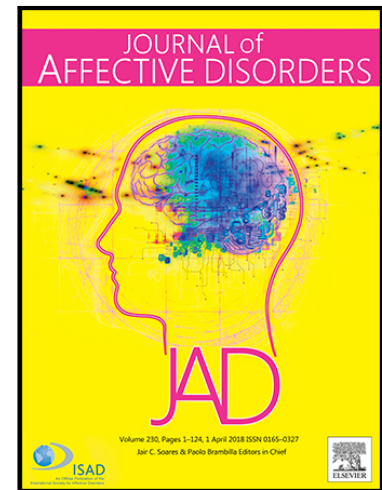


Reconsideration of the factorial structure of the Barratt Impulsiveness Scale (BIS-11): assessment of impulsivity in a large population of euthymic bipolar patients

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Highlights

- Assessing impulsivity is highly useful, since it is the second most frequently cited symptom in DSM-5 and its level predicts suicidal behaviors.
- The Barratt Impulsiveness Scale 11th version (BIS-11) is the most widely used inventory for assessing impulsivity, but the reliability of its three dimensional structure is challenged.
- An alternative bidimensional structure of the scale was conceived and a shortened 12 items Impulsivity Scale (IS-12) was obtained with high reliability. We named it IS-12.
- The IS-12 evidences two distinct dimensions: “behavioral impulsivity” and “cognitive impulsivity”.
- Behavioral impulsivity is specifically associated with the number of past suicidal attempts.

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Reconsideration of the factorial structure of the Barratt Impulsiveness Scale (BIS-11): assessment of impulsivity in a large population of euthymic bipolar patients

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APPENDIX

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Abstract:

Background: Impulsivity is commonly assessed using the Barratt Impulsiveness Scale (BIS-11). Some studies challenged the reliability of its three dimensional structure and proposed a bi-dimensional structure.

Methods: The psychometric reliability of the BIS-11 scale was studied in a sample of 580 euthymic bipolar patients. An alternative structure of the scale was conceived, using confirmatory factorial analysis (CFA) in the first half (N=290) and cross-validated in the second half of our sample. Associations between the newly defined shortened scale and predefined clinical variables were computed.

Results: The original three dimensional structure did not fit in our sample according to statistical criteria in CFA. A 12 items Impulsivity Scale (IS-12) was designed with strong indices of fitting in the first half of our sample and replicated in the second half of our sample. The IS-12 evidences two dimensions: “behavioral impulsivity” and “cognitive impulsivity”. Associations between “behavioral impulsivity” and both presence of past suicide attempts and number of suicide attempts were observed. Substance misuse was strongly associated with both subscores of the new scale.

Limitations: The rating of the items assessing the two dimensions of the IS-12 is reversed. The population is restricted to euthymic bipolar patients.

Conclusions: The Impulsivity Scale assesses two distinct dimensions named behavioral and cognitive impulsivity. It was reliable and valid in our sample and associated with the existence of suicidal behavior and with substance misuse (alcohol and cannabis). Further studies are needed to demonstrate its predictive validity.

Keywords:

Impulsivity, bipolar disorder, Barratt Impulsiveness Scale 11, psychometric study, suicidality, substance misuse

Words count: 249

INTRODUCTION

The BIS-11 is the most widely internationally used instrument to assess impulsivity in clinical populations. Since the seminal work of Ernest Barratt and his first version of the Barratt Impulsiveness Scale (Barratt, 1959), the concept of impulsivity has evolved from an unidimensional to a multidimensional model, through successive revisions of the Barratt Impulsiveness Scale (BIS) until the last and 11th version of the BIS, published in 1995 (Patton et al., 1995).

The BIS-11 was designed from ratings obtained from a heterogeneous population of 733 persons (412 undergraduate students, 248 psychiatric in-patients and 73 male prison inmates). Using two successive “Principal Component Analyses” (PCA), the authors isolated three dimensions of the scale, which they called “*motor impulsiveness*”, “*non-planning impulsiveness*” and “*attentional impulsiveness*”. In 2007, Spinella presented a shortened 15 items version of the BIS-11, without questioning the three factors structure of the scale (Spinella, 2007). Unfortunately this three factors structure could not be replicated in several subsequent studies (Haden and Shiva, 2009; Reise et al., 2013; Steinberg et al., 2013). Haden & Shiva (2009), in a sample of 327 mentally ill forensic in-patients found only two factors, which they named “*motor impulsivity*” and “*nonplanning impulsivity*”. Reise et al. (2013), using the BIS-11 in a community sample (N = 691), also concluded that only a model with two factors could accurately account for their results. They called these two factors “*behavioral impulsivity*” and “*cognitive impulsivity*”. According to Reise et al., *behavioral impulsivity* depends on factors present at the time of action, while *cognitive impulsivity* depends on the awareness of factors present before the action and on the consequences of the action.

Suicidality has been strongly associated with both bipolar disorder (BD) and impulsivity (Brezo et al., 2006; Liu et al., 2017; Lynam et al., 2011). Psychological autopsy studies have shown that around 25% of suicides occur in patients suffering from bipolar disorder (Isometsä, 2005). Twenty five to 60 % of BD patients will attempt suicide at least once during lifetime (Goodwin and Jamison, 2007; Novick et al., 2010) and, according to recent estimations, around 6 to 7 % of BD patients will die by suicide (Schaffer et al., 2015).

On the other hand, patients with BD have been shown to present a higher level of trait impulsivity than controls, as measured by the BIS-11 total score, even when euthymic (Etain et al., 2013; Moëller et al., 2001; Swann et al., 2001). In bipolar disorder, our group has shown that impulsivity was higher in patients with a history of mixed states, rapid cycling and substance misuses (Etain et al., 2013); impulsivity was also higher in subjects with a predominant depressive polarity, a longer duration of illness, a history of psychotic mood episodes and a history of suicide attempts (Ekinci et al., 2011). When assessed by a behavioral task, the *Continuous Performance Test* (CPT), impulsivity is associated with suicidal attempts as well as with the severity of suicidal attempts in BD patients (Swann et al., 2005).

The relationships between suicidality and impulsivity have been studied using different psychometric instruments. Most studies using the “*Urgency, (lack of) Premeditation, (lack of) Perseverance, Sensation seeking Scale*” (UPPS, Whiteside and Lynam, 2001) to assess impulsivity consistently demonstrate its links with suicidality (Ammerman et al., 2015; Klonsky and May, 2010; Lynam et al., 2011); in contrast, when assessing impulsivity with the BIS, results are inconsistent (Doihara et al., 2012; Etain et al., 2013; Ferraz et al., 2013; Olié et al., 2015; Swann et al., 2005; Wu et al., 2009). These results seem to demonstrate the instable predictive value of the BIS-11 total score.

Therefore, we wanted to address the question of the use of subscores of the BIS to improve its predictive value. To this day, no research has shown, in a large population of euthymic patients with bipolar disorder, if a two factors structure of the BIS-11 could have a better predictive value than the classical three factors structure. This is the aim of the present article.

1. AIMS OF THE STUDY

The aims of this study are to check if 1: a two factors structure of the BIS-11, could be assessed in a reliable and reproducible manner in bipolar disorder patients; 2: if this bi-dimensional version has a better predictive value than the classical three factor structure and 3: if a specific factorial structure is associated with clinical characteristics of bipolar disorder, such as a history of suicide attempts, mixed states, rapid cycling and substance misuse. These associations could demonstrate the criterion validity of the BIS bi-dimensional version.

2. MATERIALS AND METHODS

3.1. Clinical samples

Five hundred eighty euthymic bipolar patients have been included, among which 305 women (age: $m = 41.3$, $SD = 12.7$), 240 men (age: $m = 41.6$, $SD = 13.3$) and 35 subjects (6% of the sample) for which gender was not recorded (age: $m = 40.9$, $SD = 11.7$). The patients were recruited through the “FondaMental Advanced Centers of Expertise for Bipolar Disorder” network (FACE-BD). The aims and organization of this network have been described in detail elsewhere (Henry et al., 2011).

The protocol of evaluation was approved by the French ethical committee (CPP-Ile de France IX, January 18th, 2010) and has had an authorization of the “Commission Nationale de l’Informatique et des Libertés” (DR-2011-069). Patients have been systematically informed

that their data could be used within the frame of scientific studies but, since the measurements were part of immediate care, a written consent was not necessary.

Inclusion criteria were : to be 16 years of age or over, being diagnosed with bipolar disorder (type I, II or NOS) as described in the Diagnostic and Statistical Manual of Mental Disorders, 4th ed. Text Revised (DSM-IV-TR, American Psychiatric Association, 2000). Patients had to be euthymic and their scores had to be inferior to 8 at the Montgomery and Asberg Depression Rating Scale (MADRS, Montgomery and Asberg, 1979) and inferior to 6 at the Young Mania Rating Scale (YMRS, Young et al., 1978). Other bipolar disorder characteristics (rapid cycling, history of mixed states, etc.) and comorbidity (substance use disorders) were also diagnosed according to DSM-IV-TR.

3.2. Data collection

Based on the Structured Clinical Interview for DSM-IV (SCID: First, Spitzer, Gibbon, & Williams, 2012), a large standardized clinical evaluation was performed to confirm bipolar disorder diagnosis, as well as psychiatric comorbidities and history of mood disorder (i.e.: age at onset, number and polarity of past episodes). Moreover, sociodemographic factors were collected (age, gender, education). A standardized clinical interview was used to assess manic symptoms with the YMRS and depressive symptoms with the MADRS. Evaluations were performed by senior clinical psychiatrists and psychologists.

3.3. Barratt Impulsiveness Scale

The French version of the Barratt Impulsiveness Scale, version 10 (BIS-10) was used, since it is the latest validated version in French to this day (Bayle et al., 2000; Patton et al., 1995). This 10th version comprises 34 items but, in Patton's analysis (1995), four of the items of the BIS-10 did not meet their criteria to be included in the final version: BIS-11. Therefore, these four items of the BIS-10 were not included in our analysis. The BIS-11 is a thirty items self-

report questionnaire which includes nineteen items indicating impulsivity, which are answered on a 4-point scale (“rarely or never” = 1; “occasionally”= 2; “often”= 3; “almost always” = 4) and 11 items indicating non-impulsivity, which are scored in a reverse order (“rarely or never” = 4; ...). The BIS-11 is considered to evaluate three major factors: attentional (8 items), motor (11 items) and non-planning impulsivity (11 items). High scores indicate high levels of the different dimensions of impulsivity.

3.4. Statistical analysis

3.4.1. Scores and internal consistency coefficients of the BIS-11

The internal consistency of the total score and the three subscores described by Patton et al. (1995) were computed. An alpha reliability coefficient $\geq .70$ was considered as satisfactory, according to Nunnally and Bernstein (1994).

3.4.2. Fit of the original three factor model:

A Confirmatory Factor Analysis (CFA) of the BIS-11 was computed to check if the original three factor structure of the BIS-11 fitted in our sample. The CFA model was fitted with package *Lavaan* (Rosseel, 2012) for R statistical software, with the diagonal weighted least squares (WLSMV) estimation method (Beauducel and Herzberg, 2009; Brown, 2006). The variance of the first indicator of each latent variable was set to 1, to ensure model identification.

As an indication of a fit of a good model, the following indicators were used across this study, based on the Satorra-Bentler χ^2 : the Comparative Fit Index (CFI: cut-off $>.90$), the Tucker-Levis-Index (TLI: cut-off $>.90$), Root Mean Square Error of Approximation (RMSEA: $< .08$ for a fair fitting model or $<.05$ for a well-fitting model) and the Weighted Root Mean Square

Residual (WRMR, cut-off < .90; McDonald, 1999; Yu, 2002). The same statistical criteria (CFI, TLI, RMSEA and WRMR) were used to study the fit of all the other CFA models.

3.4.3. Determination of the best factorial structure of the BIS-11: construction of a new scale

Since, in our analysis, these indices showed a really poor fit of the original three-dimensional factorial model of the BIS-11, the sample was randomly split in two sub-samples of 290 subjects. On the first sub-sample, we searched step-by-step for a better factorial structure of the BIS. The second half of the sample allowed us to check directly if the newly identified scale's structure could be replicated, since in the first sub-sample the psychometric characteristics of the scale could have been due to try-and-error processes.

In the first sample, a series of analysis were performed to select the items which could constitute a better factorial model. First, a hierarchical cluster analysis of the items (with package *Psych*, Revelle, 2014) was performed to study the clusterization of the items. The items used in the following Exploratory Factorial Analysis (EFA) were selected by studying the coefficients of reliability of the different clusters (coefficients alpha and beta >.70). Thereafter, an EFA was used to find the best factorial solution: the items with loadings above 0.32 on a unique factor after an oblimin rotation were selected (Tabachnick and Fidell, 2001). Afterwards, a CFA was performed to check if the newly defined bi-dimensional structure fitted according to the statistical criteria (CFI, TLI, RMSEA and WRMR).

The last CFA was then repeated in the second sub-sample (see supplementary material for detailed description of the statistical analysis), in order to test if the scale constructed step by step in the first sub-sample could be validated.

3.4.4. Predictive validity of the new scale for specific clinical variables

In order to test the predictive validity of the new scale, we studied its association with the specific clinical variables, previously studied in Etain et al. (2013): residual mood symptoms, past clinical episodes, suicidal behavior, substance use disorder.

The correlation between residual symptomatology and the subscores of our new scale were computed. For sub-depression, subjects with a MADRS < 8 were included and for hypomania subjects with a YMRS < 6 were included.

A succession of linear regressions was computed with successively, as dependent variables the two scores at the new scale (“cognitive impulsivity”: F1 and “behavioral impulsivity”: F2). The following independent variables were used successively as quantitative predictors: number of past mixed, depressive and manic episodes. The suicide attempts were predicted with a hurdle regression model with the five subscores of the two scales (BIS-11 and our new scale) as predictors, to detect the most important predictor(s) (Frees, 2009).

For the two scale’s sub-scores, the means obtained by the following clinical groups were compared: rapid cycling vs. non rapid cycling, alcohol use disorder (dependence and abuse) vs. no alcohol use disorder, cannabis use disorder (dependence and abuse) vs. no cannabis use disorder. MANOVA (with the two subscores as dependent variables) followed by one-way ANOVA and Tukey’s HSD tests were used to identify exact sources of variations. All differences were considered as significant at a $p < .05$ level.

Finally, to compare our results with the ratings obtained by Reise et al. (2013), Pearson correlations between our two subscores and Reise et al.’s two factor scores were computed.

Our variables comprised few missing data (less than 5 %); therefore the listwise deletion method was chosen.

The software R 3.2 (R Development Core Team, 2015) was used for all the analyses.

3. RESULTS

4.1. Socio-demographic and clinical variables

The main clinical characteristics of the 580 patients are presented in Table 1. The mean age of patients at interview was 41.4 years (± 12.9 , range 16-86). The median age at onset of illness was 18 years (± 10.7 , range 7 - 66). The proportion of suicide attempters was 36.2 % among the total population, 42.0 % among women and 25.5 % among men. The mean number of past suicide attempts for suicide attempters differed significantly according to gender ($t = 2.74$; $p < .01$): it was higher for women: 2.58 (± 2.87 , range 1-20), than for men: 1.80 ($\pm .98$, range 1-5).

(Insert Table 1 about here)

4.2. Scores and internal consistency of the BIS-11

On the whole sample ($N=580$), the mean total score of the BIS-11 was 64.4 (± 10.2 , range 42-99, median = 63). The alpha reliability coefficient of the total scale and the original three subscales of the BIS-11 were the following: total score: $\alpha = 0.802$, 95% CI [0.776; 0.824]; motor impulsivity: $\alpha = 0.551$, 95% CI [0.484; 0.615]; attentional impulsivity: $\alpha = 0.713$, 95% CI [0.675; 0.753]; non-planning impulsivity: $\alpha = 0.642$, 95% CI [0.590; 0.683]. As observed, only attentional impulsivity and the total score obtained an alpha superior to 0.70.

4.3. Fit of the BIS-11 original factorial structure

The original three dimensional structure of the BIS-11 did not fit in the CFA model: CFI=0.675; TLI=0.648; RMSEA = 0.145; 95% CI [0.141-0.149], WRMR= 2.745. These results indicated a strong misfit of the original model in our sample. The modification indices were computed in an attempt to maximize the fit of the model, but, even after seven steps of

modifications (freeing of covariance between residuals of the variables), an acceptable fit was not obtained.

4.4. Selection of the items constituting reliable dimensions of impulsivity from the BIS-11 in the first half of the sample

Step 1: Hierarchical clustering of items

Some clusters of items were identified in the first half of our sample. A large cluster of items ($n=18$) with good psychometric reliability ($\alpha = 0.83$; $\beta = 0.79$) was identified. These items belong to two clusters which aggregate in one higher level cluster (cf. figure S1 in supplementary material).

Step 2: Exploratory Factorial Analysis

In order to determine the loading on each factor of these 18 items, an EFA was performed with two factors, as suggested by the results of the previous analysis. The results are presented as factorial results (loadings after rotation, cf. Table 4). The items number 2, 5, 7, 10 and 13 were excluded (loadings < 0.32).

Therefore, we obtained a structure with two dimensions: the first was called “*cognitive impulsivity*” and the second “*behavioral impulsivity*” (see discussion for explanations).

(Insert Table 2 about here)

Step 3: Fit in CFA of the newly defined structure in the first half of the sample

This model was then tested in CFA on the first half of the sample, in order to find the best fitting model. Item 26 was removed, as it loads on the dimension “*behavioral impulsivity*” (loading = 0.433), but is also highly correlated with the score of “*cognitive impulsivity*” ($r = .43$), thus lacking specificity. A new analysis of the data without item 26 was performed

and an excellent fit was obtained: CFI=0.976, TLI=0.969, RMSEA=0.047, 95% CI [0.027; 0.064], WRMR=0.771.

4.5. Replication of the newly defined scale's structure in the second half of our sample in CFA

The replication of the CFA model, with one free covariance, leads to the following results, which confirm the bi-dimensional factorial structure found in the first half of the sample. A high level fit was obtained: CFI=0.946>0.90, TLI=0.931>0.90, RMSEA 0.076<0.08, 95% CI [0.061-0.091], WRMR=0.987. The standardized covariance between the two factors was significant ($p < 0.001$).

Modification indices, which could augment the fit of the model, were checked. A free covariance between residuals of item 8 and item 9 was added. The fit was excellent: CFI = 0.981; TLI= 0.976; RMSEA = 0.045, 95% CI [0.025-0.063], WRMR = 0.728<0.90. Therefore, the structure was replicated in the second half of our sample.

A model without covariance between “cognitive impulsivity” and “behavioral impulsivity” (orthogonal model) was computed and a badly fitting model was obtained according to our criteria; therefore, the covariance between the two factors is necessary to the good fit of our model.

The rating of Reise et al. (2013) was used to compute correlations between their dimensions and our dimensions. The scores at the “cognitive impulsivity” following our rating and at the same dimension following Reise’s rating were highly significantly correlated ($r = .96$; $p < .0001$) and the scores at the “behavioral impulsivity” according to our rating and at the same dimension following Reise’s rating were equally highly significantly correlated ($r = .85$; $p < .0001$).

To summarize, our results confirm that impulsivity could be reliably explored with a scale comprising 12 items from the BIS-11, aggregating in two correlated but distinct dimensions. We named this new scale “IS-12” (for: 12 items Impulsivity Scale). We kept Reise et al.’s denomination and named its two dimensions “cognitive impulsivity” (F1) and “behavioral impulsivity” (F2).

4.6. Construct validity and clinical utility of the 12 items impulsivity bi-dimensional scale

To obtain the score on the two factors, the scores at each item of each dimension were summed and a total score was obtained for the two dimensions: “cognitive impulsivity” (F1) and “behavioral impulsivity” (F2).

4.6.1. Correlations with residual symptoms:

The scores of these two dimensions (F1 and F2) from the IS-12 correlated significantly with residual depressive symptoms (MADRS, F1: $r = .21$; $p < .001$; F2: $r = .11$; $p < .001$), but only “behavioral impulsivity” was correlated with residual hypomanic symptoms (YMRS, $r = .11$; $p < .01$).

4.6.2. Relationship with presence or absence of rapid cycling and past clinical episodes:

Neither rapid cycling nor past episodes were associated with any of the scores at our 12 items impulsivity scale (all $p > .10$).

4.6.3. Relationship with suicidal attempts:

A hurdle regression model with “cognitive impulsivity”, “behavioral impulsivity” (both from IS-12) and the classical three subscores of the BIS-11 as predictors of the number of past suicide attempts showed that “behavioral impulsivity” only was linked to the history of

suicide attempts and with the number of suicide attempts, whereas other variables were not significantly associated with suicidal attempts ($p < .05$).

4.6.4. Substances use disorders:

The diagnostic of alcohol dependence disorder was associated with greater mean scores on cognitive impulsivity and on behavioral impulsivity subscales from IS-12 than in the group without alcohol use disorder ($p < .05$); other differences were not significant (see table S2).

The diagnostic of cannabis dependence disorder was associated with greater scores on the cognitive impulsivity and behavioral impulsivity subscales from IS-12 than in the non cannabis use disorder group and the cannabis abuse disorder group; whereas the patients with abuse disorder were not significantly different from patients without cannabis use disorder.

(Insert Table 3 about here)

4. DISCUSSION

The Barratt Impulsiveness Scale (BIS, 11th version) is the most widely used scale to assess impulsivity, but its total score is used more frequently than its three sub-scores, according to the original authors (Stanford et al., 2009). They advise to use the sub-scores, since impulsivity is clearly a multidimensional concept. But, many researchers did not succeed to confirm the original three second order structure of the scale and rather found a bi-dimensional structure (Haden and Shiva, 2009; Reise et al., 2013). Even the total score, sometimes, failed to be associated with suicidal behavior (Etain et al., 2013; Olié et al., 2015; Swann et al., 2005). If the three dimensional structure is not reliable, then this strongly impacts the usefulness of these sub-scores.

The present study confirms previous studies and the lack of replicability of the initially proposed three dimensional structure of the BIS, 11th version. It introduces a new impulsivity

scale with only 12 items (named IS-12), aggregating in two dimensions, which we named “cognitive impulsivity” (5 items) and “behavioral impulsivity” (7 items). They correlated highly with the rating of Reise et al. (2013), who proposed these denominations. These two dimensions of impulsivity present a strong content proximity to those regularly described in previous studies (Haden and Shiva, 2009; Ireland and Archer, 2008; Reise et al., 2013). Cognitive impulsivity seems to involve the anticipation of the result of actions and therefore be closer to the concept of “non-planned impulsivity” found in the previous analysis of the BIS-11 (Haden and Shiva, 2009). This cognitive impulsivity dimension comprises the same items as dimension 1 of Reise et al. (2013) except item 7, which did not load significantly in dimension 1 in our study. Behavioral impulsivity seems to be dependent of an excessive sensitivity to present stimuli and is therefore close to “motor impulsivity”, as found by Haden and Shiva (2009). Compared to Reise et al. (2013), the “behavioral impulsivity” dimension shares only 4 items among the 7 proposed by Reise et al., but the dimension “behavioral impulsivity” in Reise et al. and in our study correlated highly. Interestingly, the same two dimensions appeared in Reise’s and our studies, although using different statistical methodologies and different populations (non-clinical in Reise et al. 2013 and clinical in our study). Our psychometrical methodology allowed us to select 12 items among the original thirty, which reliably assess two distinct dimensions of impulsivity. This study highlights, once more, the multidimensional aspect of impulsivity and suggests that a reliable assessment of sub-dimensions of impulsivity is possible and useful. The remaining 18 items of the BIS-11 were discarded from the new scale, since they did not segregate in a coherent separate dimension, nor segregate distinctively between the two dimensions F1 and F2.

The free covariances added between residuals of items 22 (“I buy things on impulse”) and 25 (“I spend or charged more than I earned”) could be explained since they explore the same facet of impulsivity. We suppressed item 26 of the BIS-11, because it loaded simultaneously

on both dimensions of the new scale. Furthermore, its suppression allowed a better fit of the model and a better distinction between the two dimensions (cognitive impulsivity and behavioral impulsivity).

The IS-12 showed a correlation between subclinical depressive symptoms and both cognitive and behavioral impulsivity dimensions, but only on the behavioral impulsivity dimension for hypomanic symptoms. Therefore, even if subjects were euthymic according to stringent criteria ($\text{MADRS} < 8$ and $\text{YMRS} < 6$), the IS-12 allowed us to detect subtle relationships between impulsivity and subclinical symptoms. This result underscores the sensitivity of the new scale and the importance of residual mood symptomatology in the persistence of a strong impulsivity, during inter-episodic periods.

The association between rapid cycling and impulsivity did not appear, even though this result was found in a previous publication of our group (Etain et al. 2013), but in a different sample.

The presence and number of past suicide attempts only correlated with “behavioral impulsivity”. Suicidal behavior, in a sub-group of bipolar patients, could be an impulsive behavior, since behavioral impulsivity has a strong relationship with the immediate psychological condition of the patient. This phenomenon could contribute to explain why suicide is frequent in patients with bipolar disorder. These patients often present two particularly dangerous features when associated: an acute awareness of psychological pain during depression, associated with a general hyper-emotionality (Chan and Tse, 2018; Henry et al., 2013) and a strong tendency to act impulsively (Etain et al., 2013; Olié et al., 2015). These two characteristics (general emotional dysregulation and impulsivity) have been found associated with suicidal behavior in a general population of 2295 students among which were 108 past suicidal attempters (Ammerman et al., 2015). Our results confirm the relevance of our new scale, since the original three subscores of the BIS-11 were not associated to

suicidality in the hurdle regression models. The results of this study suggest the potential utility of the IS-12 to predict suicidality in patients with bipolar disorder. Future studies will be necessary to test the IS-12 in various clinical populations, where impulsivity is frequent.

5. LIMITATIONS

From a metrological perspective, a weakness of the IS-12 is the formulation used in the assessment of its both dimensions. In the behavioral impulsivity dimension, the items all have the same rating system (the higher the score, the higher impulsivity), while items of the cognitive dimension are all reverse-rated. But we demonstrated that behavioral and cognitive impulsivity related differently to suicidality.

Another limit is intrinsic to our study: our population comprised only euthymic bipolar disorders patients. It would be of clinical interest to test the IS-12 in healthy controls and other clinical populations.

6. STRENGTHS

A strength of this study is the size of the cohort (N total = 580), which allowed us to split the sample in two sufficiently large sub-samples. The minimal size of a sample to use factor analysis is around three hundred, according to Rouquette and Falissard (2011), which corresponds approximately to the size of each sub-sample (N=290).

This large sample allowed us to use up to date statistical methodology and therefore to use specific methods which take into account, in all phases of the study, the ordinal scale of the responses to items from the BIS-11 (Likert scale; see supplementary material).

Another strength of the study comes from the use of strict criteria to define bipolar diagnosis, using semi-structured clinical interviews (SCID-I; DSM-IV-TR criteria) performed by

experienced clinicians and the strict definition of euthymic states in patients (MADRS < 8 and YMRS < 6). Therefore, the sample was highly homogenous.

7. CONCLUSIONS

This study did not support a three factors structure of the BIS-11, as published by Patton et al. (1995). In line with the contributions of Haden and Shiva (2009) and Reise et al. (2013), our results support a structure with two dimensions that we name “cognitive impulsivity” and “behavioral impulsivity”. We present a new twelve items impulsivity scale (IS-12), with the same criterion validity for substance use disorder and better criterion validity for suicidal behavior than the 30 items Barratt Impulsiveness Scale. We demonstrated that the behavioral impulsivity subscale only is related to the presence and number of previous suicidal attempts, thus emphasizing the usefulness of the distinction between cognitive and behavioral impulsivity. Therefore, we recommend that, besides the total score, both sub-scores be analyzed separately in future impulsivity research.

Indeed, impulsivity is highly correlated to suicidal behavior and patients with bipolar disorder are at high risk for suicide. Therefore, a short scale reliably assessing impulsivity, could be a useful instrument to assess risk factors of suicidality. Longitudinal studies are required to investigate further the predictive validity of the IS-12 in other healthy and clinical populations.

Conflict of interest

None. The authors declare that they have no competing financial interests, or other interests that might be perceived to influence the results and discussion reported in this paper.

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Table 1: Clinical characteristics of the total cohort

Variables	% or Means (SD) N = 580
Gender (Men / Women / missing)	41.4% / 52.6% / 6.0%
BD subtype (I/II/NOS)	55.7% / 33.2% / 11.1%
Age at onset (years)	20.68 (10.65)
Age at interview (years)	41.39 (12.87)
Duration of illness (years)	22.49 (12.32)
Number of hospitalizations	2.9 (2.9)
Psychotic features (yes / missing)*	28.4% / 30.2%
Suicide attempt (Total/ Women / Men) **	36% / 42.0% / 25.5%
Suicide attempts***	2.34 (2.38)
Number of Depressive Episodes	4.18 (3.27)
Number of Manic Episodes	1.43 (2.02)
Number of Hypomanic Episodes	6.03 (5.52)
Number of Mixed Episodes	0.33 (1.06)
Alcohol abuse / dependant	9.8% / 5.0%
Cannabis abuse / dependant	7.1% / 4.8%

* Presence during at least one major mood episode

** Lifetime history

*** Lifetime history for patients with at least one suicide attempt

Table 2: Analysis of the two dimensional structure of the BIS-11

	Item number	Item' content	F1	F2
Items with main loading on F1 > 0.32 "cognitive impulsivity"	Item1	I plan tasks carefully	0.481	-0.08
	Item 8	I am self controlled	0.445	0.028
	Item 9	I concentrate easily	0.55	0.048
	Item 12	I am a careful thinker	0.761	-0.021
	Item 20	I am a steady thinker	0.659	0.046
Items with main loading on F2 > 0.32 "behavioral impulsivity"	Item 6	I have "racing" thoughts	-0.14	0.367
	Item 14	I say things without thinking	-0.011	0.478
	Item 17	I act "on impulse"	0.054	0.74
	Item 19	I act on the spur of the moment	-0.073	0.586
	Item 22	I buy things on impulse	-0.034	0.614
	Item 24	I change hobbies	0.024	0.347
	Item 25	I spend or charge more than I earn	0.053	0.344
Items with loading < 0.32 on both dimensions	Item 26	I often have extraneous thoughts when thinking	0.158	0.433
	Item 2	I do things without thinking	0.071	0.179
	Item 5	I don't "pay attention"	0.236	0.16
	Item 7	I plan trips well ahead of time	0.236	-0.046
	Item 10	I save regularly	0.211	0.187
	Item 13	I plan for job security	0.213	0.039

Eighteen items, among 30 of the original BIS-11, were retained after a hierarchical cluster analysis. Among those, 13 had loadings superior to 0.32 (in bold)

Table 3: Dimensions of impulsivity in bipolar patients with and without substance use disorder, as evaluated with the 12 items Impulsivity Scale (IS-12)

Alcohol	No Alcohol use disorder	Abuse	Dependence
IS12 Cognitive impulsivity	10.89 (± 2.94) a	11.84 (± 3.32) b 14.47 (± 3.88)	12.79 (± 2.57) b
IS12 Behavioral impulsivity	13.79 (± 3.51) a	a,b	15.41 (± 4.38) b
Cannabis	No cannabis use disorder	Abuse	Dependence
IS12 Cognitive impulsivity	11.03 (± 2.94) a	11.15 (± 2.82) a	13.64 (± 3.13) b
IS12 Behavioral impulsivity	13.82 (± 3.54) a	14.00 (± 4.10) a	16.07 (± 3.73) b

IS-12: our 12 items revised Impulsivity Scale

Results are expressed as means \pm standard deviation.

When two groups present no statistically significant difference, they share the same letter (i.e. "a" or "b"), whereas when two groups present statistically significant difference at a $p < .05$ level, they are associated with different letters ("a" versus "b").