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Assessing impulsivity: Relationships between behavioral and self-report measures in individuals with and without self-reported ADHD

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ABSTRACT

The present study examined relationships between self-report and behavioral measures of impulsivity, a personality characteristic linked to diagnostic criteria for multiple psychological disorders, in individuals who either self-reported ($n = 28$) or did not self-report ($n = 147$) a history of Attention-Deficit/Hyperactivity Disorder (ADHD) diagnosis. Undergraduate student participants completed several self-report measures of impulsivity (Barratt Impulsiveness Scale, Impulsive Sensation Seeking subscale, BIS/BAS Scale, Conner's Adult ADHD Rating Scale, and Frontal Systems Behavior Rating Scale) and three behavioral measures of impulsivity (Balloon Analogue Risk Task, Delay Discounting Task, Stroop). A principal components analysis indicated three components encompassing attentional impulsiveness, reward sensitivity, and behavioral and motor impulsiveness; however, none of the behavioral measures factored with the self-report measures. Logistic regressions found attentional impulsiveness to distinguish between individuals with and without a self-reported history of ADHD diagnosis. Impulsivity is a multi-faceted construct, and the utilization of multiple measures, both self-report and behavioral, can aid to more fully and accurately assess the construct in both research and clinical settings.

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1. Introduction

1.1. Background

Impulsivity is a widely-used term that is often associated with increased involvement in health-risk behaviors including various addictions (Brown, Benoit, Juhas, Lebel, et al., 2015; Cyders et al., 2007; Mishra & Lalumiere, 2011). Additionally, impulsivity is included in the diagnostic criteria for a number of psychological disorders, including borderline personality disorder, attention-deficit/hyperactivity disorder (ADHD), bipolar disorder, and the impulse control disorders (Evenden, 1999; Seidl, Pastorek, Troyanskaya, & Scheibel, 2015; Smith et al., 2007). Higher rates of impulsivity are even seen in individuals with bipolar disorder who are in a euthymic state, but with variability seen across self-report and behavioral measures of impulsivity (Lijffijt, Lane, Moeller, Steinberg, & Swann, 2015). Accurate assessment of impulsivity is crucial for clinicians, as information from self-report and/or behavioral measures can aid in the diagnostic and treatment processes. The present study sought to examine relationships between self-report and behavioral measures of impulsivity in individuals with and without a self-reported history of ADHD diagnosis.

Although no universally-accepted definition exists, there are commonalities among current definitions of impulsivity. Some components include: early/anticipatory responding, inattention, hyperactivity, discounting of future (delayed) rewards, disinhibition, failure to consider alternatives before acting, inhibitory control, non-planning, reward sensitivity, risk taking, and sensation seeking (Bechara, Damasio, Damasio, & Anderson, 1994; Cloninger, Svrakic, & Przybeck, 1993; Dalley, Everitt, & Robbins, 2015; Dawe, Gullo, & Loxton, 2004; Depue & Collins, 1999; Winstanley, Eagle, & Robbins, 2006). Impulsivity can be thought of as a failure to plan ahead, including both acting without thinking and failure to show constraint (Bechara, et al., 1994; Duckworth & Kern, 2011; Tellegen, 1982; Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993). Additionally, impulsivity can include choices of smaller, more immediate rewards over larger but distant rewards, reflecting an inability to inhibit behaviors that may—in the long run—hold negative consequences (Fino, Melogno, Iliceto, D'Aliesio, et al., 2014; Gullo & Potenza, 2014; Horn, Dolan, Elliott, Deakin, & Woodruff, 2003).

Research investigating relationships between different measures of impulsivity has been mixed. Significant (Hamilton, Sinha, & Potenza, 2014; Leshem & Glicksohn, 2012; Meule, 2013) and non-significant correlations (Fino et al., 2014; Meda et al., 2009) were found among self-report measures. Self-report and behavioral measures may represent different components of impulsivity, as evidenced by limited relationships among measures (Cyders & Coskunpinar, 2012; Dally, 2011; Hopko, Lejuez, Daughters, Aklin, et al., 2006; Horn et al., 2003; Kraplin

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et al., 2014; Reynolds, Ortengren, Richards, & de Wit, 2006; Reynolds, Penfold, & Patak, 2008). However, correlations between self-report and behavioral measures of impulsivity have been found in several studies (Bayard, Raffard, & Gely-Nargeot, 2011; Buelow & Suhr, 2013; Cheung, Mitsis, & Halperin, 2004; Keilp, Sackeim, & Mann, 2005).

Recent factor and meta-analyses support a multidimensional approach to impulsivity, with the exact number of factors depending on the number of measures included. For example, Sharma, Kohl, Morgan, and Clark (2013) reported a 3-factor structure based on self-report measures of impulsivity: behavioral dyscontrol, distractibility/urgency, and sensation seeking. In a follow-up study, Sharma, Markon, and Clark (2014) found a 3-factor structure, again based on self-report measures of impulsivity that included extraversion/positive emotionality, disinhibition versus constraint, and neuroticism/negative emotionality. As a secondary component of this study, few correlations were found between behavioral and self-report measures. Smith et al. (2007) found a 4-factor model of impulsivity, including urgency, sensation seeking, lack of planning, and lack of persistence. Finally, a recent meta-analysis (Duckworth & Kern, 2011) found relationships between self-report and some behavioral measures of impulsivity (Balloon Analogue Risk Task [BART], Lejuez, Read, Kahler, Richards, et al., 2002; Delay Discounting Task [DDT], Kirby, Petry, & Bickel, 1999). These inconsistent findings led to speculation that self-report measures may assess stable, underlying personality traits of impulsivity, whereas behavioral measures may be more state-dependent and transient, with performance varying depending on the current situation (Cyders & Coskunpinar, 2012; Meule, 2013).

Much of the research to date has focused on self-report measures such as the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995) and the UPPS Impulsive Behavior Scale (UPPS; Whiteside & Lynam, 2001). However, the Conner's Adult ADHD Rating Scale (CAARS; Conners, Erhardt, & Sparrow, 1998) and Frontal Systems Behavior Rating Scale (FrSBe; Grace & Malloy, 2001), self-report measures of impulsivity and disinhibition, respectively, are commonly used as part of the diagnostic process. To date, only the FrSBe has been examined in conjunction with the BIS-11 (LoBue, Cullum, Braud, Walker, et al., 2014; Lyvers, Duff, Basch, & Edwards, 2012), leaving correlations between the CAARS and other self-report measures, as well as between the CAARS and FrSBe, unknown. The utilization of multiple measurements, such as multiple self-report or behavioral measures of impulsivity, allows for a more nuanced assessment of a construct. Knowledge of relationships among these and other measures of impulsivity will inform future clinical and experimental research, as it would allow for more accurate assessment of the construct across different clinical populations.

1.2. Objectives and hypotheses

The present study sought to examine relationships between self-report and behavioral measures of impulsivity. Two groups were compared: individuals self-reporting a history of ADHD diagnosis and individuals self-reporting no history of ADHD diagnosis. We first examined relationships between self-report and behavioral measures of impulsivity with a principal components analysis (PCA). We hypothesized a multi-component solution, given previous research suggesting a 3- or 4-factor solution depending on the number of measures examined (Duckworth & Kern, 2011; Sharma et al., 2013, 2014; Smith et al., 2007). We also hypothesized that, in general, self-report and behavioral measures would load on different components given previous research showing little overlap between measures (e.g., Cyders & Coskunpinar, 2012; Hopko et al., 2006; Horn et al., 2003; Kraplin et al., 2014; Reynolds et al., 2006, 2008). Next, we utilized a logistic regression to predict group assignment (self-report/no self-report of ADHD diagnosis) based on the components derived from the PCA. We hypothesized that those measures assessing attentional impulsivity, one of the diagnostic criteria for ADHD, would predict group assignment.

2. Methods

2.1. Participants

The university's Institutional Review Board approved the study. We utilized a convenience sample of 195 undergraduates who received partial course credit. Twenty participants were removed from analyses due to self-report of a psychiatric disorder other than ADHD. Analyses were conducted on the final sample of 175 participants (95 females, 78.9% Caucasian, $M_{age} = 19.06$, $SD_{age} = 1.72$). Twenty-eight participants (12 females) self-reported a previous diagnosis of ADHD (median age = 13) by a physician/psychiatrist ($n = 20$) or psychologist ($n = 8$). Current prescription use included Adderall ($n = 16$), Concerta ($n = 10$), and Ritalin ($n = 7$). There were no differences in gender ratio between the two subgroups, $\chi^2(1, N = 175) = 1.75$, $p = 0.19$. Some participants were included in a previous analysis of risky decision making (BLINDED).

2.2. Procedure and measures

All participants provided written informed consent. Data were compiled from other studies of personality and decision making in our lab. The BIS-11 (Patton et al., 1995), Behavioral Inhibition/Behavioral Approach System scale (BIS/BAS; Carver & White, 1994), CAARS (Conners et al., 1998), FrSBe (Grace & Malloy, 2001), Impulsive Sensation Seeking subscale (ImpSS; Zuckerman et al., 1993), BART (Lejuez et al., 2002), DDT (Kirby et al., 1999), and Stroop Color Word Interference Task (Golden, 1978) were administered. Participants completed all tasks, except the BART, in a random order before being debriefed. The BART was always conducted last due to the nature of the overall study assessing correlates of decision making processes.

2.2.1. Self-report measures

The BIS-11 considers impulsivity as a multifaceted construct, encompassing both first- and second-order factors (Patton et al., 1995). The present analyses focused on the second-order factors (αs = 0.61–0.69; attentional [AI]: $M = 17.85$, $SD = 3.61$; motor [MI]: $M = 22.83$, $SD = 4.61$; nonplanning [NPI]: $M = 25.34$, $SD = 4.48$). The BIS/BAS assesses two behavioral systems: high BIS is associated with risk-avoidant behavior in response to threat while high BAS is associated with approach behaviors in response to signals of reward (Carver & White, 1994). Scores were calculated for BIS ($M = 20.09$, $SD = 4.09$) and the BAS subscales (drive: $M = 10.98$, $SD = 2.85$; fun seeking: $M = 12.01$, $SD = 2.54$; reward responsiveness: $M = 17.27$, $SD = 2.89$; αs = 0.71–0.80). The 19-item ImpSS examines impulsivity ($M = 2.92$, $SD = 2.45$) and sensation seeking ($M = 6.26$, $SD = 2.83$) separately (αs = 0.75–0.80; Zuckerman et al., 1993). The 66-item CAARS assesses the presence and severity of ADHD symptoms in adulthood (Conners et al., 1998). Only the Impulsivity/Emotional Lability (Scale C; $M = 11.14$, $SD = 6.52$) and Diagnostic and Statistical Manual-IV Hyperactivity/Impulsivity (Scale F; $M = 9.45$, $SD = 4.84$) scores were calculated (αs = 0.80–0.86). The 46-item FrSBe (Grace & Malloy, 2001) was administered, and scores were only calculated for the disinhibition subscale ($\alpha = 0.68$; $M = 39.66$, $SD = 7.17$). The UPPS Impulsive Behavior Scale (UPPS; Whiteside & Lynam, 2001) was also administered; however, it was removed from further analyses due to low internal consistency (αs = 0.16–0.35).

2.2.2. Behavioral measures

The BART assesses real-world risk-taking behaviors by having participants pump up 30 balloons, one at a time, earning money for each pump (Lejuez et al., 2002). However, balloons may pop at any time, and accumulated money will be lost unless it is banked. Each pump shows both increased reward (money) and increased risk (balloon popping; Lejuez et al., 2002), with risk-taking evidenced by a higher average number of pumps per balloon on only the unexploded balloons ($M =$

27.50, $SD = 12.42$). The BART likely falls into the impulsive choice or lack of analysis of future outcomes component of impulsivity (Winstanley et al., 2006). The 27-item DDT assesses delay discounting—a preference for smaller, immediate rewards over larger but distant rewards—by varying the level of reward and time intervals (Kirby et al., 1999). *k*-Values were calculated ($M = 0.03$, $SD = 0.04$), with higher values indicating a greater preference for immediate over delayed rewards (Kirby et al., 1999). The DDT likely falls into the discounting of future rewards component of impulsivity (Dalley et al., 2015; Winstanley et al., 2006). The Stroop assesses cognitive flexibility and response inhibition across three tasks: 1) reading color words, 2) naming ink color, and 3) color-word interference (i.e., naming the color of ink while inhibiting the incongruent color word; Golden, 1978). The total number of correct words on the interference trial was calculated ($M = 47.50$, $SD = 9.71$), with higher scores indicating greater ability to inhibit the prepotent response (e.g., greater inhibitory control). The Stroop likely assesses impulsive actions and difficulties with inhibitory control (Winstanley et al., 2006).

2.3. Data analysis

First, scores were transformed into *z*-scores for each measure. A principal components analysis (PCA) with oblique rotation was conducted. To determine which components to retain, a parallel analysis was conducted on a randomly generated data set with 15 variables. Components in the PCA were retained if the eigenvalue was greater than the corresponding eigenvalue in the parallel analysis (O'Connor, 2000). Finally, a logistic regression analysis was conducted to predict group assignment (self-reported/no self-reported history of ADHD diagnosis), with each of the retained components from the PCA included as predictors.

3. Results

3.1. Principal components analysis

The Kaiser-Meyer-Olkin measure indicated the analysis was acceptable (KMO = 0.83), and Bartlett's test of sphericity was significant, $\chi^2 = 943.16$, $p < 0.001$. Five components had eigenvalues over 1.00, but only three eigenvalues were greater than in the parallel analysis. The three retained components accounted for 53.06% of the total variance (Table 1). The first component included only self-report measures (CAARS-C, CAARS-F, BIS-AI, FrSBe) and explained 32.52% of the variance. The second component included only the BAS subscales (BAS-d, BAS-f, BAS-r), explaining 10.43% of the variance. The third component included the remaining self-report measures (BIS-MI, BIS-NPI, BIS, ImpSS-I, ImpSS-SS) and explained 10.11% of the variance. None of the behavioral measures loaded on any of these three components. Significant correlations were found between each component (1 and 2: $r = -0.231$, $p = 0.002$; 1 and 3: $r = -0.306$, $p < 0.001$; 2 and 3: $r = 0.153$, $p = 0.047$).

Table 1
Principal components analysis component loadings.

Variable	Component 1	Component 2	Component 3
CAARS-C	**0.91**	−0.07	0.13
CAARS-F	**0.89**	0.00	−0.01
ImpSS-I	0.27	−0.01	**−0.75**
BIS-AI	**0.74**	0.05	−0.04
FrSBe	**0.67**	−0.10	−0.22
Stroop	0.09	0.09	0.13
BIS-MI	**0.44**	−0.18	**−0.44**
BIS-NPI	0.38	0.05	**−0.41**
BART	−0.22	−0.11	−0.07
DDT	0.13	0.06	−0.01
BIS	0.32	−0.13	**0.73**
BAS-d	0.09	**−0.72**	−0.07
BAS-f	0.07	**−0.71**	−0.40
BAS-r	−0.05	**−0.86**	0.23
ImpSS-SS	0.19	−0.16	**−0.68**
Eigenvalue	4.88	1.57	1.52
% Variance	32.52%	10.43%	10.11%

Note: BIS-11 = attentional impulsiveness (AI), motor impulsiveness (MI), and nonplanning impulsiveness (NPI); BIS/BAS = behavioral inhibition (BIS) and behavioral activation (BAS; d = drive, f = fun seeking, r = reward responsiveness); ImpSS = impulsivity (I) and sensation seeking (SS); CAARS = impulsivity/emotional lability (C) and DSM-IV hyperactivity/impulsivity (F); FrSBe = disinhibition subscale; BART = balloon analogue risk task, average adjusted pumps per balloon; DDT = delay discounting task; stroop = interference trial.

3.2. Logistic regression

Prior to conducting the logistic regression, composite scores were created for each component of the PCA by summing the *z*-scores for each scale. These three composite scores were then entered into the logistic regression to determine if they could predict group assignment (self-reported/no self-reported history of ADHD diagnosis; Table 2). A test of the full model was significant, $\chi^2(3) = 14.76$, $p = 0.002$, Nagelkerke's $R^2 = 0.141$. Overall prediction success was 85.3%. The first component, comprised of the CAARS-C, CAARS-F, BIS-AI, and FrSBe, was the only significant predictor in the model. Individuals with higher scores on these measures were 1.23 times more likely to have self-reported a history of ADHD diagnosis.

As none of the behavioral measures were included in the retained PCA components, a second logistic regression was conducted with the BART, Stroop, and DDT as predictors. A test of the full model was not significant, $\chi^2(3) = 1.61$, $p = 0.66$, Nagelkerke's $R^2 = 0.02$, and no significant predictors emerged ($p > 0.26$).

4. Discussion

The present study sought to examine impulsivity in individuals with and without a self-reported history of ADHD diagnosis across self-report and behavioral measures. The first study aim was to examine relationships between self-report and behavioral measures of impulsivity with a principal components analysis. Consistent with previous research identifying a multi-component solution (Duckworth & Kern, 2011; Sharma et al., 2013, 2014; Smith et al., 2007), the present results revealed a 3-component solution. The solution supported our hypothesis that the self-report and behavioral measures of impulsivity would show little overlap on the components, a finding that replicates previous research (Cyders & Coskunpinar, 2012; Dalley et al., 2015; Hopko et al., 2006; Horn et al., 2003; Kraplin et al., 2014; Reynolds et al., 2006, 2008).

Examining the individual components, the first component included the CAARS-C, CAARS-F, FrSBe, and BIS-AI. These measures appear to assess elements of attentional impulsivity (e.g., inattention, disinhibition, hyperactivity). That the CAARS, FrSBe, and BIS factored together suggests that the FrSBe and BIS might be an effective way to supplement self-report of ADHD symptoms in clinical evaluations or to determine group assignment in research studies. To date, much research has relied on a single self-report measure of current ADHD symptoms (see Tucha, Fuermaier, Koerts, Groen, & Thome, 2014, for review), and CAARS scores, for example, are non-specific to ADHD symptoms (van Vorhees, Hardy, & Kollins, 2011) and susceptible to malingering or symptom exaggeration (Hirsch & Christiansen, 2015; Musso & Gouvier, 2014; Quinn, 2003; Sollman, Ranseen, & Berry, 2010).

Table 2
Logistic regression predicting history of ADHD diagnosis.

Predictor	B	SE	Wald	*p*	Exp (B)
Component 1	0.21	0.09	6.04	**0.01**	1.23
Component 2	0.10	0.10	0.87	0.35	1.10
Component 3	0.03	0.08	0.17	0.68	1.03

Two other components emerged. The second component included all of the BAS subscales from the BIS/BAS (fun seeking, drive, reward responsiveness). This component can be thought of as assessing reward sensitivity, one component of impulsivity that could drive individuals to take greater risks in hopes of a larger reward. However, we also assessed this reward sensitivity with both the BART and DDT, two behavioral measures that failed to load with these self-report measures—a finding inconsistent with Duckworth and Kern (2011). It is possible the BAS subscales reflect more of a "trait" of reward sensitivity, while the BART and DDT are more susceptible to state-based fluctuations in reward sensitivity. The third component included the ImpSS subscales (Impulsivity, Sensation Seeking), BIS-MI, BIS-NPI, and the BIS from the BIS/BAS. These scales assess a variety of impulsive characteristics that fall more in the behavioral and motor realms than the attentional realm indicated by Component 1. Of note, the ImpSS-I measures impulsivity and should likely factor with the other attentional impulsivity measures. However, examination of the items indicates a greater focus on behaviors than cognitions, likely contributing to its placement on the behavioral/motor impulsivity factor. Individuals low in behavioral inhibition and high in sensation seeking and motor impulsiveness may lack sensitivity to the negative consequences of their impulsive behaviors, in turn sharing a failure to plan ahead.

The results of the PCA are largely consistent with previous research examining relationships between impulsivity measures. Our results provide further support for the multidimensionality of impulsivity, with the specific number of components that emerge dependent on the number and type of measures included in each study (Meda et al., 2009; Sharma et al., 2013; Smith et al., 2007). For example, our attentional impulsiveness component is consistent with that of Sharma et al. (2013), though utilizing different self-report measures. Inconsistent with Duckworth and Kern (2011), but consistent with Sharma et al. (2014), we found no evidence that behavioral and self-report measures of impulsivity factored together. Based on this finding, we recommend the utilization of multiple assessment measures to fully assess impulsivity in clinical evaluations and research studies. As no overlap was seen between self-report and behavioral measures in the present study as well as previous studies (e.g., Cyders & Coskunpinar, 2012; Dalley et al., 2015; Reynolds et al., 2006, 2008), it is important for researchers and clinicians alike to assess impulsivity with both self-report and behavioral measures. Multiple measurements would provide additional insight into the specific facets of impulsivity affecting an individual—including those leading to impairments in everyday life.

The second aim of the present study was to utilize logistic regression to predict group assignment based on the PCA components. Consistent with our hypothesis, the first component, encompassing measures of attentional impulsivity, significantly predicted group assignment as higher scores on the component (CAARS-C, CAARS-F, FrSBe, BIS-AI) were associated with a 1.23 times greater chance of a self-reported history of ADHD diagnosis. This finding is consistent with the diagnostic criteria for ADHD, which focuses on elements of attentional impulsivity. Utilizing a combination of these measures (CAARS, BIS-11, FrSBe) may help elucidate self-reported symptoms of ADHD in a clinical evaluation or research study focused on individuals with ADHD, as reliance on a single self-report measure of ADHD symptoms could fail to differentiate ADHD from other disorders (Lewandowski, Lovett, Codding, & Gordon, 2008). The other two components (reward sensitivity, behavioral and motor impulsivity) failed to predict group assignment even, as an exploratory analysis, when entered into the logistic regression individually. This may again be due to the focus on attentional components of impulsivity in the ADHD diagnostic criteria. In addition, the second logistic regression that focused on behavioral measures, with no significant predictors emerging, may point towards these measures being more sensitive to state-dependent fluctuations in impulsivity (Cyders & Coskunpinar, 2012; Meule, 2013).

The present results provide some evidence of additional measures of impulsivity that could be utilized in a clinical evaluation. Many evaluations rely on a single self-report measure of current ADHD symptoms and a single self-report measure of childhood ADHD symptoms (Tucha et al., 2014), yet self-report measures are often unable to detect deliberate faking of symptoms (Hirsch & Christiansen, 2015) or could instead reflect anxiety, depression, or other symptomatology. Our results indicate that those measures included in the attentional impulsivity component—the CAARS, FrSBe, and BIS-11—could be utilized together in clinical and research evaluations of ADHD symptoms. Additional research would be needed, however, to examine susceptibility of the FrSBe and BIS-11 to symptom exaggeration.

4.1. Limitations

The present study focused on a small subset of self-report and behavioral measures of impulsivity, as data were collected from several studies assessing predictors of risky decision making. A more complete picture of the relationships between behavioral and self-report measures of impulsivity may be gleaned from utilizing additional measures of the construct, especially among those presenting for formal evaluation of ADHD symptoms. The present study utilized relatively small samples, most notably of participants self-reporting a history of ADHD diagnosis in childhood (a convenience sample), and it is important for these findings to be examined in larger samples with more diverse and clinically verifiable diagnoses (e.g., substance dependence, bipolar disorder, impulse control disorders). As such, the present results should be considered preliminary and warrant replication.

4.2. Conclusions

The present results add to the literature suggesting that impulsivity is a multidimensional construct, with our specific findings suggesting three components encompassing elements of attentional impulsivity, reward sensitivity, and behavioral and motor impulsivity. Our analyses failed to detect any relationships between self-report and behavioral measures, which—although consistent with some previous research—points to continued concerns regarding how self-report and behavioral measures assess the underlying construct of impulsivity. We advocate for a multidimensional assessment of impulsivity, in both lab and clinical settings, to improve our understanding of components of impulsivity that affect everyday functioning, as well as to more fully and accurately assess impulsive characteristics that can contribute to psychological disorders.

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