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

4
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1 **Reconsideration of the factorial structure of the Barratt Impulsiveness**
2 **Scale (BIS-11): assessment of impulsivity in a large population of euthymic**
3 **bipolar patients**

4 **INTRODUCTION**

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

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

25 depends on the awareness of factors present before the action and on the consequences of the
26 action.

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

33 On the other hand, patients with BD have been shown to present a higher level of trait
34 impulsivity than controls, as measured by the BIS-11 total score, even when euthymic (Etain
35 et al., 2013; Moëller et al., 2001; Swann et al., 2001). In bipolar disorder, our group has
36 shown that impulsivity was higher in patients with a history of mixed states, rapid cycling and
37 substance misuses (Etain et al., 2013) ; impulsivity was also higher in subjects with a
38 predominant depressive polarity, a longer duration of illness, a history of psychotic mood
39 episodes and a history of suicide attempts (Ekinici et al., 2011). When assessed by a
40 behavioral task, the *Continuous Performance Test* (CPT), impulsivity is associated with
41 suicidal attempts as well as with the severity of suicidal attempts in BD patients (Swann et al.,
42 2005).

43 The relationships between suicidality and impulsivity have been studied using different
44 psychometric instruments. Most studies using the “*Urgency, (lack of) Premeditation, (lack of)*
45 *Perseverance, Sensation seeking Scale*” (UPPS, Whiteside and Lynam, 2001) to assess
46 impulsivity consistently demonstrate its links with suicidality (Ammerman et al., 2015;
47 Klonsky and May, 2010; Lynam et al., 2011) ; in contrast, when assessing impulsivity with
48 the BIS, results are inconsistent (Doihara et al., 2012; Etain et al., 2013; Ferraz et al., 2013;

49 Olié et al., 2015; Swann et al., 2005; Wu et al., 2009). These results seem to demonstrate the
50 instable predictive value of the BIS-11 total score.

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

55 **1. AIMS OF THE STUDY**

56 The aims of this study are to check if 1: a two factors structure of the BIS-11, could be
57 assessed in a reliable and reproducible manner in bipolar disorder patients; 2: if this bi-
58 dimensional version has a better predictive value than the classical three factor structure and
59 3: if a specific factorial structure is associated with clinical characteristics of bipolar disorder,
60 such as a history of suicide attempts, mixed states, rapid cycling and substance misuse. These
61 associations could demonstrate the criterion validity of the BIS bi-dimensional version.

62 **2. MATERIALS AND METHODS**

63 **3.1. Clinical samples**

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

70 The protocol of evaluation was approved by the French ethical committee (CPP-Ile de France
71 IX, January 18th, 2010) and has had an authorization of the “Commission Nationale de
72 l’Informatique et des Libertés” (DR-2011-069). Patients have been systematically informed
73 that their data could be used within the frame of scientific studies but, since the measurements
74 were part of immediate care, a written consent was not necessary.

75 Inclusion criteria were : to be 16 years of age or over, being diagnosed with bipolar disorder
76 (type I, II or NOS) as described in the Diagnostic and Statistical Manual of Mental Disorders,
77 4th ed. Text Revised (DSM-IV-TR, American Psychiatric Association, 2000). Patients had to
78 be euthymic and their scores had to be inferior to 8 at the Montgomery and Asberg
79 Depression Rating Scale (MADRS, Montgomery and Asberg, 1979) and inferior to 6 at the
80 Young Mania Rating Scale (YMRS, Young et al., 1978). Other bipolar disorder
81 characteristics (rapid cycling, history of mixed states, etc.) and comorbidity (substance use
82 disorders) were also diagnosed according to DSM-IV-TR.

83 **3.2. Data collection**

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

91 **3.3. Barratt Impulsiveness Scale**

92 The French version of the Barratt Impulsiveness Scale, version 10 (BIS-10) was used, since it
93 is the latest validated version in French to this day (Bayle et al., 2000; Patton et al., 1995).

94 This 10th version comprises 34 items but, in Patton’s analysis (1995), four of the items of the
95 BIS-10 did not meet their criteria to be included in the final version: BIS-11. Therefore, these
96 four items of the BIS-10 were not included in our analysis. The BIS-11 is a thirty items self-
97 report questionnaire which includes nineteen items indicating impulsivity, which are
98 answered on a 4-point scale (“rarely or never” = 1; “occasionally”= 2; “often”= 3; “almost
99 always” = 4) and 11 items indicating non-impulsivity, which are scored in a reverse order
100 (“rarely or never” = 4; ...). The BIS-11 is considered to evaluate three major factors:
101 attentional (8 items), motor (11 items) and non-planning impulsivity (11 items). High scores
102 indicate high levels of the different dimensions of impulsivity.

103 **3.4. Statistical analysis**

104 **3.4.1. Scores and internal consistency coefficients of the BIS-11**

105 The internal consistency of the total score and the three subscores described by Patton et al.
106 (1995) were computed. An alpha reliability coefficient $\geq .70$ was considered as satisfactory,
107 according to Nunnally and Bernstein (1994).

108 **3.4.2. Fit of the original three factor model:**

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

115 As an indication of a fit of a good model, the following indicators were used across this study,
116 based on the Satorra-Bentler χ^2 : the Comparative Fit Index (CFI: cut-off $>.90$), the Tucker-

117 Levis-Index (TLI: cut-off $>.90$), Root Mean Square Error of Approximation (RMSEA: $< .08$
118 for a fair fitting model or $<.05$ for a well-fitting model) and the Weighted Root Mean Square
119 Residual (WRMR, cut-off $< .90$; McDonald, 1999; Yu, 2002). The same statistical criteria
120 (CFI, TLI, RMSEA and WRMR) were used to study the fit of all the other CFA models.

121 **3.4.3. Determination of the best factorial structure of the BIS-11: construction of a new** 122 **scale**

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

129 In the first sample, a series of analysis were performed to select the items which could
130 constitute a better factorial model. First, a hierarchical cluster analysis of the items (with
131 package *Psych*, Revelle, 2014) was performed to study the clusterization of the items. The
132 items used in the following Exploratory Factorial Analysis (EFA) were selected by studying
133 the coefficients of reliability of the different clusters (coefficients alpha and beta $>.70$).
134 Thereafter, an EFA was used to find the best factorial solution: the items with loadings above
135 0.32 on a unique factor after an oblimin rotation were selected (Tabachnick and Fidell, 2001).
136 Afterwards, a CFA was performed to check if the newly defined bi-dimensional structure
137 fitted according to the statistical criteria (CFI, TLI, RMSEA and WRMR).

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

141 **3.4.4. Predictive validity of the new scale for specific clinical variables**

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

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

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

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

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

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

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

165 **3. RESULTS**

166 **4.1. Socio-demographic and clinical variables**

167 The main clinical characteristics of the 580 patients are presented in Table 1. The mean age of
168 patients at interview was 41.4 years (± 12.9 , range 16-86). The median age at onset of illness
169 was 18 years (± 10.7 , range 7 - 66). The proportion of suicide attempters was 36.2 % among
170 the total population, 42.0 % among women and 25.5 % among men. The mean number of past
171 suicide attempts for suicide attempters differed significantly according to gender ($t = 2.74$;
172 $p < .01$): it was higher for women: 2.58 (± 2.87 , range 1-20), than for men: 1.80 ($\pm .98$, range
173 1-5).

174 (Insert Table 1 about here)

175 **4.2. Scores and internal consistency of the BIS-11**

176 On the whole sample (N=580), the mean total score of the BIS-11 was 64.4 (± 10.2 , range
177 42-99, median = 63). The alpha reliability coefficient of the total scale and the original three
178 subscales of the BIS-11 were the following: total score: $\alpha = 0.802$, 95% CI [0.776; 0.824];
179 motor impulsivity: $\alpha = 0.551$, 95% CI [0.484; 0.615]; attentional impulsivity: $\alpha = 0.713$, 95%
180 CI [0.675; 0.753]; non-planning impulsivity: $\alpha = 0.642$, 95% CI [0.590; 0.683]. As observed,
181 only attentional impulsivity and the total score obtained an alpha superior to 0.70.

182 **4.3. Fit of the BIS-11 original factorial structure**

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

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

189 **4.4. Selection of the items constituting reliable dimensions of impulsivity from** 190 **the BIS-11 in the first half of the sample**

191 Step 1: Hierarchical clustering of items

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

196 Step 2: Exploratory Factorial Analysis

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

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

203 (Insert Table 2 about here)

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

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

209 and an excellent fit was obtained: CFI=0.976, TLI=0.969, RMSEA=0.047, 95% CI [0.027;
210 0.064], WRMR=0.771.

211 **4.5. Replication of the newly defined scale's structure in the second half of our** 212 **sample in CFA**

213 The replication of the CFA model, with one free covariance, leads to the following results,
214 which confirm the bi-dimensional factorial structure found in the first half of the sample. A
215 high level fit was obtained: CFI=0.946>0.90, TLI=0.931>0.90, RMSEA 0.076<0.08, 95% CI
216 [0.061-0.091], WRMR=0.987. The standardized covariance between the two factors was
217 significant ($p < 0.001$).

218 Modification indices, which could augment the fit of the model, were checked. A free
219 covariance between residuals of item 8 and item 9 was added. The fit was excellent: CFI =
220 0.981; TLI= 0.976; RMSEA = 0.045, 95% CI [0.025-0.063], WRMR = 0.728<0.90.
221 Therefore, the structure was replicated in the second half of our sample.

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

226 The rating of Reise et al. (2013) was used to compute correlations between their dimensions
227 and our dimensions. The scores at the “cognitive impulsivity” following our rating and at the
228 same dimension following Reise's rating were highly significantly correlated ($r = .96$;
229 $p < .0001$) and the scores at the “behavioral impulsivity” according to our rating and at the
230 same dimension following Reise's rating were equally highly significantly correlated ($r = .85$;
231 $p < .0001$).

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

237 **4.6. Construct validity and clinical utility of the 12 items impulsivity bi-** 238 **dimensional scale**

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

242 **4.6.1. Correlations with residual symptoms:**

243 The scores of these two dimensions (F1 and F2) from the IS-12 correlated significantly with
244 residual depressive symptoms (MADRS, F1: $r = .21$; $p < .001$; F2: $r = .11$; $p < .001$), but only
245 “behavioral impulsivity” was correlated with residual hypomanic symptoms (YMRS, $r = .11$;
246 $p < .01$).

247 **4.6.2. Relationship with presence or absence of rapid cycling and past clinical episodes:**

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

250 **4.6.3. Relationship with suicidal attempts:**

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

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

256 **4.6.4. Substances use disorders:**

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

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

264 (Insert Table 3 about here)

265 **4. DISCUSSION**

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

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

277 scale with only 12 items (named IS-12), aggregating in two dimensions, which we named
278 “cognitive impulsivity” (5 items) and “behavioral impulsivity” (7 items). They correlated
279 highly with the rating of Reise et al. (2013), who proposed these denominations. These two
280 dimensions of impulsivity present a strong content proximity to those regularly described in
281 previous studies (Haden and Shiva, 2009; Ireland and Archer, 2008; Reise et al., 2013).
282 Cognitive impulsivity seems to involve the anticipation of the result of actions and therefore
283 be closer to the concept of “non-planned impulsivity” found in the previous analysis of the
284 BIS-11 (Haden and Shiva, 2009). This cognitive impulsivity dimension comprises the same
285 items as dimension 1 of Reise et al. (2013) except item 7, which did not load significantly in
286 dimension 1 in our study. Behavioral impulsivity seems to be dependent of an excessive
287 sensitivity to present stimuli and is therefore close to “motor impulsivity”, as found by Haden
288 and Shiva (2009). Compared to Reise et al. (2013), the “behavioral impulsivity” dimension
289 shares only 4 items among the 7 proposed by Reise et al., but the dimension “behavioral
290 impulsivity” in Reise et al. and in our study correlated highly. Interestingly, the same two
291 dimensions appeared in Reise’s and our studies, although using different statistical
292 methodologies and different populations (non-clinical in Reise et al. 2013 and clinical in our
293 study). Our psychometrical methodology allowed us to select 12 items among the original
294 thirty, which reliably assess two distinct dimensions of impulsivity. This study highlights,
295 once more, the multidimensional aspect of impulsivity and suggests that a reliable assessment
296 of sub-dimensions of impulsivity is possible and useful. The remaining 18 items of the BIS-
297 11 were discarded from the new scale, since they did not segregate in a coherent separate
298 dimension, nor segregate distinctively between the two dimensions F1 and F2.

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

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

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

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

314 The presence and number of past suicide attempts only correlated with “behavioral
315 impulsivity”. Suicidal behavior, in a sub-group of bipolar patients, could be an impulsive
316 behavior, since behavioral impulsivity has a strong relationship with the immediate
317 psychological condition of the patient. This phenomenon could contribute to explain why
318 suicide is frequent in patients with bipolar disorder. These patients often present two
319 particularly dangerous features when associated: an acute awareness of psychological pain
320 during depression, associated with a general hyper-emotionality (Chan and Tse, 2018; Henry
321 et al., 2013) and a strong tendency to act impulsively (Etain et al., 2013; Olié et al., 2015).
322 These two characteristics (general emotional dysregulation and impulsivity) have been found
323 associated with suicidal behavior in a general population of 2295 students among which were
324 108 past suicidal attempters (Ammerman et al., 2015). Our results confirm the relevance of
325 our new scale, since the original three subscores of the BIS-11 were not associated to

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

329 **5. LIMITATIONS**

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

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

338 **6. STRENGTHS**

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

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

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

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

350 **7. CONCLUSIONS**

351 This study did not support a three factors structure of the BIS-11, as published by Patton et al.
352 (1995). In line with the contributions of Haden and Shiva (2009) and Reise et al. (2013), our
353 results support a structure with two dimensions that we name “cognitive impulsivity” and
354 “behavioral impulsivity”. We present a new twelve items impulsivity scale (IS-12), with the
355 same criterion validity for substance use disorder and better criterion validity for suicidal
356 behavior than the 30 items Barratt Impulsiveness Scale. We demonstrated that the behavioral
357 impulsivity subscale only is related to the presence and number of previous suicidal attempts,
358 thus emphasizing the usefulness of the distinction between cognitive and behavioral
359 impulsivity. Therefore, we recommend that, besides the total score, both sub-scores be
360 analyzed separately in future impulsivity research.

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

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474

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
	Item 26	I often have extraneous thoughts when thinking	0.158	0.433
Items with loading < 0.32 on both dimensions	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	12.79 (± 2.57) b
IS12 Behavioral impulsivity	13.79 (± 3.51) a	14.47 (± 3.88) 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”).