Assessment of impulsivity after moderate to severe traumatic brain injury

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Abstract
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Assessment of impulsivity after moderate to severe traumatic brain injury

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1Cognitive Psychopathology and Neuropsychology Unit, University of Geneva, Switzerland; 2Neurological Reeducation Centre, Versailles-Saint-Quentin University, Garches, France; 3Neuropsychology Unit, Geneva University Hospital, Switzerland; 4Cognitive Psychopathology Unit, University of Liège, Belgium

The aim of the study was to develop and validate a short questionnaire assessing four dimensions of impulsivity (urgency, lack of premeditation, lack of perseverance, sensation seeking) in patients with traumatic brain injury (TBI). To this end, 82 patients with TBI and their caregivers completed a short questionnaire adapted from the UPPS Impulsive Behavior Scale designed to assess impulsivity changes after TBI. Confirmatory factor analyses (CFAs) performed on the version of the scale completed by the relatives revealed that a hierarchical model holding that lack of premeditation and lack of perseverance are facets of a higher order construct (lack of conscientiousness), with urgency and sensation seeking as separate correlated factors, fit the data best. Urgency, lack of premeditation, and lack of perseverance increased after the TBI, whereas sensation seeking decreased. CFA failed to reveal a satisfactory model in the version of the scale completed by the patients. The psychological processes related to these impulsivity changes and the discrepancy observed between self-report and informant-report are discussed. This short questionnaire opens up interesting prospects for better comprehension and assessment of behavioural symptoms of TBI.

**Keywords:** TBI; Impulsivity; Executive functions; UPPS.
INTRODUCTION

Poor impulse control is a common feature in patients with traumatic brain injury (TBI) (Kolitz, Vanderploeg, & Curtiss, 2003; Levin & Kraus, 1994; McAllister, 2008). Impulsive behaviours might result in increased irritability, verbal or physical aggression, loss of temper, impatience and poor decision-making or judgement abilities (McAllister, 2008; Wood, 2001). Consequently, such behaviours have a strong negative impact on rehabilitation processes and more broadly on the social outcomes resulting from the TBI (e.g., interpersonal relationships, professional integration) (Wood, 2001). However, despite the prevalence of these behaviours and their social and economic costs, there is still no valid tool specifically designed to assess impulsivity changes after TBI.

Behaviours considered to be impulsive are heterogeneous. Indeed, some authors have recently underscored the need to consider impulsivity as a multi-faceted construct (Evenden, 1999), and several studies have thus been conducted to investigate its various facets. Among these studies, that by Whiteside and Lynam (2001) sheds light on the multidimensional aspect of impulsivity by using a well-established, comprehensive model of personality: the Five Factor Model (FFM) of personality as assessed by the Revised NEO Personality Inventory (NEO-PI-R; Costa & McCrae, 1992) which measures five broad higher order factors of personality. The central argument of Whiteside and Lynam (2001) is that although some impulsivity traits result in similar overt behaviours (i.e., acting without forethought), their aetiologies may be different. Whiteside and Lynam (2001) administered several widely used measures of impulsivity and the NEO-PI-R to 437 undergraduate students. A factor analysis conducted on these impulsivity scales and on the facets of the NEO-PI-R related to impulsivity resulted in a four-factor solution. The four components of impulsivity they identified were labelled urgency (the tendency to experience strong reactions, frequently under conditions of negative affects); (lack of) premeditation (the tendency to think and reflect on the consequences of an act before engaging in that act); (lack of) perseverance (the ability to remain focused on a task that may be boring or difficult); and sensation seeking (the tendency to enjoy and pursue activities that are exciting, and openness to trying new experiences). Whiteside and Lynam then selected the items with the highest loadings on each factor to create the UPPS Impulsive Behavior Scale. Each of the four factors of impulsivity strongly correlated with a specific factor of the NEO-PI-R. Indeed, urgency was related to the impulsivity facet of neuroticism, lack of premeditation to low scores on the deliberation facet of conscientiousness, and lack of perseverance to low scores on the self-discipline facet of conscientiousness, whereas sensation seeking was related to the excitement-seeking facet of extraversion. This scale appears to have a high internal consistency.
(Whiteside & Lynam, 2001) and some studies support the construct validity of these four impulsivity-related traits (e.g., Whiteside & Lynam, 2001; Whiteside, Lynam, Miller, & Reynolds, 2005). Moreover, by using a semi-structured interview assessment of each of the four factors of impulsivity in addition to the UPPS Impulsive Behavior Scale, Smith et al. (2007) found a clear convergent and discriminant validity among these constructs.

Many studies using this multi-dimensional conception of impulsivity have indicated specific relationships between the four dimensions of impulsivity and several psychopathological states and problematic behaviours. More specifically, urgency has been related to borderline personality disorders (Miller, Flory, Lynam, & Leukefeld, 2003; Whiteside & Lynam, 2003; Whiteside et al., 2005), tobacco craving (Billieux, Van der Linden, & Ceschi, 2007), compulsive buying (Billieux, Rochat, Rebetez, & Van der Linden, 2008), bulimia nervosa (e.g., Claes, Vandesteycken, & Vertommen, 2005), and night-time as well as daytime aspects of insomnia (Schmidt, Gay, & Van der Linden, 2008); lack of premeditation has been closely related to antisocial personality and psychopathic features (Miller et al., 2003; Whiteside & Lynam, 2003; Whiteside et al., 2005); and lack of perseverance may represent an important dimension of predominantly inattentive subtypes of attention-deficit hyperactivity disorder (Miller et al., 2003; Whiteside & Lynam, 2001) and insomnia-related impairments in daytime functioning (Schmidt et al., 2008b). Finally, sensation seeking has been associated with delinquent acts, drug and alcohol use, and risky sexual behaviours (Miller et al., 2003). Furthermore, sensation seeking has been related to the frequency of engaging in risky behaviours, whereas urgency has been specifically associated with problematic levels of engagement in those behaviours (Smith et al., 2007). In addition, the original UPPS Impulsive Behavior Scale has been recently translated and validated in French and in German using a confirmatory factor analysis (CFA) in a sample of undergraduate students (Schmidt, Gay, d’Acremont, & Van der Linden, 2008a; Van der Linden et al., 2006), as well as in a sample of French-speaking adolescents (d’Acremont & Van der Linden, 2005). Moreover, the four-factor structure of a short version of the UPPS Impulsive Behavior Scale, specifically designed to assess impulsivity changes occurring in the course of neurodegenerative diseases, has been confirmed by exploratory factor analysis and CFA in a sample of 82 patients with mild-to-moderate Alzheimer’s disease (AD) (Rochat et al., 2008). More specifically, an increase in urgency, lack of premeditation and lack of perseverance have been highlighted, whereas a decrease in sensation seeking has been observed in the course of the disease (Rochat et al., 2008).

Although poor impulse control is often considered as a core feature of TBI, literature about impulsivity in TBI is scarce. However, several studies have suggested that impulsivity could account for problematic behaviours in patients with TBI. Indeed, a study recently highlighted that self-report
impulsivity assessed by the Barratt Impulsiveness Scale-11 (BIS-11; Patton, Stanford, & Barratt, 1995), a scale containing three impulsivity factors (non-planning, motor and attentional impulsivity), was higher in patients with TBI than in control participants (McHugh & Wood, 2008). More specifically, by using a temporal discounting task, it has been found that (1) the value of rewards decreased more steeply in patients with TBI than in control participants when the delay to obtain the reward increased and (2) impulsivity was related to a preference for a smaller reward that could be obtained immediately rather than a larger reward that could be obtained after a delay (McHugh & Wood, 2008). Another study designed to assess the personality traits and cognitive deficits underlying impulsive aggression in patients with TBI highlighted that patients described as impulsive-aggressive had a higher self-reported impulsivity (assessed by the BIS-11, Patton et al., 1995) than did non-impulsive, aggressive patients with TBI (Greve et al., 2001). However, the two groups of patients with TBI did not differ on the neurocognitive measures designed to assess executive functioning. Finally, Votruba et al. (2008) highlighted that in vivo verbal impulsivity was best predicted by a rating scale of impulsivity completed by the patients’ therapists (the Impulsivity Rating Scale; Lecrubier, Braconnier, Said, & Payan, 1995), whereas in vivo motor impulsivity was best predicted by a performance measure of impulsivity (the Trail Making Test part B completion time; Reitan & Wolfson, 1985).

Although these studies shed light on impulsive behaviours in patients with TBI, a valid tool based on a comprehensive theoretical framework and specifically designed to assess the multidimensional aspects of impulsivity after TBI is still lacking. In a recent review discussing issues surrounding the assessment and comprehension of behavioural disorders after acquired brain injury, Wood, Alderman, and Williams (2008) highlighted several relevant points to address when measuring neurobehavioural disorders, in particular, (1) using a clear theoretical and conceptual framework, (2) taking into account the pre-morbid level of functioning, (3) using a target population to assess the psychometric properties of the tool, (4) using Likert-type rating scales to adequately quantify patient behaviours, and (5) not only relying on the patients’ point of view, but also on the caregivers’ ratings because patients’ anosognosia could constitute a threat to validity.

In accord with the recommendations by Wood et al. (2008), the objectives of the current study are to develop and evaluate the factor structure and internal reliability of a short questionnaire adapted from the French version of the UPPS Impulsive Behavior Scale specifically designed to assess impulsivity changes in patients with TBI. We assume that the theoretical framework developed by Whiteside and Lynam (2001) considering four distinct facets of impulsivity should enable a better comprehension of impulsive-related behaviours after the occurrence of a TBI.
METHOD

Participants

A convenience sample of 82 adults with TBI (67 men, 15 women) between 18 and 64 years of age ($M = 37.44$, $SD = 13.45$) was recruited from four outpatient clinics in Switzerland and France. No formal cognitive criteria were used to assess the severity of cognitive disturbances. Only participants for whom a significant other could provide information about the patient’s current and pre-morbid behaviours were included in the study, and both patients and relatives spoke French fluently. Among the relatives who completed the questionnaire, 43.2% were spouses/husbands, 40.24% were parents, 3.66% were adult children, and the remaining 9.76% were siblings. Patients’ years of schooling varied from 8 to 24 ($M = 13.43$, $SD = 3.07$), and time since the onset of the TBI ranged from 5 to 283 months ($M = 44.94$, $SD = 42.99$). The patients had moderate to very severe TBI (Mazaux & Joseph, 2000), with the duration of post-traumatic amnesia (PTA) ranging from 0.5 to 120 days ($M = 47.83$, $SD = 42.49$). PTA duration was estimated retrospectively by questioning each patient about his or her first post-injury memories to identify the point of return of continuous memory. This result was corroborated by additional information available from the hospital notes (e.g., dated entries documenting disorientation) and/or from a close relative. Exclusion criteria were any history of pre-morbid psychiatric or neurological disease. The study was approved by the local ethical committee, and informed consent was obtained for each patient.

Procedure

All the patients and one of their close relatives were given a short version of the UPPS Impulsive Behavior Scale specifically designed to assess impulsivity changes after TBI. On the basis of the French version of this questionnaire (Van der Linden et al., 2006), we selected the four items that loaded most strongly on each of the four factors of this scale. Thus, this short version of the UPPS Impulsive Behavior Scale contains 16 items (4 per factor). These items were then adapted and transformed so that patients and their relatives could assess impulsive behaviours both at the pre-morbid and at the current level on a 4-point Likert scale (from 1 “almost never” to 4 “almost always”). The four impulsivity-related factors are labelled urgency (e.g., “When he/she is upset, he/she acts without thinking”), lack of premeditation (e.g., “He/she thinks carefully before doing anything”), lack of perseverance (e.g., “He/she likes to see things through to the end”) and sensation seeking (e.g., “He/she likes doing things that are a bit frightening”). Two scores are then computed for each factor, a pre-morbid and a current score of impulsivity.
Note that the scoring for items referring to lack of premeditation and lack of perseverance is reversed (see questionnaire, Appendix). Higher scores indicate higher impulsivity.

Data analysis

To determine the factor structure of the short form of the UPPS Impulsive Behavior Scale for both the self-report and the version completed by the relatives, we computed CFAs with Mplus (Muthén & Muthén, 2006) on the current scores of impulsivity. CFA was performed instead of exploratory factor analysis because CFA allows the testing of a priori specific hypotheses about the factor structure of the scale. Thus, to investigate the factor structure of the short form of the UPPS Impulsive Behavior Scale in patients with TBI, we compared four different models which considered the relationships among the four components of impulsivity. The first model holds that there is a single, unitary impulsivity construct. The second model identifies four inter-related impulsivity constructs. Indeed, prior studies using the UPPS Impulsivity Behavior Scale in young adults from the community (Schmidt et al., 2008a; Van der Linden et al., 2006) and adolescents (d’Acremont & Van der Linden, 2005), or using a short form of this scale designed to assess impulsivity changes in AD (Rochat et al., 2008), highlighted that a four inter-correlated factor solution fit the data best. However, according to Whiteside and Lynam (2001), (lack of) premeditation and (lack of) perseverance are both related to the higher order personality factor “conscientiousness” defined in the FFM (Costa & McCrae, 1992), and therefore two additional models were tested. The third model recognises three inter-related factors, namely, urgency, sensation seeking and lack of conscientiousness (a single factor represented by the items referring to the lack of premeditation and lack of perseverance facets). Smith et al. (2007) recently showed that a hierarchical model holding that lack of premeditation and lack of perseverance are separate from each other, yet loaded on a common factor which is distinct from urgency and sensation seeking factors, fit the data best. Therefore, according to Smith et al. (2007), the fourth model identifies lack of premeditation and lack of perseverance as two distinct factors loading both on a higher order factor called lack of conscientiousness, whereas urgency and sensation seeking are separate constructs.

Goodness of fit was tested with the $\chi^2$ (a non-significant value corresponds to an acceptable fit). However, $\chi^2$ is known to increase with sample size, and some authors have noticed that it is unusual to obtain non-significant $\chi^2$ values when performing CFAs on self-report questionnaires (Byrne, 1994). Consequently, in addition to $\chi^2$, two other indices that depend on a conventional cut-off were also computed: the root mean square error of approximation (RMSEA) and the standardised root mean square residual (SRMR)
(Hu & Bentler, 1999). The combination of these two indices is valuable because the RMSEA is sensitive to the misspecification of the factor “loadings” and the SRMR is sensitive to the misspecification of the factor “covariances”. An RMSEA of between 0 and 0.05 indicates a good fit, and between 0.05 and 0.08 an acceptable fit. An SRMR of between 0 and 0.05 indicates a good fit, and between 0.05 and 0.10 an acceptable fit (Schermelleh-Engel, Moosbrugger, & Müller, 2003). We also reported the Comparative Fit Index (CFI). A CFI > .90 is generally interpreted as indicating an acceptable fit.

Note that the same statistical procedure was used to analyse the factor structure of both versions of the scale, the one completed by the patients themselves and the other completed by their relatives. In addition, repeated-measure multivariate analyses of variance (MANOVAs) were performed on the four dimensions of impulsivity to appraise the changes between the pre-morbid and the current scores and to compare self versus informants’ ratings. Furthermore, in order to investigate the inter-observer agreement on individual differences within the group, we computed correlations between the self-report and relative-report scores on each subscale for pre-morbid ratings, current ratings, and change scores.

RESULTS

Relatives’ assessment of impulsivity

Of the 82 patients, 3 had one item or more with missing values. The Cronbach’s alphas calculated for participants with no missing values were .83 for urgency, .91 for lack of premeditation, .92 for lack of perseverance and .73 for sensation seeking for the current level of impulsivity. These indices indicate that all four subscales have acceptable to very good internal reliability.

CFA was then computed on the 16 items related to the current level of impulsivity. Four models differing in the way they consider the relationships between the four constructs of impulsivity were compared (Figures 1 and 2). Absolute fit indices of the four models tested are summarised in Table 1. First, the results showed that the one-factor model in which all the items loaded on a single, unique latent factor (Figure 1, model 1) fit the data poorly. Therefore, these data do not support a unidimensional construct of impulsivity in patients with TBI. Second, as in previous research (e.g., Rochat et al., 2008), the model with four distinct but related factors of impulsivity (Figure 1, model 2) had an acceptable fit. Third, the three-factor model (Figure 2, model 3), holding that lack of premeditation and lack of perseverance loaded on one factor called lack of conscientiousness, fit the data poorly. Fourth, the hierarchical model (Figure 2, model 4), assuming that lack of premeditation and lack of perseverance are two distinct facets of an overall low
conscientiousness factor, with urgency and sensation seeking as separate factors, also had an acceptable fit. The fit indices of this model are far superior to those of the three-factor model (model 3). On the whole, model 2 and model 4 both had an acceptable fit. However, model 4 is slightly more parsimonious (this model specifies less covariance between the factors) than model 2. Furthermore, by more precisely taking into account the NEO-PI-R framework underlying the four dimensions of impulsivity, model 4 is able to account for the strong relationship between lack of premeditation and lack of perseverance dimensions (.77, see Figure 2, model 3). On the basis of these theoretical and statistical considerations, model 4 can thus be retained.

Figure 1. Unique factor and four distinct factor models of impulsivity. The top panel depicts the one-factor model in which all the items load on a single, unique latent factor of impulsivity (model 1). The bottom panel depicts the four-factor model identifying four inter-related impulsivity constructs, namely, urgency (U), sensation seeking (SS), lack of perseverance (Lpers) and lack of premeditation (Lprem) (model 2). Circles reflect latent variables and squares reflect manifest variables. Curved arrows reflect correlations between the latent variables, whereas straight arrows reflect factor loadings. All factor loadings are statistically significant at $p < .001$, except item 8 which is significant at $p < .05$ in the bottom panel. Furthermore, items 2, 8 and 12 in the top panel are not significant. All factor intercorrelations are significant (at $p < .05$), except the correlation between sensation seeking and urgency in the bottom panel. For ease of presentation, error variances are not presented.
Figure 2. Factors model of urgency, sensation seeking and low conscientiousness. The top panel depicts a three-factor model in which lack of premeditation (Lprem) and lack of perseverance (Lpers) represent a unique, single factor called lack of conscientiousness (L consc) (model 3). The bottom panel depicts a model in which lack of premeditation and lack of perseverance depend on a common, higher order construct which refers to lack of conscientiousness (L consc), whereas urgency (U) and sensation seeking (SS) are separate constructs (model 4). Circles reflect latent variables and squares reflect manifest variables. Curved arrows reflect correlations between the latent variables, whereas straight arrows reflect factor loadings. All factor loadings are statistically significant at \( p < .001 \), except item 8 which is significant at \( p < .01 \) in both the top and the bottom panels. All factor intercorrelations are significant at \( p < .05 \), except the correlation between sensation seeking and urgency which is not significant in both models. For ease of presentation, error variances are not presented.

### TABLE 1

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>( \chi^2 )</th>
<th>RMSEA (90% CI)</th>
<th>SRMR</th>
<th>CFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>104</td>
<td>342.74**</td>
<td>0.167 (0.148, 0.187)</td>
<td>0.123</td>
<td>0.686</td>
</tr>
<tr>
<td>Model 2</td>
<td>98</td>
<td>149.65**</td>
<td>0.080 (0.053, 0.105)</td>
<td>0.074</td>
<td>0.932</td>
</tr>
<tr>
<td>Model 3</td>
<td>101</td>
<td>214.26**</td>
<td>0.117 (0.095, 0.139)</td>
<td>0.079</td>
<td>0.851</td>
</tr>
<tr>
<td>Model 4</td>
<td>99</td>
<td>150.02**</td>
<td>0.079 (0.052, 0.104)</td>
<td>0.075</td>
<td>0.933</td>
</tr>
</tbody>
</table>

**\( p < .001 \).
The same statistical procedure was used to analyse the factor structure of the scale completed by the patients with TBI. Of the 82 patients, none had missing data. The Cronbach’s alphas were .82 for urgency, .67 for lack of premeditation, .86 for lack of perseverance and .84 for sensation seeking. Although slightly lower than the Cronbach’s alpha observed for the scale completed by the relatives, these indices indicate that all the subscales have good internal reliability, except for a lack of premeditation dimension which shows a lower internal consistency. Contrary to the results obtained with the version of the scale completed by the patients’ relatives, CFA highlighted that the models, including one global impulsivity factor (model 1), four inter-related factors of impulsivity (model 2), and the three-factor model (model 3) or the hierarchical model (model 4) did not fit the data according to criteria developed by Hu and Bentler (1999) (Table 2).

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>$\chi^2$</th>
<th>RMSEA (90% CI)</th>
<th>SRMR</th>
<th>CFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>104</td>
<td>464.27**</td>
<td>0.206 (0.187, 0.225)</td>
<td>0.172</td>
<td>0.416</td>
</tr>
<tr>
<td>Model 2</td>
<td>98</td>
<td>210.67**</td>
<td>0.118 (0.096, 0.140)</td>
<td>0.097</td>
<td>0.817</td>
</tr>
<tr>
<td>Model 3</td>
<td>101</td>
<td>238.93**</td>
<td>0.129 (0.108, 0.150)</td>
<td>0.103</td>
<td>0.777</td>
</tr>
<tr>
<td>Model 4</td>
<td>99</td>
<td>213.86**</td>
<td>0.119 (0.097, 0.141)</td>
<td>0.096</td>
<td>0.814</td>
</tr>
</tbody>
</table>

**p < .0001.

Patients’ assessment of impulsivity

The same statistical procedure was used to analyse the factor structure of the scale completed by the patients with TBI. Of the 82 patients, none had missing data. The Cronbach’s alphas were .82 for urgency, .67 for lack of premeditation, .86 for lack of perseverance and .84 for sensation seeking. Although slightly lower than the Cronbach’s alpha observed for the scale completed by the relatives, these indices indicate that all the subscales have good internal reliability, except for a lack of premeditation dimension which shows a lower internal consistency. Contrary to the results obtained with the version of the scale completed by the patients’ relatives, CFA highlighted that the models, including one global impulsivity factor (model 1), four inter-related factors of impulsivity (model 2), and the three-factor model (model 3) or the hierarchical model (model 4) did not fit the data according to criteria developed by Hu and Bentler (1999) (Table 2).

Patients’ versus informants’ ratings

In order to compare self and other ratings on the pre-injury and the current presentations, we performed a 2 (raters: patients vs. informants) × 2 (condition: pre-injury vs. current) repeated-measure MANOVA on the four dimensions of impulsivity. Note that the factor “raters” was considered as a within-subject factor. The analyses revealed a significant main effect of raters, $F(4, 74) = 4.59$, $p < .01$, $\eta^2 = .20$, and condition, $F(4, 74) = 32.42$, $p < .0001$, $\eta^2 = .64$, as well as a significant raters × condition interaction, $F(4, 74) = 4.91$, $p < .01$, $\eta^2 = .19$.

A series of post-hoc Bonferroni comparison tests yielded the following findings:

- Informants’ ratings indicated that from pre- to post-injury, patients showed significant increases in urgency, lack of premeditation, and lack of perseverance, and a significant decrease in sensation seeking (all $ps < .001$);
Patients’ self-ratings of changes in the various subtraits paralleled those of the informants, except that they did not perceive premeditation to change \((p = .99; \text{for all other subtraits, } p < .001)\);

Patients’ and informants’ ratings did not significantly differ from each other at the pre-injury level on the four dimensions of impulsivity (all \(ps > .05)\);

Informants’ ratings are significantly higher than patients’ on the current level of impulsivity for lack of premeditation \((p < .001)\), lack of perseverance \((p < .01)\), and sensation seeking \((p < .05)\). However, no significant difference was found for current urgency \((p = .97)\).

Finally, a repeated-measure MANOVA with raters as a within-subject factor performed on the four impulsivity change scores revealed a significant effect of raters, \(F(4, 74) = 4.21, p < .01, \eta^2 = .19\). Post hoc Bonferroni tests showed significant differences for lack of premeditation \((p < .01)\), lack of perseverance \((p < .01)\), and sensation seeking dimensions \((p < .05)\), indicating that impulsivity changes are higher on the informant than on the self-report version of the scale for these factors. No significant difference was found for urgency (see Table 3 for the raw scores).

In addition, in order to investigate the inter-observer agreement on individual differences within the group, we computed correlations between the self-report and relative-report scores on each subscale for pre-morbid ratings, current ratings, and change scores. Note that we used Bonferroni corrections in order to control for type I error. Consequently, the \(\alpha\) level was set to .0042.

**TABLE 3**

Means (SDs) of the pre-morbid level, the current level and the change scores of impulsivity for the informant and the self-report version of the scale

<table>
<thead>
<tr>
<th>Scale</th>
<th>Pre-morbid M (SD)</th>
<th>Current M (SD)</th>
<th>Change M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urgency</td>
<td>7.17 (2.56)</td>
<td>9.59 (3.29)</td>
<td>2.42 (3.62)</td>
</tr>
<tr>
<td>Lack of premeditation</td>
<td>8.15 (3.33)</td>
<td>10.22 (3.39)</td>
<td>2.07 (4.32)</td>
</tr>
<tr>
<td>Lack of perseverance</td>
<td>6.35 (2.75)</td>
<td>9.89 (3.64)</td>
<td>3.54 (4.33)</td>
</tr>
<tr>
<td>Sensation seeking</td>
<td>9.81 (3.26)</td>
<td>6.93 (2.32)</td>
<td>-2.88 (3.00)</td>
</tr>
<tr>
<td>Self-report</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urgency</td>
<td>7.06 (1.86)</td>
<td>9.55 (3.36)</td>
<td>2.49 (3.89)</td>
</tr>
<tr>
<td>Lack of premeditation</td>
<td>8.20 (2.73)</td>
<td>8.38 (2.70)</td>
<td>0.18 (4.06)</td>
</tr>
<tr>
<td>Lack of perseverance</td>
<td>5.99 (2.22)</td>
<td>8.10 (3.18)</td>
<td>2.11 (4.14)</td>
</tr>
<tr>
<td>Sensation seeking</td>
<td>10.12 (3.15)</td>
<td>8.38 (3.51)</td>
<td>-1.74 (3.57)</td>
</tr>
</tbody>
</table>
The results of these analyses emphasised an inter-observer agreement for sensation seeking ($r = .46, p < .001$) at the pre-injury level, for urgency, lack of perseverance, and sensation seeking ($r = .35, .41, \text{ and } .38$, respectively, all $ps < .003$) at the current level and for lack of perseverance ($r = .45, p < .001$) on the change scores. No other correlation reached statistical significance.

Finally, because one can argue that the redundancy in the wording of some of the items might engender over-inflated reliability scores (Cronbach’s alpha) or CFA model fit statistics, we re-ran the CFA, taking into account only three items per factor. More specifically, we excluded one item per factor that could be considered as too redundant when used with other items belonging to the same factor. The item that most strongly correlated with the other items within each factor was considered redundant. The results showed that item 3 (urgency), item 16 (lack of premeditation), item 9 (lack of perseverance), and item 15 (sensation seeking) are the more redundant items and were thus excluded from the subsequent analyses. As described earlier, we compared four different models that considered the relationships among the four components of impulsivity. The results of the CFAs conducted with this 12-item questionnaire are very similar to those obtained with the 16-item version of the scale. More specifically, the hierarchical model holding that lack of premeditation and lack of perseverance are facets of a higher order construct (lack of conscientiousness), with urgency and sensation seeking as separate correlated factors, fit the data best ($\chi^2 = 86.19, p < .001; \text{RMSEA} = 0.096; \text{SRMR} = 0.068; \text{CFI} = 0.903$). Furthermore, the internal consistencies (Cronbach’s alpha) are also very similar (although slightly lower) to those obtained with the 16-item scale (urgency: .79; lack of premeditation: .88; lack of perseverance: .87; sensation seeking: .67). These results showed that after the exclusion of hypothetically redundant items, the hierarchical model still fit the data best. Of note, the RMSEA (0.096) of this model is slightly higher than that in the 16-item version of the scale (0.079) and corresponds to a marginal fit (see Browne & Cudeck, 1993).

**DISCUSSION**

As a first step towards a better understanding of impulsivity in patients with moderate-to-severe TBI, we developed a short version of the UPPS Impulsive Behavior Scale designed to assess impulsivity changes on four distinct dimensions of impulsivity, namely, urgency, lack of premeditation, lack of perseverance, and sensation seeking. First, the results highlighted that the multifaceted nature of impulsivity was confirmed in a sample of patients with TBI by using the scale completed by the patients’ relatives. More specifically, the hierarchical model holding that lack of premeditation and lack of
perseverance are facets of a higher order construct (lack of conscientiousness), with urgency and sensation seeking as separate correlated factors, fit the data best. Second, the short form of the UPPS questionnaire completed by the relatives possesses satisfying internal reliability. Third, a significant increase of impulsivity from the pre-morbid condition was observed on three of the four dimensions of the UPPS (urgency, lack of perseverance, and lack of premeditation), whereas a decrease was observed in the sensation seeking dimension (for similar results in patients with AD, see Rochat et al., 2008). Fourth, CFA failed to reveal a satisfactory model in the version of the scale completed by the patients. Fifth, the results highlighted that patients and relatives are in close agreement on their ratings of the patients’ pre-morbid presentation but differed on the current condition for lack of premeditation, lack of perseverance, and sensation seeking. On the whole, by emphasising the necessity to consider four distinct impulsivity-related traits instead of one or three traits, these results open up interesting prospects for a better comprehension and assessment of impulsive-related disorders frequently described after TBI. In addition, this multidimensional approach to impulsivity within brain-injured groups has the potential to provide valuable insights into the nature of brain systems and cognitive processes underlying impulsiveness in neurologically intact individuals. Questions that remain to be considered are (1) the specific processes that may have led to the impulsivity changes observed in patients with TBI and (2) the reasons that CFA performed on the self-report version of the questionnaire indicated that no models fit the data.

Some authors have recently proposed relating the various facets of impulsivity to specific cognitive processes, such as inhibition of prepotent responses (for urgency), resistance to proactive interference in working memory and sustained attention (for perseverance), and decision-making ability (for premeditation) (see Bechara & Van der Linden, 2005; Gay, Rochat, Billieux, d’Acremont, & Van der Linden, 2008; Whiteside & Lynam, 2001; Zermatten, Van der Linden, d’Acremont, Jermann, & Bechara, 2005). In this perspective, the increase in impulsivity observed on the urgency, lack of premeditation and lack of perseverance dimensions in patients with TBI is congruent with the inhibition of pre-potent responses (Roche et al., 2004), sustained attention (Dockree et al., 2004), decision-making processes (Levine et al., 2005), planning (Fortin, Godbout, & Braun, 2003) and working memory (e.g., Vallat-Azouvi, Weber, Legrand, & Azouvi, 2007) deficits observed after TBI. In the same vein, a recent study highlighted that poor multitasking performances had been specifically related to the occurrence of externalising behaviours in a sample of patients with TBI (Rochat, Ammann, Mayer, Annoni, & Van der Linden, 2009), suggesting that it might be particularly relevant to consider specific executive processes to better understand neurobehavioural disorders after TBI. In this context, the theoretical framework surrounding the
multidimensional components of impulsivity (e.g., Bechara & Van der Linden, 2005) is of particular interest in order to disentangle the specific cognitive processes that could account for the various neurobehavioural changes frequently described after TBI.

Moreover, the decrease observed on the sensation seeking dimension is worth comment. Indeed, this result is congruent with the drive and motivation disorders that are quite common after TBI (Wood, 2001). Tentatively, a disruption in the “circuitry of reward” due to TBI could account for the presence of apathy (McAllister, 2008), generally defined as a reduction of goal-related behaviours (Levy & Dubois, 2005). It may thus be hypothesised that apathy leads to a lack of motivation to pursue activities that are exciting or risky. Further studies are thus needed to investigate the relationships between apathy and sensation seeking in patients with TBI.

According to Wood et al. (2008), lack of insight/self-awareness might constitute a threat to the validity of questionnaires completed by the patients, which could explain why CFAs failed to reveal any satisfactory model in the self-report version of the scale. Indeed, lack of insight/self-awareness is frequently described after TBI, in particular in patients with executive disturbances (e.g., Bivona et al., 2008). Interestingly, although the correlation analysis indicated that there is some inter-observer agreement on individual differences within the group, self-report versus informant-report comparisons showed that patients tend to underestimate their impulsivity. More specifically, the results highlighted that patients and relatives are in close agreement on their ratings of the patients’ pre-morbid presentation. However, patients and relatives differ on the current condition for lack of premeditation, lack of perseverance, and sensation seeking, but not for urgency. Thus, whatever cognitive impairments may characterise the patients, these impairments do not compromise the patients’ ability to give ratings of their pre-morbid functioning. Consequently, patients’ underestimation of their current impulsivity (except for urgency) and impulsivity change scores might reflect a lack of insight/self-awareness rather than a more basic ability to understand the questions or give meaningful responses. On the whole, these data are in accordance with previous studies highlighting that caregivers reported a higher frequency of dysexecutive syndrome behaviours in patients with TBI (e.g., Marsh & Kersel, 2006).

However, although patients’ lack of insight/self-awareness might somehow constitute a threat to the validity of a self-report questionnaire, we do not assume that relatives’ ratings represent a reliable gold standard to assess behavioural changes in persons with TBI. Indeed, it could be argued that informants’ judgements might be biased for various reasons. First, because relatives have a rather limited insight into any given individual’s preferences and cognitive/affective processes, there might be a poor inter-observer agreement on individual differences in both brain-damaged and healthy persons.
Therefore, in order to explore whether there is a general agreement/disagreement between self- and other-ratings on the UPPS Impulsive Behavior Scale, further studies should specifically investigate this question in healthy populations. Second, relatives’ social role and reactions (e.g., stress) toward the changes provoked by the TBI (Weddell & Legget, 2006), personality traits (e.g., neuroticism, see McKinley & Brooks, 1984) or specific coping strategies such as denial, might also constitute a source of biased judgements. Consequently, the optimal way to assess behavioural changes in patients with brain damage probably lies in combining different assessment techniques, such as questionnaires, semi-structured interviews, and in vivo observations, to evaluate various traits or problematic behaviours (e.g., multi trait-multimethod assessment).

Finally, although lack of premeditation and lack of perseverance are related to a higher order factor (low conscientiousness), the clinical assessment of impulsivity should focus on the distinction of four impulsivity traits rather than on only three distinct traits for at least two reasons. First, the model considering three dimensions of impulsivity (urgency, low conscientiousness, and sensation seeking; model 3) fit the data poorly. Second, lack of premeditation and lack of perseverance are predictors of specific problematic or risky behaviours (e.g., lack of premeditation, increased risk for binge eating and problem gambling, whereas lack of perseverance did not; see, e.g., Smith et al., 2007). In addition, Whiteside and Lynam (2001) previously showed that lack of premeditation and lack of perseverance are strongly related to specific subcomponents of a larger personality trait (lack of conscientiousness), namely, lack of self-discipline (for lack of perseverance) and low deliberation (for lack of premeditation). According to this theoretical rationale, Smith et al. (2007) found in a large sample of young adults that the hierarchical model (model 4) described earlier fit the data best. In this context, we are confident that each subscale of the questionnaire refers to specific content and that the belonging of lack of premeditation and lack of perseverance to a higher order factor reflects an underlying conceptual reality instead of a byproduct that is due, for instance, to the similar wording of some items.

To sum up, the present results suggest that the multifaceted approach to impulsivity, taking into account various dimensions of impulsivity, could be of interest in understanding the neurobehavioural symptoms occurring after TBI. Of note, clinicians or researchers might use either the 12-item or the 16-item version of the scale because both questionnaires have appropriate factor structure and internal consistency. Furthermore, identifying which component of impulsivity is associated with specific problematic behaviours in patients with TBI could help clinicians design tailored rehabilitation programmes that address challenging behaviours often described in these patients. In this perspective, rehabilitation should focus on the
impulsivity-related processes that might be specifically impaired in patients with TBI, such as difficulties in the inhibition of prepotent responses related to urgency, decision-making or planning abilities related to lack of premeditation or problems resisting intrusive thoughts related to lack of perseverance. However, further studies are needed to explore the concurrent and predictive validity, and test-retest reliability of this new scale. Moreover, the relationships between the changes observed on each of the four dimensions and specific cognitive and motivational processes should be explored by using specific laboratory tasks. Finally, an integrative account of impulsivity changes after TBI should also consider both the specific processes involved in each dimension of impulsivity and the location of lesions.

REFERENCES


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APPENDIX

Sixteen items of the short version of the UPPS impulsive Behavior Scale (French/English)

Urgency

3. *Quand il (elle) est contrarié(e), il (elle) agit sans réfléchir*/ When he (she) is upset, he (she) acts without thinking.
5. *Il (elle) aggrave les choses parce qu’il (elle) agit sans réfléchir quand il (elle) est contrarié(e)*/ He (she) make matters worse because he (she) acts without thinking when he (she) is upset.
10. *Quand la discussion s’échauffe, il (elle) dit des choses qu’il (elle) regrette ensuite*/ In the heat of an argument, he (she) will say things that he (she) later regrets.
13. *Il (elle) fait des choses sur un coup de tête qu’il (elle) regrette par la suite*/ He (she) does things on impulse that he (she) later regrets.

(Lack of) premeditation

1. *Il (elle) réfléchit soigneusement avant de faire quoi que ce soit*/ He (she) thinks carefully before doing anything.
6. *Sa manière de penser est réfléchie et méticuleuse*/ His (her) thinking is careful and purposeful.
11. *Il (elle) se décide après un raisonnement bien mûri*/ He (she) makes up his (her) mind through careful reasoning.
16. *Avant de se décider, il (elle) considère tous les avantages et inconvénients*/ Before making up his (her) mind, he (she) considers all the advantages and disadvantages.

(Lack of) perseverance

4. *Il (elle) préfère mener les choses jusqu’au bout*/ He (she) likes to see things through to the end.
7. *Il (elle) achève ce qu’il (elle) commence*/ He (she) finishes what he (she) starts.
9. *Une fois qu’il (elle) commence un projet, il (elle) le termine*/ Once he (she) starts a project, he (she) finishes it.
14. *Il (elle) est productif(ve) et termine toujours son travail*/ He (she) is a productive person who always gets the job done.

Sensation seeking

2. *Il (elle) aime faire des choses qui sont un petit peu effrayantes*/ He (she) likes doing things that are a bit frightening.
8. *Il (elle) éprouve du plaisir à prendre des risques*/ He (she) quite enjoys taking risks.

12. *Il (elle) recherche des expériences et sensations nouvelles et excitantes*/ He (she) seeks new and exciting experiences and sensations.

15. *Il (elle) se réjouit des expériences et sensations nouvelles même si elles sont un petit peu effrayantes et non-conformistes*/ He (she) welcomes new and exciting experiences and sensations, even if they are a little frightening and unconventional.