Addictive Behaviors 39 (2014) 1557–1564

Contents lists available at ScienceDirect

Addictive Behaviors

Self-reported impulsivity, but not behavioral approach or inhibition, mediates the relationship between stress and self-control

Kristen R. Hamilton [a,*], Rajita Sinha [b,c,d], Marc N. Potenza [b,c,d]

[a] Center for Addictions, Personality, and Emotion Research, Department of Psychology, University of Maryland, 2103 Cole Field House, College Park, MD 20742, United States
[b] Department of Psychiatry, Yale University School of Medicine, 1 Church Street, New Haven, CT 06511, United States
[c] Child Study Center, Yale University School of Medicine, 230 S. Frontage Road, New Haven, CT 06520, United States
[d] Department of Neurobiology, Yale University School of Medicine, 1 Church Street, New Haven, CT 06511, United States

HIGHLIGHTS

- Whether cumulative stress was associated with poor self-control was examined.
- Mediation by impulsivity and behavioral approach and inhibition was examined.
- Only impulsivity mediated the stress and self-control relation.
- There were no gender differences in patterns of mediation.
- This research has implications for behavioral interventions targeting self-control.

ARTICLE INFO

Available online 22 January 2014

Keywords:
Cumulative stress
Self-control
Impulsivity
Behavioral approach
Behavioral inhibition

ABSTRACT

Stress has been associated with poor self-control. Individual differences in impulsivity and other behavioral tendencies may influence the relationship of stress with self-control, although this possibility has not been examined to date. The present research investigated whether cumulative stress is associated with poor self-control, and whether this relationship is mediated by impulsivity, behavioral approach, and behavioral inhibition in men and women. A community sample of 566 adults (319 women and 247 men) was assessed on the Cumulative Adversity Interview, Brief Self-control Scale, Barratt Impulsivity Scale, and Behavioral Activation System and Behavioral Inhibition System Scale (BIS/BAS). Data were analyzed using regression and bootstrapping techniques. In the total sample, the effects of cumulative stress on self-control were mediated by impulsivity. Neither behavioral inhibition nor behavioral approach mediated the association between cumulative stress and self-control in the total sample. Results were similar when men and women were considered separately, with impulsivity, but not behavioral inhibition or approach, mediating the association between cumulative stress and self-control. Impulsive individuals might benefit preferentially from interventions focusing on stress management and strategies for improving self-control.

1. Introduction

Self-control involves the capacity to alter one's responses in order to adhere to values, morals, and social expectations and to support the pursuit of long-term goals (Tice, Baumeister, Shmueli, & Muraven, 2007). Self-control is related to the performance of desired behaviors (e.g., assignment completion, physical exercise) and the inhibition of undesired behaviors (e.g., delinquency, sexual infidelity) across multiple behavioral domains (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). Self-control encompasses emotion regulation, restraint, and behavioral control (Carlson & Wang, 2007; Maloney, Grawitch, & Barber, 2012). Potential contributory factors to self-control may include the psychological constructs of behavioral approach, behavioral inhibition, and impulsivity (Ansell, Gu, Tuit, & Sinjha, 2012; Hamilton, Ansell, Reynolds, Potenza, & Sinha, 2013; Tull, Gratz, Latzman, Kimbrel, & Lejuez, 2010). The first two constructs are based on Gray's theories of approach and avoidance: behavioral approach is characterized by appetitive, goal-oriented functioning and positive affect, while behavioral inhibition is characterized by inhibition in response to aversive stimuli (Gray, 1972). On the other hand, impulsivity reflects a tendency for rapid action with diminished regard for future consequences (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001).

Abbreviations: CAI, Cumulative Adversity Interview; BIS, Behavioral Inhibition System; BAS, Behavioral Approach System; BIS-11, Barratt Impulsiveness Scale, Version 11; BSCS, Brief Self-control Scale.

* Corresponding author at: University of Maryland, Center for Addictions, Personality, and Emotion Research, Department of Psychology, 2103 Cole Field House, MD 20742, United States.
E-mail address: khamilt4@umd.edu (K.R. Hamilton).

0306-4603/$ – see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.addbeh.2014.01.003

Impulsivity (Blanco et al., 2009; Dawe, Gullo, & Loxton, 2004; Lejuez et al., 2010), behavioral approach (Franken & Muris, 2006; Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008; O'Connor, Stewart, & Watt, 2009) and behavioral inhibition (Hamilton, Sinha, & Potenza, 2012) are positively associated with addictive behaviors such as substance abuse and pathological gambling. Although impulsivity, behavioral approach and behavioral inhibition each contribute to addictive behaviors, they are distinct constructs that loaded onto separate factors in a principal component analysis (Meda et al., 2009). Behavioral approach and behavioral inhibition reflect a psychological orientation to rewarding and aversive stimuli, respectively, while, impulsivity reflects a behavioral tendency toward rapid action with diminished ability or willingness to consider future consequences.

Self-control is distinct from these constructs, as it refers to an ability, capacity or willingness to alter one's responses in order to adhere to long-term goals; failures of self-control are implicated in addictive behaviors (Berkman, Falk, & Lieberman, 2011; Monterosso, Piray, & Luo, 2012). Understanding psychological factors that may impact self-control is critical for public health, given the role of diminished self-control in a broad range of potentially addictive behaviors, including drug abuse (Volkow, Wang, Tomasi, & Baler, 2013), overeating (Brook, Lee, Finch, Balka, & Brook, 2013; Volkow et al., 2013), pathological gambling (Bergen, Newby-Clark, & Brown, 2012; Slutske, Moffitt, Poulton, & Caspi, 2012), online gaming (Kim, Namkoong, Ku, & Kim, 2008), problem drinking (Visser, deWinter, Veenstra, Verhulst, & Reijneveld, 2013), and smoking (Wilson & Maclean, 2013). Higher levels of trait impulsivity, behavioral approach and behavioral inhibition each may impair self-control and increase the likelihood of engagement in addictive behaviors. Taken together, self-control encompasses a broad range of capacities and tendencies, with impulsivity and behavioral approach and inhibition representing constructs that may underlie or relate importantly to self-control.

Stress decreases self-control (Muraven & Baumeister, 2000), and exposure to stressful circumstances in childhood may influence the development of self-control (Duckworth, Kim, & Tsukayama, 2013; Kempsill & Pratt, 2000). Stress is experienced when organisms perceive that a challenge exceeds their resources for coping (Baum, Gatchel, & Krantz, 1997; Baum, Grunberg, & Singer, 1982; Baum, Singer, & Baum, 1981). This perception sets in motion a series of physiological events involving the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system in an attempt to regain homeostasis (McEwen, 2000). Physiological responses to stressors may alter brain motivational pathways, such as those involving the medial prefrontal cortex, a region implicated in self-control and the inhibition of impulses (Arnsten & Goldman-Rakic, 1998; Sinha, 2008). Repeated stress and increased engagement in addictive behaviors may generate or accelerate neurobiological alterations which further promote diminished self-control, particularly among individuals with greater impulsiveness, and this process could lead stressed individuals to engage in addictive behaviors (Sinha, 2008). Cumulative stress may increase the risk for multiple addictive behaviors (Sinha, 2008), which is consistent with associations between cumulative stress and addictive behaviors characterized by poor self-control. The effects of stress on the neurobiology of self-control support the possibility that impulsivity and behavioral approach and inhibition may mediate the relationship between stress and diminished self-control. The relationship between stress and self-control varies among individuals (Job, Dweck, & Walton, 2010; Moller, Deci, & Ryan, 2006; Muraven & Baumeister, 2000; Tice et al., 2007). Impulsivity, behavioral approach, and behavioral inhibition may contribute to individual differences in the effects of stress on self-control.

Women and men differ with respect to addictions and other behaviors characterized by poor self-control (Desai, Maciejewski, Pantalon, & Potenza, 2006; Williams & Ricciardelli, 2003). Gender-related differences have been noted in the effects of self-control on gambling (Beaver et al., 2010), and in addictive processes related to self-control, including drinking behaviors (Holmila & Raitasalo, 2005; Livingston & Room, 2009; Wilsnack et al., 2000). Similar levels of impulsivity in men and women have been reported (Hamilton et al., 2012; Patton, Stanford, & Barratt, 1995), although a meta-analysis of impulsivity studies revealed slightly elevated levels of impulsivity in men compared with women (Cross, Copping, & Campbell, 2011). Taken together, these lines of research suggest that any existing gender-related differences in trait impulsivity are minimal. Gender-related differences have been reported more consistently in research examining behavioral approach and inhibition, with women having higher levels of behavioral inhibition and reward responsiveness than men (Cross et al., 2011; Hamilton et al., 2012; Perry et al., 2013). Even when assessed as toddlers, girls were significantly more behaviorally inhibited than boys (Smith et al., 2012). Because there are gender-related differences in dimensions of behavioral approach and inhibition, any mediational effects of the constructs in the relationship of stress and self-control also may differ by gender.

Statistical mediation was used in the present study to examine the roles of impulsivity and behavioral approach and inhibition in the relationships between cumulative stress and decreased self-control. To examine mediation, statistical associations may be used within a cross-sectional sample to determine statistically whether associations with retrospectively assessed stressful life events support theoretically predicted relationships. Although the cross-sectional design does not allow for the examination of stress, self-control, behavioral approach and inhibition, and impulsivity over time, associations among these variables have been established in studies with longitudinal designs (Alloy et al., 2008; Eisenberg et al., 2007; Kempsill & Pratt, 2000; Wardell, O'Connor, Read, & Colder, 2011). For this reason, it is reasonable to model retrospective reports of stressful life events over the course of the lifespan, as measured in the present study, and examine their relationships to self-control, impulsivity, behavioral approach, and behavioral inhibition. It should be noted that manipulations that decreased self-control may have increased approach motivation in one report (Schmeichel, Harmon-Jones, & Harmon-Jones, 2010). However, based on the directionality suggested by previous longitudinal studies (Alloy et al., 2008; Eisenberg et al., 2007; Kempsill & Pratt, 2000; Wardell et al., 2011), and based on the more stable natures of trait impulsivity and behavioral inhibition and approach compared with self-control, which fluctuates depending upon the situation (Muraven & Baumeister, 2000), we hypothesized that trait impulsivity, behavioral inhibition, and behavioral approach dimensions would influence self-control.

The present research was conducted to determine whether behavioral approach, behavioral inhibition, and impulsivity statistically mediate the relationship between stress and self-control, and whether the relationships are similar or distinct in men and women. Life stress, behavioral approach, behavioral inhibition trait impulsivity, and self-control were assessed in a community-based sample of men and women. Based on previous research in which exposure to childhood stress had a detrimental impact on the development of self-control (e.g., Kempsill & Pratt, 2000), it was hypothesized that cumulative stress would be associated with decreased self-control. Based on effects of stress on the neural correlates of impulsivity and self-control (Arnsten, 2009), we hypothesized that self-reported impulsivity would mediate the relationship between stress and self-control. In addition, we hypothesized that behavioral approach dimensions, but not behavioral inhibition, would mediate the relationship between stress and self-control. This hypothesis was based on several studies indicating that behavioral approach moderated the effects of a major stressor on the development of externalizing symptoms, which involve reduced self-control (Colder & O'Connor, 2004; Gudino, Nadeem, Kataoka, & Lau, 2012). By contrast, behavioral inhibition moderated effects of the stressor on internalizing symptoms, such as those associated with depression and anxiety, which do not generally involve reduced self-control. Based on research in which sex differences were found in BIS and BAS dimensions (Carver & White, 1994; Hamilton et al., 2012) but less consistently so in impulsivity (Hamilton et al., 2012; Patton et al., 1995), we

hypothesized that any observed meditational patterns involving BIS and BAS dimensions would differ in men and women.

2. Methods

2.1. Participants

Five hundred sixty-six individuals (319 women and 247 men) were recruited from the greater New Haven community via advertisements placed either on-line or in local newspapers and community centers. Eligibility was ascertained via an initial phone screen. All participants were required to be between the ages of 18 and 50 years and able to read and write in English to at least a 6th grade level. Exclusion criteria included DSM-IV dependence for any drug other than alcohol or nicotine. Participants using prescribed medications for any psychiatric or medical disorders also were excluded. Participants were administered breath alcohol testing and urine toxicology screens to verify self-reported drug and alcohol information. Participants were required to have normal values on all bloodwork lab results, and were excluded if they tested positive for drugs of abuse other than alcohol or nicotine. 6.3% of eligible individuals declined participation (i.e., refused to participate or dropped out of the study after initially agreeing to participate). All participants gave both written and verbal informed consent and the study was approved by the Human Investigation Committee of the Yale University School of Medicine.

2.2. Assessments

2.2.1. The Cumulative Adversity Interview (CAI) (Turner & Wheaton, 1995)

This 140-item event interview is a comprehensive measure of cumulative adversity that covers major life events, life trauma and chronic stress. Recent life events are also included. The *Recent Life Events* section is composed of a checklist of 33 items referring to discrete stressful events occurring in the previous 12 months. These are broadly divided into items referring to exits from the social field (e.g., death, divorce, relationships ending), and undesirable events, both interpersonal and financial (e.g., being attacked, financial crises, robberies). The *Major Life Events* section includes 11 items relating to social adversities, not typically violent in nature, but which differ from standard life events due to their severity and potentially long-term consequences (Turner & Lloyd, 2003). Examples of items are parental divorce and failing a grade in school. The *Life Traumas* section is comprised of 34 items relating to life trauma, witnessed violence and traumatic news. Life trauma includes events which imply force or coercion and include physical, emotional and/or sexual abuse, such as rape and being injured with a weapon. Witnessed violence items involve being present in dangerous or upsetting situations, such as seeing someone get shot or attacked with a weapon. Traumatic news items involve not being present, but instead hearing news about someone else being killed, abused or injured. The *Chronic Stress* section is composed of 62 items relating to continuous stressors or ongoing life problems. Items refer to longer-term interpersonal, social and financial relationships and responsibilities including work and home environment and relationships with family and significant others. As described previously (Hamilton et al., 2013), the total score is computed by standardizing each subscale and summing the scores. This approach ensures that each category of events is weighted equally in the final score. In all cases, a higher score relates to a greater number of stressful events.

2.2.2. Barratt Impulsiveness Scale (BIS-11) (Patton et al., 1995)

The BIS-11 is a 30-item self-report questionnaire that assesses impulsivity and shows good test–retest reliability (Patton et al., 1995). In the BIS-11, participants endorse a response on the four-point Likert-like Scales (1 = Rarely/Never, 2 = Occasionally, 3 = Often, 4 = Almost Always/Always) in response to each of 30 items (e.g., "I say things without thinking"). In addition to providing an overall impulsivity score, the BIS-11 also characterizes dimensions of impulsivity with three contributory subscales: attentional, motor, and non-planning impulsivity. The attentional subscale measures tendencies related to attention and decision-making, the motor subscale measures tendencies to act without fully thinking through consequences of the action, and the non-planning subscale measures tendencies not to plan ahead. The three BIS-11 dimensions are non-overlapping and demonstrate good reliability (Spinella, 2007).

2.2.3. Behavioral Inhibition System/Behavioral Approach System Scale (Carver & White, 1994)

The BIS/BAS Scale measures behavioral inhibition and behavioral approach (Gray, 1972, 1981). The measure consists of 24 statements regarding behavioral style (e.g., "When I get something I want, I feel excited and energized") with which the participant may indicate agreement or disagreement using a Likert-style Scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree). The BIS/BAS Scale is both reliable and valid (Carver & White, 1994; Jorm, Christensen, Henderson, & Jacomb, 1998). The Behavioral Inhibition System (BIS) Scale measures inhibition in response to aversive stimuli, while the behavioral activation system-related subscales assess aspects of behavioral approach. The 3 dimensions of the BIS/BAS Scale are Reward Responsiveness, Drive, and Fun-Seeking. Specifically, the Reward–Responsiveness subscale measures positive responses to anticipated or granted rewards, the Drive subscale measures the pursuit of goals, and the Fun-Seeking subscale measures the spontaneous approach of potential rewards and a desire for new rewards (Carver & White, 1994).

2.2.4. Brief Self-control Scale (BSCS; (Tangney, Baumeister, & Boone, 2004))

The BSCS measures dispositional self-regulatory behaviors using 13 items rated on a 5-point scale, ranging from 1 (Not at all like me) to 5 (Very much like me). Example items are "I am good at resisting temptation" and "I refuse things that are bad for me." Total scores on the BSCS can range from 13 to 65, with higher scores indicating greater self-control. The BSCS is correlated with measures of constructs that have some relevance to self-control, including trait impulsivity and choice impulsivity. BSCS scores were positively correlated with Eysenck Junior Impulsiveness Scale scores and Delay Choice Task scores (Duckworth et al., unpublished data), and negatively correlated with discount rates on the Kirby Monetary Choice Questionnaire (Farley, unpublished data) in adolescent samples. In adults, BSCS scores were associated with good adjustment, less pathology, better grades, and interpersonal success (Tangney et al., 2004).

2.3. Analyses

Gender-related differences in demographic variables and psychological factors were examined using Chi-square tests. The indirect effects of the models were tested using the SPSS macro for multiple mediatior models (Preacher & Hayes, 2008). In this macro, linear regressions were employed to test *a*, *b*, *c*, and *c′* pathways. The proposed mediators, BIS-11, BIS, and BAS scores, were tested together in one model. The *a* pathway represents unstandardized beta from the regression of the stress score on the proposed mediators. The *b* pathway represents the unstandardized path of the proposed mediators on BSCS score, *controlling* for stress score. *Specific indirect effects* of stress on BSCS via one of the proposed mediators (e.g., BIS-11) are defined as the product of the two unstandardized paths linking stress and BSCS via that mediator (e.g., a_1b_1, with the subscript 1 representing BIS-11). The *ab* pathways represent the specific indirect effects of stress on BSCS score via the effects of BIS-11, BIS, and BAS scores. The *total indirect effect* of stress on BSCS is the sum of the specific indirect effects. The *total effect* of stress on BSCS is the sum of the direct effect of stress on BSCS scores and all of the specific indirect effects. The *c* pathway represents the total effect.

The c' pathway represents the unstandardized path of the stress score on BSCS score with the effects of BIS-11, BIS, and BAS controlled. The c' pathway is also called the *direct effect* of stress on BSCS score as it represents the effects of stress on self-control independent of BIS-11, BIS, and BAS. In the model, BSCS score was the dependent variable. To test the significance of the Indirect Effects of Stress Scale on BSCS score via BIS-11 impulsivity, BIS, and BAS, we employed the approach by Preacher and Hayes (2008) using the SPSS INDIRECT bootstrapping macro. As indirect effects do not meet normal assumptions for statistical analysis, bootstrapping was used to estimate the significance of the indirect effects. Bias corrected and accelerated 95% Confidence Intervals (CI) were computed using 10,000 bootstrapped re-samples for each indirect point estimate. CIs which do not contain a zero value indicate a significant effect. The k^2 statistic was used to denote effect size. The k^2 statistic is interpreted as the proportion of the maximum possible indirect effect that could have occurred, had the constituent effects been as large as the design and data permitted (Preacher & Kelley, 2011).

3. Results

Demographics and mean scores on the scales for the sample are displayed in Table 1. Women and men did not differ on age or years of education, although there were more women than men among African Americans and people characterized as "Other." Women and men scored similarly on all psychological measures except for BIS, with women having higher scores than men on this measure.

3.1. Correlations between measures

Among all participants, cumulative stress was related to self-control ($r = -0.194$, $p < 0.01$), and this relationship was observed among men ($r = -0.211$, $p < 0.01$) and women ($r = -0.194$, $p < 0.01$).

3.2. Mediation model involving the total sample

The results for the multiple mediation model examining the relationships between the CAI, BIS-11, BIS/BAS, and BSCS scores are presented in Table 2. The total effect of cumulative stress on self-control was significant [$b = -.53$, $t(561) = -3.36$, $p < 0.001$], but the direct effect, which controls for BIS-11, BIS, and BAS was not significant [$b = -.11$, $t(561) = -.95$, $p = .34$]. The overall model, which included BIS, BAS, and BIS-11 scores, was significant [Model $R^2 = .45$, $F(4, 561) = 116.09$, $p < 0.001$].

Table 1
Demographics and psychological factors.

	Women (N = 319)	Men (N = 247)
Age (mean years (S.D.))	29.21 (9.20)	28.70 (8.42)
Education (mean years (S.D.))	15.28 (2.15)	15.34 (2.33)
Gender (n (%))	319 (56.4%)	247 (43.6%)
Race/ethnicity (n (%))		
African American[a]	68 (64%)	39 (36%)
Asian	11 (50%)	11 (50%)
Caucasian	203 (53%)	180 (47%)
Other[a]	15 (83%)	3 (17%)
Psychological factors (mean (S.D.))		
BIS-11	59.98 (10.88)	60.71 (10.61)
BIS[b]	20.25 (3.74)	18.16 (3.80)
BAS	39.50 (5.63)	39.09 (5.29)
Cumulative adversity	0.05 (2.30)	−0.33 (2.17)
BSCS self-control	46.53 (8.50)	45.66 (8.34)

BIS = Behavioral Inhibition System.
BAS = Behavioral Approach System.
BSCS = Brief Self-control Scales.
S.D. = Standard Deviation.
[a] Sex difference at $p < 0.05$ in a Chi square test.
[b] Sex difference at $p < 0.01$ in a t-test, females > males.

Table 2
Correlations.

		1	2	3	4
Men and women	1. CAI				
	2. BSCS	−.14**			
	3. BIS-11	.16**	−.64**		
	4. BIS	.07	−.39**	.32**	
	5. BAS	.09*	−.23**	.25**	.18**
Women	1. CAI				
	2. BSCS	−.13*			
	3. BIS-11	.15**	−.66**		
	4. BIS	.08	−.32**	.30**	
	5. BAS	.05	−.27**	.31**	.26**
Men	1. CAI				
	2. BSCS	−.17**			
	3. BIS-11	.19**	−.62**		
	4. BIS	.01	−.53**	.40**	
	5. BAS	.15*	−.18**	.18**	.07

** Significant at $p < 0.01$.
* Significant at $p < 0.05$.

3.2.1. BIS-11 in the total sample

The relationship between cumulative stress and self-control was mediated by BIS-11 total impulsivity. Cumulative stress was positively associated with overall impulsivity [$a = .78$, $t(561) = 3.90$, $p < .001$] and overall impulsivity was significantly inversely associated with BSCS score [$b = -.44$, $t(561) = -16.59$, $p < .001$]. The specific indirect effect for cumulative stress total score on BSCS score via BIS-11 total score also was significant [$a \times b = -.34$, Confidence Interval (CI) = −.53 to −.19] supporting a statistical mediation effect such that greater stress was associated with greater impulsivity, which was associated with lower scores on the BSCS. Taken together, these results suggest that the effects of cumulative stress on BSCS were mediated by total impulsivity. The effect size of the mediation by impulsivity was $k^2 = 0.108$.

3.2.2. BIS in the total sample

Behavioral inhibition did not mediate the relationship between cumulative stress and self-control. Cumulative stress was not associated with behavioral inhibition [$a = .13$, $t(561) = 1.7$, $p = .09$], although behavioral inhibition was significantly inversely associated with BSCS score [$b = -.41$, $t(561) = -5.79$, $p < .001$]. The specific indirect effect for cumulative stress total score on BSCS score via BIS was not significant [$a \times b = -.05$, CI = −.12–.01], indicating that there was no statistical mediation effect by BIS of the relationship between cumulative stress and self-control. Taken together, these results suggest that the effects of cumulative stress on BSCS were not mediated by behavioral inhibition.

3.2.3. BAS in the total sample

Behavioral approach did not mediate the relationship between cumulative stress and self-control. Although cumulative stress was positively associated with behavioral inhibition [$a = .22$, $t(561) = 2.1$, $p < .05$], behavioral approach was not associated with BSCS score [$b = -.08$, $t(561) = -1.5$, $p = .13$]. The specific indirect effect for cumulative stress total score on BSCS score via BAS was not significant [$a \times b = -.02$, CI = −.06–.004], indicating that there was no statistical mediation effect by BAS of the relationship between cumulative stress and self-control. Taken together, these results suggest that the effects of cumulative stress on BSCS were not mediated by behavioral approach.

3.3. Mediation model in men

The results for the multiple mediation model examining the relationship between the CAI, BIS-11, BIS/BAS, and BSCS scores in men are presented in Table 3. The total effect of cumulative stress on self-

Table 3
Mediation of association of stress with self-control by impulsivity, BIS, and BAS.

	Effect of IV on M (a)	Effect of M on DV (b)	Total effect (c)	Direct effect (c')	Indirect effect ($a \times b$) (95% CI)
Total sample					
Impulsivity	.78**	−.44**	−.53**	−.11	−.34* (−.53 to −.19)
BIS	.13	−.41**	−.53**	−.11	−.05 (−.12–.01)
BAS	.22*	−.08	−.53**	−.11	−.02 (−.06–.004)
Men					
Impulsivity	.94*	−.44**	−.65*	−.27	−.33* (−.61 to −.13)
BIS	.02	−.76**	−.65*	−.27	−.01 (−.18–.15)
BAS	.36*	−.11	−.65*	−.27	−.04 (−.15–.01)
Women					
Impulsivity	.70*	−.48**	−.47*	−.09	−.33* (−.56 to −.11)
BIS	.14	−.29*	−.47*	−.09	−.04 (−.12–.003)
BAS	.11	−.07	−.47*	−.09	−.01 (−.07–.01)

a = the unstandardized beta from the regression of the stress score on the proposed mediators; b = the unstandardized beta from the regression of the proposed mediators on self-control, controlling for stress score; c = the unstandardized beta from the regression of stress on self-control (i.e., the total effect); c' = the unstandardized beta from the regression of stress on self-control independent of the proposed mediators (i.e., the direct effect); IV = independent variable (i.e., cumulative stress); M = mediator (e.g., overall self-reported impulsivity, BIS, and BAS); DV = dependent variable (self-control). The total effect is the effect of the IV on the DV without including the mediators in the model. The direct effect is the effect of the IV on the DV, controlling for the effects of the mediators. The indirect effect is the effect of the IV on the DV via the mediator.

* Denotes significance level of $p < 0.05$.

** Denotes significance level of $p < 0.001$.

control was significant [b = −.65, $t(242) = -2.70$, $p < 0.01$], and the direct effect, which controls for BIS-11, BIS, and BAS was not significant [b = −.27, $t(242) = -1.48$, p = .14]. The overall model, which included BIS, BAS, and BIS-11 scores, was significant [Model $R^2 = .49$, $F(4242) = 57.39$, $p < 0.001$].

3.3.1. BIS-11 in men

The relationship between cumulative stress and self-control was mediated by BIS-11 total impulsivity in men. Cumulative stress was positively associated with overall impulsivity [$a = .94$, $t(242) = 3.05$, $p < .01$] and overall impulsivity was significantly inversely associated with BSCS score [$b = -.44$, $t(242) = -16.59$, $p < .001$]. The specific indirect effect for cumulative stress total score on BSCS score via BIS-11 total score also was significant [$a \times b = -.33$, Confidence Interval (CI) = −.61 to −.13] supporting a statistical mediation effect such that greater stress was associated with greater impulsivity, which was associated with lower scores on the BSCS. Taken together, these results suggest that the effects of cumulative stress on BSCS were mediated by total impulsivity in men. The effect size of the mediation by impulsivity was $k^2 = 0.098$.

3.3.2. BIS in men

Behavioral inhibition did not mediate the relationship between cumulative stress and self-control in men. Cumulative stress was not associated with behavioral inhibition [$a = .02$, $t(242) = .14$, $p = .89$], although behavioral inhibition was significantly inversely associated with BSCS score [$b = -.76$, $t(242) = -6.85$, $p < .001$]. The specific indirect effect for cumulative stress total score on BSCS score via BIS was not significant [$a \times b = -.01$, CI = −.18–.15], indicating that there was no statistical mediation effect by BIS of the relationship between cumulative stress and self-control. Taken together, these results suggest that the effects of cumulative stress on BSCS were not mediated by behavioral inhibition in men.

3.3.3. BAS in men

Behavioral approach did not mediate the relationship between cumulative stress and self-control in men. Although cumulative stress was positively associated with behavioral approach [$a = .36$, $t(242) = 2.32$, $p < .05$], behavioral approach was not associated with BSCS score [$b = -.11$, $t(242) = -1.5$, $p = .14$]. The specific indirect effect for cumulative stress total score on BSCS score via BAS was not significant [$a \times b = -.04$, CI = −.15–.01], indicating that there was no statistical mediation effect by BAS of the relationship between cumulative stress and self-control. Taken together, these results suggest that the effects of cumulative stress on BSCS were not mediated by behavioral approach in men.

3.4. Mediation model in women

The results for the multiple mediation model examining the relationship between the CAI, BIS-11, BIS/BAS, and BSCS scores in women are presented in Table 3. The total effect of cumulative stress on self-control in women was significant [b = −.47, $t(314) = -2.30$, $p < 0.05$], and the direct effect, which controls for BIS-11, BIS, and BAS, was not significant [b = −.09, $t(314) = -.59$, p = .56]. The overall model, which included BIS, BAS, and BIS-11 scores, was significant [Model $R^2 = .46$, $F(4314) = 66.67$, $p < 0.001$].

3.4.1. BIS-11 in women

The relationship between cumulative stress and self-control was mediated by BIS-11 total impulsivity in men. Cumulative stress was positively associated with overall impulsivity [$a = .70$, $t(314) = 2.66$, $p < .01$] and overall impulsivity was significantly inversely associated with BSCS score [$b = -.48$, $t(314) = -13.41$, $p < .001$]. The specific indirect effect for cumulative stress total score on BSCS score via BIS-11 total score also was significant [$a \times b = -.33$, Confidence Interval (CI) = −.56 to −.11] supporting a statistical mediation effect such that greater stress was associated with greater impulsivity, which was associated with lower scores on the BSCS. Taken together, these results suggest that the effects of cumulative stress on BSCS were mediated by total impulsivity in women. Similar to the total sample, the effect size of the mediation by impulsivity was $k^2 = 0.108$.

3.4.2. BIS in women

Behavioral inhibition did not mediate the relationship between cumulative stress and self-control in men. Cumulative stress was not associated with behavioral inhibition [$a = .14$, $t(314) = 1.51$, $p = .13$], although behavioral inhibition was significantly inversely associated with BSCS score [$b = -.29$, $t(314) = -2.89$, $p < .01$]. The specific indirect effect for cumulative stress total score on BSCS score via BIS was not significant [$a \times b = -.04$, CI = −.12–.003], indicating that there was no statistical mediation effect by BIS of the relationship between cumulative stress and self-control. Taken together, these results suggest that the effects of cumulative stress on BSCS were not mediated by behavioral inhibition in women.

3.4.3. BAS in women

Behavioral approach did not mediate the relationship between cumulative stress and self-control in women. Cumulative stress was not

associated with behavioral approach [$a = .11$, $t(314) = .81$, $p = .42$], and behavioral approach was not associated with BSCS score [$b = -.07$, $t(314) = -.97$, $p = .34$]. The specific indirect effect for cumulative stress total score on BSCS score via BAS was not significant [$a \times b = -.01$, CI = −.07–.01], indicating that there was no statistical mediation effect by BAS of the relationship between cumulative stress and self-control. Taken together, these results suggest that the effects of cumulative stress on BSCS were not mediated by behavioral approach in women.

4. Discussion

It was hypothesized that cumulative stress would be associated with decreased self-control, and that self-reported impulsivity and behavioral approach would mediate the relationship in women and men. There were several major findings. First, cumulative stress was associated with decreased self-control in both men and women. Second, self-reported impulsivity, but not behavioral inhibition or behavioral approach, mediated the relationship between cumulative stress and decreased self-control in the overall sample. Third, there were no gender-related differences in patterns of mediation. A discussion of each of the major findings follows.

To our knowledge, this is the first report of an association of decreased self-control with cumulative stress. This finding is consistent with research reporting effects of acute stress on self-control (Muraven & Baumeister, 2000) and effects of childhood stress on later self-control (Alloy et al., 2008; Eisenberg et al., 2007; Kempsill & Pratt, 2000; Wardell et al., 2011). Low self-control is implicated in alcohol drinking and cigarette-smoking, two behaviors that are associated with stress (Ansell, Gu, Tuit, & Sinjha, 2012; Hamilton et al., 2013). The results of this research are consonant with previous reports indicating statistical mediation by self-reported impulsivity of the association between cumulative stress and alcohol consumption (Fox, Bergquist, Gu, & Sinha, 2010). It is possible that decreased self-control may be the mechanism by which stress increases substance use, although additional research would be needed to make this determination. Given the role of self-control in problematic behaviors including drug addiction (Volkow et al., 2013), obesity (Brook et al., 2013; Volkow et al., 2013), pathological gambling (Bergen et al., 2012; Slutske et al., 2012), online gaming (Kim et al., 2008), problem drinking (Visser et al., 2013), and smoking (Wilson & Maclean, 2013), strategies to diminish the detrimental effects of stress on self-control would be valuable for public health. Such strategies could include behavioral and pharmacological interventions to manage stress or to increase self-control.

Our second major finding is that BIS-11 total impulsivity, but not behavioral approach or inhibition, mediated the inverse relationship between cumulative stress and self-control in men and women. This is the first report in which the joint contributions of behavioral inhibition, behavioral approach, and impulsivity to the relationship between cumulative stress and self-control were examined in a mediation model. The relationship between cumulative stress and decreased self-control was influenced by an individual's level of impulsivity, and the effect size of this relationship was medium (Cohen, 1988; Preacher & Kelley, 2011). In other words, stress was associated with impulsivity, and impulsivity was associated with decreased self-control. It is through this path that stress was associated with decreased self-control, which is evidenced by the finding that the association between stress and self-control was no longer significant after controlling for the indirect effect of impulsivity. Because impulsivity mediated the relationship between stress and reduced self-control, it follows that behavioral and pharmacological interventions to decrease impulsivity also may reduce the detrimental effects of stress on self-control.

One possible pharmacological intervention may target self-control on a molecular level. Several studies indicate that the 7-repeat allele of the Dopamine Receptor D4 (DRD4) gene may alter susceptibility to positive and negative environmental influences (Belsky & Pluess, 2009; Knafo, Israel, & Ebstein, 2011; Sheese, Voelker, Rothbart, & Posner, 2007). This gene interacted with parenting quality to predict effortful control in four-year-old children, such that the association between parenting quality and effortful control was significant only for the children with the 7-repeat allele, but not for those without this allele (Sheese, Rothbart, Voelker, & Posner, 2012). This gene also interacted with life stress to predict escalations in drug use in emerging adults, with the highest levels of drug use escalation occurring in those who reported high life stress and carried an allele of the DRD4 gene with 7 or more repeats (Brody et al., 2012). Together these lines of research suggest that the presence of the DRD4 7-repeat allele in an individual may contribute to the relationship between environmental factors (such as stress) and self-control. Following from this research, a pharmacological intervention targeting the 7-repeat allele of the DRD4 gene may have implications for reducing associations of stress with decreased self-control. Additionally, previously reported associations of cumulative stress with decreased volume in brain regions including the ventromedial prefrontal cortex (Ansell, Rando, Tuit, Guarnaccia, & Sinha, 2012) suggest a potential neurobiological mechanism of the stress and self-control relationship for future study.

The hypothesis that there would be gender-related differences in patterns of mediation was not supported; impulsivity mediated the stress and self-control relationship to a similar degree in men and women, while behavioral approach and inhibition did not mediate the relationship in either men or women. The lack of gender-related differences is consonant with previous reports of no (Hamilton et al., 2012; Patton et al., 1995) or minimal (Cross et al., 2011) gender-related differences in impulsivity. The mediation of the stress and self-control association had a medium effect size in the total sample, as well as in men and women considered separately. The similarity of the effect sizes provides further support for the absence of gender-related differences in the mediation of the stress and self-control relationship.

Notably, a recent revision to the model of behavioral inhibition (Gray & McNaughton, 2000; Schmeichel et al., 2010) posits that the Behavioral Inhibition System (BIS) resolves conflicts between the behavioral approach system (BAS) and fight–flight–freeze system (FFFS), a system that mediates reactions to aversive stimuli. The original BIS and BAS models were used in the present research because it has been well-validated in community samples (Hamilton et al., 2012; Rahman, Xu, & Potenza, 2014). However, the revised conflict resolution conceptualization of BIS also may relate to self-control. As such, future research should examine the relationship of self-control to alternative and revised models of behavioral inhibition.

It is important to note that mediation analyses cannot prove causation. Results of mediation analyses can provide support for or against hypotheses, but cannot prove them (Preacher & Hayes, 2008). Overall these findings extend previous research that has established the effects of stress on self-control by examining statistical mediation models of stress, self-control, impulsivity, and behavioral approach and inhibition. These findings support the stress-vulnerability theory and emphasize the impact that cumulative stress and adversity may have on self-control. The results of this research can be used to inform the development of treatment and prevention strategies focused on enhancing both stress management and self-control. Treatment and prevention strategies targeted toward impulsive individuals may be particularly valuable. This research emphasizes the importance of examining cumulative stress and adversity as experienced over the lifespan when examining temperamental constructs relevant to self-control. These findings do not preclude the examination of impulsivity, behavioral approach, or behavioral inhibition as moderators of the effects of stress on self-control, nor do they preclude the reciprocal impact of decreased self-control on individual differences in impulsivity, behavioral approach, and behavioral inhibition. Additional factors, such as genetic variations, were not examined in this model but may also contribute to decreased self-control.

An important limitation of the current findings is the cross-sectional nature of the sample. Potential causal mechanisms of change should be further studied in research with longitudinal designs to examine the indirect pathway by which cumulative stress may impact self-control. The current cross-sectional analysis provides additional evidence that history of cumulative adversity is directly and indirectly associated with decreased self-control. Future research should be conducted with a longitudinal design to assess the effects of cumulative stress, behavioral approach, and behavioral inhibition on self-control and real-world health risk behaviors. A second limitation of the present study is the use of the original conceptualization of behavioral inhibition, rather than the more recently revised model (J. A. Gray & McNaughton, 2000; Schmeichel et al., 2010). Future research should examine the relation of self-control to alternative and revised models of behavioral inhibition.

Role of funding sources

This work was supported in part by the NIH (T32 DA007238, RL1- AA017539, P20-DA027844, UL1- DE019586, and PL1-DA024859), and the NIH Roadmap for Medical Research Common Fund. The funding sources had no role in the preparation of the manuscript, nor did they have a role in the decision to submit the manuscript. The content of the manuscript reflects the contributions and thoughts of the authors and does not necessarily reflect the views of the funding agencies.

Contributors

Drs. Sinha and Potenza designed the study and wrote the protocol. Dr. Hamilton conducted literature searches and statistical analyses and wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

The authors report that they have no financial conflicts of interest with respect to the content of this manuscript. Dr. Sinha is on the Scientific Advisory Board for Embera Neurotherapeutics and is also a consultant for Glaxo-Smith Kline Pharmaceuticals. Dr. Potenza has consulted for and advised Boehringer Ingelheim; has consulted for and has financial interests in Somaxon; has received research support from the National Institutes of Health, Veteran's Administration, Mohegan Sun Casino, the National Center for Responsible Gaming and its affiliated Institute for Research on Gambling Disorders, and Forest Laboratories, Ortho-McNeil, Oy-Control/Biotie, Psyadon and Glaxo-SmithKline pharmaceuticals; has participated in surveys, mailings or telephone consultations related to drug addiction, impulse control disorders or other health topics; has consulted for law offices and the federal public defender's office in issues related to impulse control disorders; provides clinical care in the Connecticut Department of Mental Health and Addiction Services Problem Gambling Services Program; has performed grant reviews for the National Institutes of Health and other agencies; has guest-edited journal sections; has given academic lectures in grand rounds, CME events and other clinical or scientific venues; and has generated books or book chapters for publishers of mental health texts.

References

Alloy, L. B., Abramson, L. Y., Walshaw, P. D., Cogswell, A., Grandin, L. D., Hughes, M. E., et al. (2008). Behavioral Approach System and Behavioral Inhibition System sensitivities and bipolar spectrum disorders: Prospective prediction of bipolar mood episodes. *Bipolar Disorders*, *10*, 310–322.

Ansell, E. B., Gu, P., Tuit, K., & Sinjha, R. (2012). Effects of cumulative stress and impulsivity on smoking status. *Human Psychopharmacology*, *27*, 200–208.

Ansell, E. B., Rando, K., Tuit, K., Guarnaccia, J., & Sinha, R. (2012). Cumulative adversity and smaller gray matter volume in medial prefrontal, anterior cingulate, and insula regions. *Biological Psychiatry*, *72*, 57–64.

Arnsten, A. F. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. *Nature Reviews Neuroscience*, *10*, 410–422.

Arnsten, A. F., & Goldman-Rakic, P.S. (1998). Noise stress impairs prefrontal cortical cognitive function in monkeys: Evidence for a hyperdopaminergic mechanism. *Archives of General Psychiatry*, *55*, 362–368.

Baum, A., Gatchel, R. J., & Krantz, D. S. (1997). *An introduction to health psychology* (3rd ed.). New York: McGraw-Hill.

Baum, A., Grunberg, N. E., & Singer, J. E. (1982). The use of psychological and neuroendocrinological measurements in the study of stress. *Health Psychology*, *1*, 217–236.

Baum, A., Singer, J. E., & Baum, C. S. (1981). Stress and the environment. *Journal of Social Issues*, *37*, 4–35.

Beaver, K. M., Hoffman, T., Shields, R. T., Vaughn, M. G., DeLisi, M., & Wright, J. P. (2010). Gender differences in genetic and environmental influences on gambling: Results from a sample of twins from the National Longitudinal Study of Adolescent Health. *Addiction*, *105*, 536–542.

Belsky, J., & Pluess, M. (2009). Beyond diathesis stress: Differential susceptibility to environmental influences. *Psychological Bulletin*, *135*, 885–908.

Bergen, A. E., Newby-Clark, I. R., & Brown, A. (2012). Low trait self-control in problem gamblers: Evidence from self-report and behavioral measures. *Journal of Gambling Studies*, *28*, 637–648.

Berkman, E. T., Falk, E. B., & Lieberman, M.D. (2011). In the trenches of real-world self-control: Neural correlates of breaking the link between craving and smoking. *Psychological Science*, *22*, 498–506.

Blanco, C., Potenza, M. N., Kim, S. W., Ibáñez, A., Zaninelli, R., Saiz-Ruiz, J., et al. (2009). A pilot study of impulsivity and compulsivity in pathological gambling. *Psychiatry Research*, *167*, 161–168.

Brody, G. H., Chen, Y. F., Yu, T., Beach, S. R., Kogan, S. M., Simons, R. L., et al. (2012). Life stress, the dopamine receptor gene, and emerging adult drug use trajectories: A longitudinal, multilevel, mediated moderation analysis. *Development and Psychopathology*, *24*, 941–951.

Brook, J. S., Lee, J. Y., Finch, S. J., Balka, E. B., & Brook, D. W. (2013). Physical factors, personal characteristics, and substance use: Associations with obesity. *Substance Abuse*, *34*, 273–276.

Carlson, S. M., & Wang, T. S. (2007). Inhibitory control and emotion regulation in preschool children. *Cognitive Development*, *22*, 489–510.

Carver, C., & White, T. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology*, *67*, 319–333.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Earlbaum.

Colder, C. R., & O'Connor, R. M. (2004). Gray's reinforcement sensitivity model and child psychopathology: Laboratory and questionnaire assessment of the BAS and BIS. *Journal of Abnormal Child Psychology*, *32*, 435–451.

Cross, C., Copping, L., & Campbell, A. (2011). Sex differences in impulsivity: A meta-analysis. *Psychological Bulletin*, *137*, 97–130.

Dawe, S., Gullo, M., & Loxton, N. J. (2004). Reward drive and rash impulsiveness as dimensions of impulsivity: Implications for substance misuse. *Addictive Behaviours*, *29*, 1389–1406.

de Ridder, D. T., Lensvelt-Mulders, G., Finkenauer, C., Stok, F. M., & Baumeister, R. F. (2012). Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors. *Personality and Social Psychology Review*, *16*, 76–99.

Desai, R. A., Maciejewski, P. K., Pantalon, M. V., & Potenza, M. N. (2006). Gender differences among recreational gamblers: Association with the frequency of alcohol use. *Psychology of Addictive Behaviors*, *20*, 145–153.

Duckworth, A. L., Kim, B., & Tsukayama, E. (2013). Life stress impairs self-control in early adolescence. *Frontiers in Psychology*, *3*, 608.

Eisenberg, D. A., MacKillop, J., Modi, M., Beauchemin, J., Dang, D., Lisman, S. A., et al. (2007). Examining impulsivity as an endophenotype using a behavioral approach: A DRD2 TaqI A and DRD4 48-bp VNTR association study. *Behavioral and Brain Functions*, *3*, 2.

Fox, H., Bergquist, K., Gu, P., & Sinha, R. (2010). Interactive effects of cumulative stress and impulsivity on alcohol consumption. *Alcoholism, Clinical and Experimental Research*, *34*, 1–10.

Franken, I. H. A., & Muris, P. (2006). BIS/BAS personality characteristics and college students' substance use. *Personality and Individual Differences*, *40*.

Gray, J. (1972). The psychophysiological basis of introversion–extraversion: A modification of Eysenck's theory. In V. Nebylitsyn, & J. Gray (Eds.), *The biological bases of individual behavior* (pp. 182–205). San Diego, CA: Academic Press.

Gray, J. A. (1981). A critique of Eysenck's theory of personality. In H. J. Eysenck (Ed.), *A model for personality* (pp. 246–276).

Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system* (2nd ed.). Oxford: Oxford University Press.

Gudino, O. G., Nadeem, E., Kataoka, S. H., & Lau, A. S. (2012). Reinforcement sensitivity and risk for psychopathology following exposure to violence: A vulnerability-specificity model in Latino youth. *Child Psychiatry and Human Development*, *43*, 306–321.

Hamilton, K. R., Ansell, E. B., Reynolds, B., Potenza, M. N., & Sinha, R. (2013). Self-reported impulsivity, but not behavioral choice or response impulsivity, partially mediates the effect of stress on drinking behavior. *Stress*, *16*, 3–15.

Hamilton, K. R., Sinha, R., & Potenza, M. N. (2012). Hazardous drinking and dimensions of impulsivity, behavioral approach, and inhibition in adult men and women. *Alcoholism, Clinical and Experimental Research*, *36*, 958–966.

Holmila, M., & Raitasalo, K. (2005). Gender differences in drinking: Why do they still exist? *Addiction*, *100*, 1763–1769.

Hundt, N., Kimbrel, N., Mitchell, J., & Nelson-Gray, R. (2008). High BAS, but not low BIS, predicts externalizing symptoms in adults. *Personality and Individual Differences*, *44*, 565–575.

Job, V., Dweck, C. S., & Walton, G. M. (2010). Ego depletion — is it all in your head? Implicit theories about willpower affect self-regulation. *Psychological Science*, *21*, 1686–1693.

Jorm, A., Christensen, A., Henderson, P., & Jacomb, A. (1998). Using the BIS/BAS Scales to measure behavioural inhibition and behavioural activation: Factor structure, validity and norms in a large community sample. *Personality and Individual Differences*, *26*, 49–58.

Kempsill, F. E., & Pratt, J. A. (2000). Mecamylamine but not the alpha7 receptor antagonist alpha-bungarotoxin blocks sensitization to the locomotor stimulant effects of nicotine. *British Journal of Pharmacology*, *131*, 997–1003.

Kim, E. J., Namkoong, K., Ku, T., & Kim, S. J. (2008). The relationship between online game addiction and aggression, self-control and narcissistic personality traits. *European Psychiatry*, *23*, 212–218.

Knafo, A., Israel, S., & Ebstein, R. P. (2011). Heritability of children's prosocial behavior and differential susceptibility to parenting by variation in the dopamine receptor D4 gene. *Development and Psychopathology*, *23*, 53–67.

Lejuez, C. W., Magidson, J. F., Mitchell, S. H., Sinha, R., Stevens, M. C., & de Wit, H. (2010). Behavioral and biological indicators of impulsivity in the development of alcohol use, problems, and disorders. *Alcoholism, Clinical and Experimental Research*, *34*, 1334–1345.

Livingston, M., & Room, R. (2009). Variations by age and sex in alcohol-related problematic behaviour per drinking volume and heavier drinking occasion. *Drug and Alcohol Dependence*, *101*, 169–175.
Maloney, P. W., Grawitch, M. J., & Barber, L. K. (2012). The multi-factor structure of the Brief Self-control Scale: Discriminant validity of restraint and impulsivity. *Journal of Research in Personality*, *46*, 111–115.
McEwen, B.S. (2000). The neurobiology of stress: From serendipity to clinical relevance. *Brain Research*, *886*, 172–189.
Meda, S., Stevens, M. C., Potenza, M. N., Pittman, B., Gueorguieva, R., Andrews, M. M., et al. (2009). Investigating the behavioral and self-report constructs of impulsivity domains using principal component analysis. *Behavioral Pharmacology*, *20*, 390–399.
Moeller, F. G., Barratt, E. S., Dougherty, D.M., Schmitz, J. M., & Swann, A.C. (2001). Psychiatric aspects of impulsivity. *The American Journal of Psychiatry*, *158*, 1783–1793.
Moller, A.C., Deci, E. L., & Ryan, R. M. (2006). Choice and ego-depletion: The moderating role of autonomy. *Personality and Social Psychology Bulletin*, *32*, 1024–1036.
Monterosso, J., Piray, P., & Luo, S. (2012). Neuroeconomics and the study of addiction. *Biological Psychiatry*, *72*, 107–112.
Muraven, M., & Baumeister, R. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin*, *126*, 247–259.
O'Connor, R., Stewart, S., & Watt, M. (2009). Distinguishing BAS risk for university students' drinking, smoking, and gambling behaviors. *Personality and Individual Differences*, *46*, 514–519.
Patton, J. M., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology*, *51*, 768–774.
Perry, R. I., Krmpotich, T., Thompson, L. L., Mikulich-Gilbertson, S. K., Banich, M. T., & Tanabe, J. (2013). Sex modulates approach systems and impulsivity in substance dependence. *Drug and Alcohol Dependence*, *133*, 222–227.
Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*, 879–891.
Preacher, K. J., & Kelley, K. (2011). Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychological Methods*, *16*, 93–115.
Rahman, A. S., Xu, J., & Potenza, M. N. (2014). Hippocampal and amygdalar volumetric differences in pathological gambling: A preliminary study of the associations with the behavioral inhibition system. *Neuropsychopharmacology*, *39*, 738–745.
Schmeichel, B. J., Harmon-Jones, C., & Harmon-Jones, E. (2010). Exercising self-control increases approach motivation. *Journal of Personality and Social Psychology*, *99*, 162–173.
Sheese, B. E., Rothbart, M. K., Voelker, P.M., & Posner, M. I. (2012). The dopamine receptor D4 gene 7-repeat allele interacts with parenting quality to predict effortful control in four-year-old children. *Child Development Research*, *2012*, 863242.
Sheese, B. E., Voelker, P.M., Rothbart, M. K., & Posner, M. I. (2007). Parenting quality interacts with genetic variation in dopamine receptor D4 to influence temperament in early childhood. *Development and Psychopathology*, *19*, 1039–1046.
Sinha, R. (2008). Chronic stress, drug use, and vulnerability to addiction. *Annals of the New York Academy of Sciences*, *1141*, 105–130.
Slutske, W. S., Moffitt, T. E., Poulton, R., & Caspi, A. (2012). Undercontrolled temperament at age 3 predicts disordered gambling at age 32: A longitudinal study of a complete birth cohort. *Psychological Science*, *23*, 510–516.
Smith, A. K., Rhee, S. H., Corley, R. P., Friedman, N.P., Hewitt, J. K., & Robinson, J. L. (2012). The magnitude of genetic and environmental influences on parental and observational measures of behavioral inhibition and shyness in toddlerhood. *Behavior Genetics*, *42*, 764–777.
Spinella, M. (2007). Normative data and a short form of the Barratt Impulsiveness Scale. *International Journal of Neuroscience*, *117*, 359–368.
Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, *72*, 271–322.
Tice, D.M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology*, *43*, 379–384.
Tull, M. T., Gratz, K. L., Latzman, R. D., Kimbrel, N. A., & Lejuez, C. W. (2010). Reinforcement sensitivity theory and emotion regulation difficulties: A multimodal investigation. *Personality and Individual Differences*, *49*, 989–994.
Turner, R. J., & Lloyd, D. A. (2003). Cumulative adversity and drug dependence in young adults: Racial/ethnic contrasts. *Addiction*, *98*, 305–315.
Turner, R. J., & Wheaton, B. (1995). Checklist measurement of stressful life events. In S. Cohen, R. Kessler, & G. L. Underwood (Eds.), *Measuring stress* (pp. 29–58). New York: Oxford University Press.
Visser, L., deWinter, A. F., Veenstra, R., Verhulst, F. C., & Reijneveld, S. A. (2013). Alcohol use and abuse in young adulthood: Do self-control and parents' perceptions of friends during adolescence modify peer influence? The TRAILS study. *Addictive Behaviors*, *38*, 2841–2846.
Volkow, N. D., Wang, G. J., Tomasi, D., & Baler, R. D. (2013). Obesity and addiction: Neurobiological overlaps. *Obesity Reviews*, *14*, 2–18.
Wardell, J.D., O'Connor, R. M., Read, J. P., & Colder, C. R. (2011). Behavioral Approach System moderates the prospective association between the Behavioral Inhibition System and alcohol outcomes in college students. *Journal of Studies on Alcohol and Drugs*, *72*, 1028–1036.
Williams, R. J., & Ricciardelli, L. A. (2003). Negative perceptions about self-control and identification with gender-role stereotypes related to binge eating, problem drinking, and to co-morbidity among adolescents. *The Journal of Adolescent Health*, *32*, 66–72.
Wilsnack, R., Vogeltanz, N., Wilsnack, S., Harris, T., Ahlström, S., Bondy, S., et al. (2000). Gender differences in alcohol consumption and adverse drinking consequences: Cross-cultural patterns. *Addiction*, *95*, 251–265.
Wilson, S. J., & Maclean, R. R. (2013). Associations between self-control and dimensions of nicotine dependence: A preliminary report. *Addictive Behaviors*, *38*, 1812–1815.