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Measuring Impulsivity in Daily Life: The Momentary Impulsivity Scale

Rachel L. Tomko,

University of Missouri—Columbia and Midwest Alcoholism Research Center, St. Louis, Missouri

Ryan W. Carpenter,

University of Missouri—Columbia and Midwest Alcoholism Research Center, St. Louis, Missouri

Whitney C. Brown,

University of Missouri—Columbia and Midwest Alcoholism Research Center, St. Louis, Missouri

Marika B. Solhan,

University of Missouri—Columbia, Midwest Alcoholism Research Center, St. Louis, Missouri, and VA Boston Healthcare System, Boston, Massachusetts

Seungmin Jahng,

University of Missouri—Columbia, Midwest Alcoholism Research Center, St. Louis, Missouri, and Hallym University

Phillip K. Wood, and

University of Missouri—Columbia and Midwest Alcoholism Research Center, St. Louis, Missouri

Timothy J. Trull

University of Missouri—Columbia and Midwest Alcoholism Research Center, St. Louis, Missouri

Abstract

Impulsivity is a core feature of many psychiatric disorders. Traditionally, impulsivity has been assessed using retrospective questionnaires or laboratory tasks. Both approaches neglect intraindividual variability in impulsivity and do not capture impulsivity as it occurs in real-world settings. The goal of the current study was to provide a method for assessing impulsivity in daily life that provides both between-individual and within-individual information. Participants with borderline personality disorder (BPD; $n = 67$) or a depressive disorder (DD; $n = 38$) carried an electronic diary for 28 days and responded to 9 impulsivity items up to 6 times per day. Item distributions and iterative exploratory factor analysis (EFA) results were examined to select the items that best captured momentary impulsivity. A brief 4-item scale was created that can be used

Correspondence concerning this article should be addressed to Timothy J. Trull, Department of Psychological Sciences, 210 McAlester Hall, University of Missouri, Columbia, MO 65211-2500. TrullT@missouri.edu.
Rachel L. Tomko, Department of Psychological Sciences, University of Missouri—Columbia, and Midwest Alcoholism Research Center, St. Louis, Missouri; Marika B. Solhan, Department of Psychological Sciences, University of Missouri—Columbia, Midwest Alcoholism Research Center, St. Louis, Missouri, and VA Boston Healthcare System, Boston, Massachusetts; Ryan W. Carpenter and Whitney C. Brown, Department of Psychological Sciences, University of Missouri—Columbia, and Midwest Alcoholism Research Center, St. Louis, Missouri; Seungmin Jahng, Department of Psychological Sciences, University of Missouri—Columbia, Midwest Alcoholism Research Center, St. Louis, Missouri, and Department of Psychology, Hallym University, Chuncheon, South Korea; Phillip K. Wood and Timothy J. Trull, Department of Psychological Sciences, University of Missouri—Columbia, and Midwest Alcoholism Research Center, St. Louis, Missouri.

for the assessment of momentary impulsivity. Model fit was good for both within- and between-individual EFA. As expected, the BPD group showed significantly higher scores on our Momentary Impulsivity Scale than the DD group, and the resulting scale was moderately correlated with common trait impulsivity scales.

Keywords

ambulatory assessment; ecological momentary assessment; impulsivity; borderline personality disorder; scale development

The construct of impulsivity can be broadly summarized as the “tendency to act spontaneously and without deliberation” (Carver, 2005, p. 313). Typically, investigators examine impulsivity at the trait level, thus classifying an individual’s propensity for impulsivity. This trait-level measurement assumes impulsivity is a stable construct and neglects variability in impulsivity across time. Evidence suggests, however, that trait constructs such as impulsivity show considerable intraindividual variability and that this variability is at least partially a result of situational factors (Fleeson, 2007). The goal of the current study was to create a momentary impulsivity scale (MIS) that can be administered multiple times per day over a period of consecutive days in experience sampling or ecological momentary assessment studies. Such a scale can provide information about the variability of impulsivity over time and open up future lines of research, such as the examination of potential antecedents (e.g., time of day, presence of stressors, mood, nutrition, amount of sleep, medication) and consequences (e.g., interpersonal conflict, change in mood, health-related concerns) of impulsivity.

Traditional Assessment of Impulsivity

Impulsivity is best conceptualized as a broad, multifaceted construct (e.g., Evenden, 1999). Given the broad nature of the construct, existing research has conceptualized impulsivity in a number of related, but distinct ways. For example, the term *impulsivity* has been used to refer to behavior that occurs prior to full evaluation of a situation, an inability to inhibit responding, or a preference for immediate gratification (Evenden, 1999).

Given the construct’s multifaceted nature, a number of efforts have been made to decompose impulsivity into several lower order factors. These attempts have produced a number of different solutions, typically resulting in two to four lower order impulsivity factors. For example, Patton, Stanford, and Barratt (1995) found evidence in favor of separate inattentive, motor, and nonplanning factors of impulsivity using their measure, the Barratt Impulsiveness Scale Version 11 (BIS-11). Their initial factor structure has not garnered substantial empirical replication, however (e.g., Haden & Shiva, 2008; Reise, Moore, Sabb, Brown, & London, 2013; Steinberg, Sharp, Stanford, & Tharp, 2013). Other investigators have found that responses to the BIS-11 better fit a two-factor solution reflecting cognitive and behavioral aspects of impulsivity (Reise et al., 2013).

Using personality trait theory to derive a measure of impulsivity, Whiteside and Lynam (2001) found support for a four-factor model of impulsive personality traits. The factors

mapped on to (a) *negative urgency*, defined as the tendency to act rashly when experiencing negative affect; (b) *lack of premeditation*, which is conceptually similar to nonplanning impulsivity; (c) *lack of perseverance*, or a tendency to abandon goal-directed behaviors; and (d) *sensation seeking*, defined as a preference for intense, novel, or risky experiences (Whiteside & Lynam, 2001).

Despite differences in these factor structures, these traditional models of impulsivity assessment are similar in that impulsivity is conceptualized as a relatively stable personality trait that can be assessed via retrospective self-report questionnaires. These trait models are helpful in identifying individuals who are predisposed to negative outcomes associated with impulsivity. The question of when predisposed individuals will experience impulsivity or behave impulsively, however, is perhaps more clinically relevant. To address this question, it is necessary to study how impulsivity is experienced in the moment and in individuals' daily lives.

Laboratory-based behavioral tasks have been used to study specific states of impulsivity at the micro-behavioral level (e.g., Dougherty, Mathias, Marsh, & Jagar, 2005). One advantage of these laboratory-based assessments is that they can provide "behavioral snap shots of what the individual would actually do in a situation" (Cyders & Coskunpinar, 2011, p. 967). These behavioral assessments are difficult to obtain in naturalistic settings, however. Thus, an alternative approach is to develop a self-report measure of state impulsivity that can be used in naturalistic settings.

Ecological Momentary Assessment of Impulsivity

Ecological momentary assessment (EMA; Stone & Shiffman, 1994) is a term used to describe frequent, repeated assessments that occur within participants' natural environments. EMA is a useful tool for measuring dynamic constructs, such as mood or impulsivity, during participants' daily lives. In this way, EMA can provide information about the contexts in which impulsivity occurs, inter- and intravariability of impulsivity, and change in impulsivity over time, making it particularly well suited for the assessment of this construct.

A number of EMA studies have included questionnaire assessments of *trait* impulsivity while investigating areas as diverse as bulimia (Engel et al., 2007; Myers et al., 2006; Steiger, Lehoux, & Gauvin, 1999), personality (Miller, Vachon, & Lynam, 2009), alcohol use (Simons, Dvorak, Batién, & Wray, 2010; Simons, Gaher, Oliver, Bush, & Palmer, 2005), and sexual intercourse in depressed adolescents (Shrier et al., 2012). Few studies, however, have examined the construct at the *momentary* level. Of the few EMA studies (or, daily survey studies) that have, all focused solely on specific behaviors associated with impulsivity (e.g., Coifman, Berenson, Rafaëli, & Downey, 2012; Epstein, 1979; Sharma, Kohl, Morgan, & Clark, 2013; Wu & Clark, 2003). This purely behavioral measurement helps demonstrate the relationship between trait impulsivity and problematic behaviors. There are a number of complications with this approach, however.

First, impulsive behaviors may occur only infrequently and may be difficult to capture over the course of just a few weeks of evaluation. For example, Sharma and colleagues (2013) distinguished between less frequent behaviors associated with impulsivity (e.g., number of

speeding tickets, number of different sex partners) and daily behaviors associated with impulsivity (e.g., skipped class on a whim, did not read instructions before starting something) among college students.

Second, although behaviors such as binge eating, excessive spending, and alcohol use may occur impulsively on some occasions, individuals may also engage in these behaviors in a nonimpulsive manner. Aspects of impulsivity such as recklessness, lack of planning or perseverance, and inattentiveness, which may be used to determine whether a behavior is impulsive or nonimpulsive, are not captured in a pure behavioral approach. Although most researchers make a distinction between impulsivity and associated behaviors (see Sharma et al., 2013), some assessments equate these constructs (e.g., *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition, text revision [DSM-IV-TR] impulsivity criterion of borderline personality disorder; American Psychiatric Association [APA], 2000). A broader and more general assessment of impulsivity as experienced in daily life, using EMA, is therefore needed to differentiate between impulsive and nonimpulsive manifestations of externalizing behaviors as they unfold in the real world.

The Current Study

The purpose of the current study was to develop a brief, reliable, and valid psychometrically sound scale that can be used in EMA studies as a measure of momentary impulsivity, particularly within clinical samples. We attempted to develop such a scale that adequately measured both inter- and intraindividual differences in impulsivity while maintaining brevity, in order to avoid overburdening research participants. First, we used within-person and between-person factor analyses to inform scale construction, and then we examined the reliability of the final scale scores across and within individuals. Next, we assessed the association between scale scores and several popular trait measures of impulsivity to provide construct and convergent validity.

The initial scale was constructed using a clinical sample of individuals diagnosed with borderline personality disorder (BPD). The link between BPD and impulsivity is well established, particularly using trait self-report measures (e.g., Bornoalova, Lejuez, Daughters, Rosenthal, & Lynch, 2005; Coffey, Schumacher, Baschnagel, Hawk, & Holloman, 2011; Crowell, Beauchaine, & Linehan, 2009; Ferraz et al., 2009; Hochhausen, Lorenz, & Newman, 2002; Links, Heslegrave, & van Reekum, 1999; McCloskey et al., 2009; Tragesser & Robinson, 2009; Whiteside, Lynam, Miller, & Reynolds, 2005; Zanarini, 1993), yet few empirical studies have examined proximal correlates of impulsivity in BPD (except see Coifman et al., 2012). By definition, difficulties associated with a BPD diagnosis extend beyond problems with impulsivity. Specifically, BPD is also characterized by emotion dysregulation, anger, and problematic relationships (APA, 2000). To ensure that our scale is capturing impulsivity specifically, rather than other difficulties in BPD that are correlated with impulsivity, we used a depressive disorder (DD) (i.e., major depressive disorder or dysthymia) control group. Impulsivity is not considered to be a major characteristic of depression; however, BPD and DD are similar in that they are both characterized by high levels of negative affect (Cheavens & Heij, 2011) and interpersonal difficulties (e.g., Joiner, 2000; Nezlak, Hampton, & Shean, 2000; Scott, Levy, & Pincus,

2009; Selby, Braithwaite, Joiner, & Fincham, 2008; Stepp, Pilkonis, Yaggi, Morse, & Feske, 2009). Therefore, differences between groups on our momentary impulsivity scale cannot be attributed to general difficulties in functioning.

In service of these goals, we expected the BPD group to score higher on the resulting momentary impulsivity scale than the depressed group. Additionally, we expected our final scale to correlate only moderately with traditional self-report measures of impulsivity (i.e., UPPS Impulsive Behavior Scale, Whiteside & Lynam, 2001; BIS-11, Patton et al., 1995) given that it was designed to assess impulsivity as experienced in the moment, rather than trait impulsivity. The average correlation between trait self-report measures and laboratory-based measures (often assumed to be a state measure) of impulsivity is $r = .10$ (Cyders & Coskunpinar, 2011). We expected the correlations between trait self-report measures and our final scale to exceed this correlation, given that both use self-report.

Method

Participants

Participants were recruited for a larger study examining affective instability in BPD, and previous results focusing on affect and affective instability are published elsewhere (see Jahng et al., 2011, Jahng, Wood, & Trull, 2008; Solhan, Trull, Jahng, & Wood, 2009; Trull et al., 2008). Participants were outpatients at one of four local clinics serving the university and/or the general community. To be included in this larger study, participants were required to be between the ages of 18 and 65 and to meet *DSMIVTR* criteria for BPD, including the specific affective instability criterion, or to meet criteria for a current *DSMIVTR* DD (i.e., major depression, dysthymia; APA, 2000) and not BPD. General exclusion criteria included psychosis, mental retardation, severe neurological dysfunction, or history of head trauma that affected mood or concentration. Structured Clinical Interview for *DSMIV* Axis I Disorders (SCID-I; First, Spitzer, Gibbons, & Williams, 1995) and the Structured Interview for *DSMIV* Personality (SIDP-IV; Pfohl, Blum, & Zimmerman, 1994) were used to establish eligibility for this study. The SIDP-IV protocol requires interviewers to rate each PD criterion (including the BPD impulsivity criterion) as 0 = absent, 1 = subthreshold, 2 = present, or 3 = extreme. Diagnostic interrater reliability was computed for a subset of participants ($n = 20$). A second interviewer listened to an audio recording of the SCID-I and SIDP-IV interviews and independently arrived at ratings and diagnoses. Our interviewers had excellent agreement on the presence or absence of affective instability ($\kappa = 1.0$), diagnosis of BPD ($\kappa = .90$), and diagnosis of a current depressive disorder ($\kappa = 1.0$).

An early phase of data collection used a binary response format for the momentary impulsivity items of interest. Thus, analyses for the current article are limited to the 105 individuals who were given the Likert scale¹ response format. Mean age was 34.8 years ($SD = 12.6$) for the DD group and 31.6 years ($SD = 11.9$) for the BPD group. The sample was predominantly female (89.5%), White (84.8%), and had annual family incomes of less than \$25,000 (71.4%). The majority of participants had current (past 12 months) diagnoses of

¹The Likert scale was adopted in an effort to reflect the dimensional nature of impulsivity features.

anxiety disorder (73.5%) and mood disorder (76.7%). Demographics and comorbid Axis I diagnoses are shown by group in Table 1.

Procedure and Measures

Participants were issued an electronic diary (ED; Palm Zire 31[®] handheld computer) they carried for 28 days. The ED sounded an alarm six times per day, prompting the individual to answer questions about current mood, behavior, and environment. The alarm times were determined by a software program that stratified the participants' usual waking hours (as reported by the participant prior to the study start) into six equal intervals, and then randomly selected a time within each interval (see Trull et al., 2008, for more details regarding the ED protocol). On average, participants were prompted 168 times over the course of the 28-day period. Compliance rates for this sample were very high (approximately 90%) and did not differ by diagnostic group (see Jahng et al., 2011; Trull et al., 2008). Following the 28-day EMA protocol, participants completed a battery of traditional retrospective self-report questionnaires, including the BIS-11 and the UPPS, which are described below.

The BIS-11 (Patton et al., 1995)—The BIS-11 is a 30-item self-report questionnaire that assesses general impulsivity and sub-facets of impulsivity (i.e., attention, nonplanning, motor) using a 4-point Likert scale ranging from 1 (*rarely/never*) to 4 (*almost always/always*). Participants in our sample reported on a 03 scale. However, in order to be able to directly compare these results with the normative data presented by Patton and colleagues (1995), the data were converted to a 14 scale. The 1-month test-retest reliability of total BIS-11 scores in this sample was .81 (BPD $r = .78$; DD $r = .84$).

The UPPS Impulsive Behavior Scale (Whiteside & Lynam, 2001)—The UPPS is a 45-item self-report questionnaire based on a four-factor model of personality traits thought to be associated with behavioral patterns of impulsivity. The factors consist of urgency, lack of premeditation, lack of perseverance, and sensation seeking. Each factor is assessed with 1012 items specific to that factor. Participants respond using a 4-point Likert scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Although results are generally interpreted at the subscale level, a total UPPS score was also computed. The 1-month test-retest reliability of total UPPS scores in this sample was .87 (BPD $r = .85$; DD $r = .89$).

The MIS—Items from the BIS-11 and from the SIDP-IV impulsivity criterion of BPD were examined and adapted to reflect momentary aspects of impulsivity. We nominated items that reflected both behavioral and internal aspects of impulsivity to avoid developing a scale that consisted only of specific impulsive behaviors. In order to reduce participant burden, only a limited number of items were administered. Specifically, the nine items shown in Table 2 were designated as potential items assessing momentary impulsivity for an EMA protocol. Although a single factor would be preferable, it seemed possible that behavioral and cognitively based items might load on two separate factors. Fabrigar, Wegener, MacCallum, and Strahan (1999) recommend the number of variables used should be at least 35 times the number of expected factors. Thus, the number of initial items was adequate for our hypothesized model.

Although it is traditionally recommended that initial item testing be overly inclusive (see Clark & Watson, 1995), specific considerations are necessary for EMA measures (see Barta, Tennen, & Litt, 2012). First, reactivity to self-monitoring is reduced when a number of *different* behaviors or constructs are monitored.² Second, time-consuming or burdensome EMA protocols are likely to decrease the amount of effort participants will dedicate to the study protocol (affecting compliance). Thus, the nine items shown in Table 2 were carefully selected in order to broadly capture the construct of impulsivity. For example, items putatively representing motor (e.g., “I acted on impulse, without caring what might happen”), nonplanning (e.g., “I said things without thinking”), and inattention (e.g., “I felt bored with what I was doing”) impulsivity were included for evaluation. At each prompt, participants rated these nine impulsivity items. Participants responded using a 5-point Likert scale (1 = *very slightly or not at all*; 2 = *a little*; 3 = *moderately*; 4 = *quite a bit*; 5 = *extremely*) describing how much each statement described their experience since the last completed prompt. These instructions were provided to focus on recent cognitions, experiences, and behaviors related to impulsivity.

Data Analysis

EMA data are nested within individuals requiring factor analysis based on both inter- and intraindividual covariance between items. An exploratory factor analysis (EFA), using iterated principal factor analysis, was conducted first using within-person covariance matrices. Factor analysis was conducted using weighted least squares mean and variance adjusted estimation in Mplus Version 6.12 (Muthén & Muthén, 2010). Data were then averaged across person for each item. For example, participants’ responses to the item, “I said things without thinking,” at each measurement occasion were summed and divided by the number of total measurement occasions. These aggregated data (average item score across the study, for each person) were then factor analyzed to provide between-individual information.

Basic descriptive statistics of the resulting scale were examined. Given that this scale is designed to capture variability and instability across time and context, an average of daily mean squared successive difference (MSSD) was computed. The MSSD takes into account temporal dependency, as well as variability (Jahng et al., 2008). As its name implies, the MSSD is the average of the squared difference between successive observations (x) at occasions $i + 1$ and i . The MSSD for a time series of n measurement occasions is given by Equation 1:

$$MSSD = \frac{1}{N-1} \sum_{i=1}^{N-1} (x_{i+1} - x_i)^2. \quad (1)$$

We adjusted for unequal time intervals (due to the random scheduling of prompts) in the computation of MSSD using a method suggested by Jahng et al. (2008).

²For details regarding the other behaviors and constructs assessed in this study, please see Trull et al. (2008) and Jahng et al. (2011).

Using an approach described by Shrout and Lane (2012), both within- and between-individual reliability for the resulting scale scores were computed. Specifically, reliability coefficients were obtained by first computing variance component estimates using analysis of variance. Then, these variance components were used to provide reliability estimates based on generalizability theory. It is important to note that within-individual and between-individual reliability have different interpretations for intensive longitudinal designs, like those for experience sampling or EMA studies. High within-individual reliability is indicative of high consistency between items within individuals. In the current study, maximizing within-individual reliability would narrow the construct of interest, given that impulsivity is broad. High between-individual reliability is indicative of high consistency of item responses over time and across all individuals. Finally, the correlations between the final MIS and self-report questionnaires were calculated in order to provide initial evidence of convergent validity for these scale scores.

Results

After examination of distributions, within-person interitem correlations, and the results of preliminary factor analysis of nested data, four of the nine initial items were dropped. Specifically, Items 1, 8, and 9 (shown in Table 2) were eliminated due to low rates of endorsement (highly positively skewed), and Item 3 was dropped because it correlated highly with Items 2 and 7 ($r = .82$ for both pairs). After removal of those items, an EFA (with Geomin rotation) was conducted using the remaining items. In the between-individual EFA, Item 5 loaded on its own factor and was not highly correlated with the first factor ($r = .15$). Consequently, this item was removed from the analysis, and an EFA was conducted on the remaining four items.

Both between- (root-mean-square error of approximation [RMSEA] < 0.01 ; comparative fit index [CFI] = 1.0; Tucker-Lewis Index [TLI] = 1.0) and within- (RMSEA = 0.023; CFI = 0.988; TLI = 0.964) individual EFA on the remaining four items suggested a one-factor solution that provided good model fit. Eigenvalues of between- and within- individual covariances were 2.69, 0.68, 0.49, and 0.15, and 2.52, 0.71, 0.54, and 0.23, respectively. Standardized item factor loadings ranged from .57 to .93 for the between-individual factor solution and from 0.55 to 0.89 for the within-individual factor solution. As shown in Table 3, between-individual correlations for the final four items (below diagonal) are comparable to within-individual (above diagonal) correlations, overall. Final factor loadings of the remaining four items from the one-factor solution for the between-individual EFA and for the within-individual EFA, respectively, were “I said things without thinking” (.928, .843); “I spent more money than I meant to” (.591, .546); “I have felt impatient” (.568, .573); and “I made a ‘spur of the moment’ decision” (.918, .893).

MIS scores were averaged across all observations for an individual in order to create the individual’s mean MIS score over the 28-day period. The means and standard deviations of the MIS scores for our sample are shown in the lower panel of Table 4. The BPD group had a mean scale score of 6.20 ($SD = 1.62$), and the DD group had a mean of 5.56 ($SD = 1.24$); the mean MIS score differed significantly between the groups, $t(103) = 2.10$, $p = .04$. The diagnostic groups also differed on the MSSD of MIS scores (BPD: $M = 6.11$; DD: $M =$

4.14), $t(99.68) = 2.75, p = .007$, with the BPD group showing significantly greater average instability in MIS scores from moment to moment.

Using SIDP-IV interview ratings, the relationship between MIS scores and the impulsivity criterion of BPD was determined. Most individuals in the DD group showed subthreshold impulsivity concerns ($n = 21$), and only one individual met the impulsivity criterion. Therefore, we limited this analysis to the BPD patients ($n = 66^3$). Among the BPD patients, three individuals endorsed “extreme” impulsivity (score = 3), 45 indicated above-threshold symptoms (score = 2), 15 exhibited subthreshold symptoms (score = 1), and three were rated as having no impulsivity concerns on the SIDP-IV (score = 0). Those endorsing above-threshold or extreme impulsivity (i.e., met the *DSMIVTR* criterion) had a significantly higher MSSD of MIS scores, $t(63) = 2.05, p = .044$, than individuals with subthreshold or no impulsivity concerns. Although the difference between mean MIS scores did not reach significance, $t(63) = 1.68, p = .097$, the expected pattern of results was observed with those scoring above threshold on the SIDP-IV impulsivity rating, exhibiting higher mean MIS scores than those below threshold.

Also shown in Table 4 (top panel) are the means and standard deviations for the questionnaire measures of impulsivity. The total sample had a mean BIS-11 total score of 72.59 ($SD = 11.28$), which is consistent with normative data for general psychiatric populations (see Patton et al., 1995). The BPD group had significantly higher BIS-11 total scores, $t(100) = 2.62, p = .01$, and motor subscale, $t(100) = 3.47, p = .001$, scores than the DD group. Despite also having higher scores on the attention and nonplanning subscales of the BIS-11, the BPD group scores were not significantly different than those for the DD group on these subscale scores. The average UPPS scores for the overall sample were 34.97 ($SD = 6.28$) for Urgency, 24.20 ($SD = 6.09$) for Lack of Premeditation, 25.06 ($SD = 5.19$) for Lack of Perseverance, and 28.86 ($SD = 8.18$) for Sensation Seeking. Interestingly, there were no significant differences between groups on any of the UPPS scales. Overall, the UPPS scores for the BPD group (see Table 4) are comparable to those found by Whiteside et al. (2005).

Between- and within-individual reliability were computed for the four-item MIS scores, using Equation 2 and Equation 3 (Nezlek & Gable, 2001; Shrout & Lane, 2012), respectively:

$$R_{KRN} = \frac{\sigma_{person}^2}{\sigma_{person}^2 + (\sigma_{time(person)}^2/k) + (\sigma_{error}^2/km)}. \quad (2)$$

$$R_{CN} = \frac{\sigma_{time(person)}^2}{[\sigma_{time(person)}^2 + (\sigma_{error}^2/m)]}. \quad (3)$$

³Specific information regarding the SIDP-IV impulsivity criterion was missing for one BPD individual, reducing the sample size from 67 to 66.

Results indicated that between-individual reliability was high ($R_{KRN} = 0.99$) and within-individual reliability was moderate ($R_{CN} = 0.56$). This suggests that the rank ordering of individuals on MIS scores across time was very stable, whereas, as expected for a momentary experience measure, MIS scores within individuals did vary across time.

Tables 3 (MIS item level) and 5 (MIS full scale) show correlations between self-report questionnaires and the mean MIS score based on between-individual (averaged across study) data. The mean MIS scores correlated significantly with the BIS-11 total scores ($r = .44$) and all subscales, UPPS total scores ($r = .44$), UPPS Urgency ($r = .45$), and UPPS Lack of Perseverance ($r = .35$). The pattern of correlations obtained for the MSSD of MIS scores was very similar, and the MSSD of MIS scores was correlated with the mean MIS scores (averaged across the entire study; $r = .59$ and $r = .72$ for the DD group and BPD group, respectively). Finally, for the BPD group, correlations between both UPPS total scores and UPPS Urgency and mean MIS scores were greater than those with the MSSD of the MIS scores for the BPD group. The reverse was true for the DD group.

Discussion

The goal of the current study was to develop and evaluate a brief momentary self-report measure of impulsivity to be used in daily life investigations conducted in real-world settings. Results suggest that when many individual MIS assessments are averaged across time, the MIS begins to approximate trait impulsivity as measured by the BIS-11 and the UPPS. Additionally, the MIS can capture moment-to-moment variability in impulsivity over time.

Content Validity

MIS items appear to capture aspects of BIS-11 motor (e.g., made a “spur of the moment” decision, spent more money than meant to), nonplanning (e.g., said without thinking, spent more money than meant to), and attentional (e.g., felt impatient) impulsivity. Additionally, the MIS total score or MSSD of MIS is significantly correlated with three out of four subscales of the UPPS: Urgency, Lack of Premeditation, and Lack of Perseverance. The MIS shows the highest correlations with UPPS Urgency, which is somewhat surprising given that affect-driven impulsivity is not measured by any of the four questions in the final scale. Given the clinical nature of the current sample, it is possible that individuals in our study have negative reactions to their own impulsivity, tend to behave impulsively when experiencing negative affect, or a combination of both. Future EMA studies can administer mood items in addition to the MIS, to determine whether momentary impulsivity occurs in the context of positive or negative mood.

With regard to the UPPS, the feature of sensation seeking was not directly included in the final set of MIS items, and there were no significant relations between sensation-seeking questionnaire scores (from the UPPS) and MIS score indices (i.e., total score, MSSD, individual item score). Some of the items that were dropped due to low base rates may have been better indicators of sensation seeking (e.g., driven recklessly, feeling bored). Sensation seeking may be more challenging to assess on a momentary basis given the infrequency of its behavioral indicators (e.g., thrill-seeking behaviors). Furthermore, emerging evidence has

also suggested that sensation seeking and one's ability to inhibit impulses (i.e., impulsivity, reverse scored) represent two separate constructs and may show distinct developmental pathways (Casey, Getz, & Galvan, 2008; Harden & Tucker-Drob, 2011; Sharma et al., 2013; Steinberg et al., 2008). Specifically, sensation seeking and impulsivity appear to have different neurological underpinnings, as sensation seeking appears to be related to subcortical regions of the brain, and impulsivity is largely related to the prefrontal cortex (Casey et al., 2008). Steinberg and colleagues (2008) found that sensation seeking peaks at age 15 and then steadily declines or remains stable, whereas impulsivity appears to peak around age 10 and then steadily declines. In addition, Harden and Tucker-Drob (2011) reported a nonsignificant relationship between change in sensation seeking and impulsivity over time, supporting the idea that these may be somewhat independent processes. Therefore, investigators interested in sensation seeking will likely need to supplement the MIS with measures specific to this construct.

Convergent Validity

Due to the lack of gold standard for assessment of momentary impulsivity, it is difficult to establish convergent validity of the MIS scores at the momentary level. The validity of the MIS scores can only be established by examining its relation with other measures in the nomological network, and construct validation is an ongoing process (Cronbach & Meehl, 1955). Therefore, we encourage other investigators to compare the MIS with new measures of momentary impulsivity, and to examine criterion-related validity of the MIS with externalizing outcomes such as alcohol use, gambling, risky sex, and the like.

The average MIS score can be compared with existing trait measures of impulsivity, however. Positive relations between the MIS scores and trait self-report measures of impulsivity offer initial construct and convergent validity for these scale scores. Mean MIS scores were significantly correlated with all BIS-11 subscale scores and most UPPS subscale scores, the notable exception being UPPS Sensation Seeking. The MSSD of the MIS scores, which reflects moment-to-moment instability in impulsivity, was significantly associated with all BIS-11 subscales except for BIS-11 Non-Planning as well as all UPPS scores except UPPS Sensation Seeking. Concerning the former, it is possible that nonplanning is a more stable characteristic and shows less variability over time. Stanford and colleagues (2009) presented 1-month BIS-11 retest reliabilities that support this notion. Post hoc analysis comparing our baseline BIS-11 scores with the end of study scores (obtained approximately 1 month later, and used in the current analyses) suggested that Attention and Non-Planning scores were more highly correlated across time ($r = .80$ and $r = .77$, respectively) than were Motor Impulsivity scores ($r = .67$).

Although the MSSD of MIS scores captured instability of impulsivity rather than overall level, the pattern of correlational results were largely similar for mean MIS mean scores and MSSDs. This is most likely a result of the moderate to high correlation between these MIS indices, especially within the BPD group ($r = .71$ in total sample; $r = .59$ for DD group, $r = .72$ for BPD group). Thus, for many applications, it may be sufficient to simply use the mean MIS score in analysis. However, there were notable differences between groups, such that the UPPS Total score and Urgency scale were more highly correlated to the mean MIS

scores for the BPD group, whereas these scales were more strongly correlated with the MSSD of MIS in the DD group. Thus, total and mood-dependent impulsivity may be better assessed using both indices in clinical samples. Further research examining how mean level and MSSD of MIS scores differentially predict outcomes for various populations is needed.

Generalizability

The current results are based on a clinical sample, at least partially consisting of patients known for difficulties with impulsivity (i.e., BPD). Given that EMA studies of impulsivity often focus on proximal risk factors for impulsive behaviors, it seems appropriate to use a sample that exhibits these behaviors. However, it is possible that the resulting factor structure may not generalize to other samples. Further research is needed to examine the factor structure in other populations of interest characterized by impulsivity (e.g., antisocial personality disorder) and also nonclinical samples. For instance, it is possible that MIS scores in a nonclinical sample could show a “floor effect” such that too little endorsement of impulsivity items would result in a sample with a restricted range near the minimum possible score.

Additionally, given the nature of the diagnostic groups used in the current study and the fact that participants were recruited from clinical settings, the current sample consisted predominantly of females (89.5%). Research has demonstrated that males tend to endorse higher levels of sensation seeking (e.g., Cross, Copping, & Campbell, 2011; Cyders, 2013). This may have impacted our ability to detect sensation-seeking-related items in the current sample. With the exception of sensation seeking, however, gender differences in impulsivity are typically not found with the UPPS (Cyders, 2013) and BIS-11 (Patton et al., 1995), used in the current study. Future studies should examine the structural invariance of MIS scores across gender.

Finally, it should be noted that generalizability of the observed factor structure across different study durations should be examined, as it is possible that study periods much longer or shorter than the 28-day study period used in the current protocol may impact the resulting factor structure.

Limitations/Future Directions

A number of limitations of the current study should be noted. First, as a result of protocol changes, the full sample did not receive the Likert scale response format for the EMA items, limiting our sample size ($n = 105$). The resulting sample size was on the lower end of acceptable ranges for between-subjects factor analysis (Fabrigar et al., 1999). Additionally, the UPPS scale was added to the protocol after the start of data collection, and only about three fourths of the participants contributed these data ($n = 77$).

EFA was conducted on a single sample with one round of data collection. As a result, the resulting four-item scale was extracted from a nine-item pool. Because neighboring items can affect responses to items, it will be important to replicate the factor structure on a separate sample with only the four items presented (Clark & Watson, 1995; Smith, McCarthy, & Anderson, 2000). Likewise, replication of the factor structure on an

independent sample is necessary, as our analysis may have reflected chance variations in the data that are specific to the sample we recruited.

Additionally, given constraints on the number of items that can be administered via an EMA protocol, the original item pool was limited. Ideally, we could have initially developed the final MIS scale using a large sample of participants for whom many repeated assessments within day, over time were available for a large number of potential items. The resulting scale could have then been applied to the samples in the current study. It is possible that alternative items not considered for inclusion in the MIS originally might perform better than the retained items. As a result of the necessary brevity, the scale does not tap into all facets of impulsivity that are assumed to underlie models of trait impulsivity (e.g., facets of UPPS). However, our results suggest that the MIS adequately assesses the general construct of impulsivity. Therefore, this scale can be used in EMA studies as a way to supplement traditional self-report measures with information regarding within-individual variability in impulsivity. However, given its length and unidimensional structure, this scale may not be ideal for differentiating between different aspects of impulsivity. Future research should examine the factor structure of impulsivity at the momentary level, as it is possible that this varies as a result of the time frame being assessed. In the current study, random assessments were completed approximately 25 hours apart. It is likely that impulsivity in this narrow time window is much different in nature than weekly, monthly, or yearly assessments, for example.

The current study relies solely on self-reported impulsivity at both trait and momentary levels. Currently, the field primarily relies on laboratory-based tasks as purported measures of state impulsivity (Cyders & Coskunpinar, 2011; Wingrove & Bond, 1997). Laboratory-based tasks and self-report measures of impulsivity are not highly correlated, as demonstrated by a recent meta-analytic review showing an average correlation of .10 (Cyders & Coskunpinar, 2011). Because the MIS assesses momentary impulsivity, correlations between MIS scores and laboratory-based measures thought to measure state impulsivity may be higher. It is also possible, however, that some behavioral lab tasks differ in the extent to which they capture state versus trait impulsivity.

Although the MIS, UPPS, and BIS-11 all rely on self-report, there are some important distinctions between retrospective, trait, and momentary self-report (Connor & Barrett, 2012). Specifically, a variety of memory heuristics or biases may influence the validity (or accuracy) of self-reports, especially those based on retrospection (e.g., What experiences did I have in the past?) or based on beliefs about the self (e.g., What am I typically like?). Such biases are less likely to influence momentary reports because these are typically concerning immediate or very recent mood, thoughts, and behavior. In addition, given that they characterize the immediate, experiencing self, momentary reports seem most likely to be associated with physiological and biological processes of these reported states as opposed to retrospective or trait self-reports (Connor & Barrett, 2012). This is not to say that trait measures, for example, are not useful in some contexts (e.g., in predicting future behavior), but rather that momentary reports may hold some unique advantages in identifying physiological and biological correlates of clinically relevant experiences.

Despite the aforementioned limitations, evidence suggests that MIS scores provide meaningful information about impulsivity. Impulsivity is rarely measured using momentary, real-world methodologies. Given the increasing interest in EMA and ambulatory assessment more generally (Trull & Ebner-Priemer, 2013), there is a need for brief, psychometrically sound measures that can be included in daily life protocols. Our results suggest that the MIS can be used for the assessment of impulsivity in daily life. We encourage other investigators to use this measure in their daily life studies in order to supplement both laboratory-based measures and traditional questionnaire measures of impulsivity. Future research using the MIS and other momentary measures of mood, experience, and behavior can fully model several psychological processes and their relations with impulsivity over time (e.g., affect and impulsivity, impulsivity and interpersonal dysfunction, etc.). Lastly, we encourage investigators using ambulatory assessment and EMA to examine the psychometrics of their momentary survey measures in order to ensure that they are measuring constructs in the real world with precision.

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Table 1

Demographics and Comorbid Conditions of the Study Sample (N = 105)

Variable	BPD (<i>n</i> = 67)		DD (<i>n</i> = 38)	
	<i>n</i>	%	<i>n</i>	%
GenderFemale	62	92.5	32	84.2
Ethnicity				
African American	5	7.5	2	5.3
Hispanic	2	3.0	2	5.3
Caucasian	55	82.1	34	89.5
Native American	1	1.5	0	0
Asian American	2	3.0	0	0
Other	2	3.0	0	0
Marital status				
Single, never married	36	53.7	16	42.1
Married	9	13.4	12	31.6
Cohabiting	9	13.4	4	10.5
Divorced or separated	13	19.4	6	15.8
Annual income				
\$0\$25,000	50	74.6	25	65.8
\$25,001\$50,000	8	11.9	7	18.4
\$50,001\$75,000	4	6.0	3	7.9
\$75,001\$100,000	3	4.5	1	2.6
Above \$100,000	2	3.0	2	5.3
Currently employed ^a	33	50.0	19	52.8
Current Axis I diagnoses ^a				
Any anxiety disorder	55	85.9	25	65.8
Any mood disorder	41	63.1	38	100.0
Any eating disorder	13	20.3	1	2.6
Any substance use disorder	14	20.9	2	5.3

Note. Axis I diagnostic data were unavailable for three people in the BPD group, with the exception of the mood disorder category, missing only two people in the BPD group. BPD = borderline personality disorder; DD = depressive disorder.

^aEmployment information was unavailable for two people in the DD group and one person in the BPD group.

Table 2

Initial Items for Momentary Impulsivity Measure

Item	Since the last prompt, ...
1	I ate so much I had stomach pain or had to throw up.
2 ^a	I said things without thinking.
3	I acted on impulse, without caring what might happen.
4 ^a	I spent more money than I meant to.
5	I felt bored with what I was doing.
6 ^a	I have felt impatient.
7 ^a	I made a "spur of the moment" decision.
8	I made an impulsive purchase.
9	I have driven recklessly (e.g., too fast or dangerously).

^aItem was retained in the final scale.

Table 3

Interitem Correlations and Between-Individual Correlations With Self-Report Measures

Variable	Said without thinking	Impatient	Spent money	Spur of the moment
Scale items				
Said without thinking	—	.52*	.39*	.75*
Impatient	.53*	—	.31*	.48*
Spent money	.55*	.34*	—	.53*
Spur of the moment	.85*	.52*	.54*	—
Self-report				
BIS Total	.33*	.41*	.36*	.37*
BIS Motor	.33*	.26*	.38*	.37*
BIS Non-planning	.20 [†]	.25 [†]	.19	.20 [†]
BIS Attention	.26*	.51*	.29*	.32*
UPPS Total	.43*	.34*	.42*	.37*
UPPS Urgency	.42*	.41*	.36*	.31*
UPPS Lack of Premeditation	.26 [†]	.16	.32*	.26 [†]
UPPS Lack of Perseverance	.33*	.34*	.23 [†]	.23 [†]
UPPS Sensation Seeking	.12	.02	.17	.17

Note. UPPS data are based on an n of 77, as earlier participants were not given this measure. Within-individual correlations did not account for correlations at the person level. Within-individual correlations appear above the diagonal; between-individual correlations appear below the diagonal. BIS = Barratt Impulsiveness Scale Version 11; UPPS = UPPS Impulsive Behavior Scale.

[†] $p < .05$.

* $p < .01$.

Table 4

Means and Standard Deviations of Questionnaire and EMA Self-Report Measures

Questionnaire self-report	BPD (<i>n</i> = 67)		DD (<i>n</i> = 38)		Overall sample (<i>N</i> = 105)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
BIS Total*	74.73	10.77	68.82	11.29	72.59	11.28
BIS Motor*	25.38	4.46	22.14	4.69	24.21	4.79
BIS Non-planning	28.28	5.56	26.78	5.08	27.74	5.41
BIS Attention	21.07	3.65	19.89	4.55	20.64	4.02
UPPS Total	115.63	14.83	108.38	17.84	113.09	16.21
UPPS Urgency	35.97	6.09	33.11	6.33	34.97	6.28
UPPS Lack of Premeditation	24.98	5.39	22.76	7.10	24.20	6.09
UPPS Lack of Perseverance	25.22	5.12	24.78	5.40	25.06	5.19
UPPS Sensation Seeking	29.47	8.23	27.73	8.13	28.86	8.18
EMA indices (averaged across study)						
Momentary Impulsivity Scale (MIS)*	6.20	1.62	5.56	1.24	5.97	1.52
MSSD of MIS Scale*	6.11	4.36	4.14	2.95	5.40	4.01

Note. UPPS data are based on an *n* of 77, as earlier participants were not given this measure. An asterisk denotes significant difference between groups ($p < .05$). EMA = ecological momentary assessment; BPD = borderline personality disorder; DD = depressive disorder; BIS = Barratt Impulsiveness Scale Version 11; UPPS = UPPS Impulsive Behavior Scale; MSSD = mean squared successive difference.

Table 5

Bivariate Correlations Between Momentary Impulsivity Scale (MIS) Scores (Averaged Across Time Points), Instability in MIS Scores (MSSD), and Questionnaire Self-Report Measures

Questionnaire	MIS			MSSD of MIS scores		
	BPD	DD	Overall	BPD	DD	Overall
BIS Total	.40*	.46*	.44*	.34*	.38 [†]	.38*
BIS Motor	.37*	.28	.38*	.34*	.34 [†]	.38*
BIS Non-planning	.23	.27	.26*	.18	.14	.22 [†]
BIS Attention	.38*	.55*	.44*	.31*	.31	.32*
UPPS Total	.50*	.33	.44*	.46*	.61*	.50*
UPPS Urgency	.48*	.35	.45*	.37*	.62*	.45*
UPPS Lack of Premeditation	.29 [†]	.20	.26 [†]	.28 [†]	.32	.30*
UPPS Lack of Perseverance	.36*	.33	.35*	.33 [†]	.41 [†]	.34*
UPPS Sensation Seeking	.14	.05	.12	.16	.29	.21

Note. UPPS data is based on an *n* of 77, as earlier participants were not given this measure. MSSD = mean squared successive difference; BPD = borderline personality disorder; DD = depressive disorder; BIS = Barratt Impulsiveness Scale Version 11; UPPS = UPPS Impulsive Behavior Scale.

[†] *p* < .05.

* *p* < .01.