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Factor structure and psychometric properties of a French and German shortened version of the
Behavioural Inhibition System/Behavioural Activation System scales

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Short title: French and German version of the BIS/BAS scales

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Abstract

The Behavioural Inhibition System/Behavioural Activation System scales (BIS/BAS scales) constitute one of the most prominent questionnaires to assess individual differences in sensitivity to punishment and reward. However, some studies questioned its validity, especially that of the French and German translations. The aim of the present study was to re-evaluate the psychometric characteristics of the BIS/BAS scales in a large sample of French- and German-speaking young Swiss men (N=5,872). Results showed that factor structures previously found in the literature did not meet the standards of fit. Nine items had to be removed to achieve adequate fit statistics in confirmatory factor analysis, yielding a shortened version with four factors: one BIS factor comprising five items and three BAS factors, namely Reward Reactivity, Drive and Fun Seeking, each comprising two items. Convergent validity and group invariance analyses suggest that the shortened BIS/BAS scales constitute a valid and reliable instrument. Researchers interested in assessing individual differences in BIS and BAS reactivity in French- and German-speaking individuals should avoid using the BIS/BAS scales as originally specified. The shortened version may be a sound alternative at least in samples of young adults. Its shorter format may be particularly suited for surveys with constraints on questionnaire length.

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Introduction

Personality is rooted in a long evolutionary process and reflects the expression of different biologically-based systems that govern individuals' sensitivity to positive and negative stimuli (Eysenck, 1990; Gray, 1982). One of the most important theories of personality is the Reinforcement Sensitivity Theory (RST; Gray, 1982, 1987). In its original formulation, three motivational brain systems, namely the Behavioural Activation System (BAS), the Behavioural Inhibition System (BIS) and the Fight-Flight System (FFS) were thought to support sensitivity to positive and negative stimuli. BAS was hypothesized to mediate reactions to both conditioned and unconditioned appetitive stimuli, and to underpin anticipation of pleasure and approach behaviours. BIS was thought to control avoidance of conditioned aversive stimuli and high intensity or novel stimuli and to relate to anxiety, fear, sadness and frustration (Corr and McNaughton, 2008). FFS was assumed to mediate reactions of rage and panic in response to unconditioned aversive stimuli and to be associated with defensive aggression (fight) or escape response (flight) (Heym et al., 2008).

In the most recent version, Gray and McNaughton (2000) proposed a revised model of RST (rRST). The conceptualisation of BAS remained unchanged. However, freeze response was incorporated to the FFS, renamed as Fight/Flight/Freeze system (FFFS). In rRST, FFFS is assumed to mediate reactions to both conditioned and unconditioned aversive stimuli and is responsible for the detection of threats, and the avoidance and escape behaviours. Finally, the BIS is thought to mediate the detection and resolution of goal conflicts, e.g. competing reward and punishment cues (Corr et al., 2013). For example, alcohol cues may activate a conflict between the desire to drink alcohol because of its positive reinforcement properties (activation of BAS) and the fear of the negative consequences of alcohol use (activation of FFFS). Activation

of BIS raises attention to the potential dangers or desirable outcomes of a behaviour, resulting in enhanced anxiety and rumination, until conflict resolution occurs in favour of approach or avoidance (Corr and McNaughton, 2008; Gray and McNaughton, 2000).

Individual differences in reactivity of the BAS, FFFS and BIS are thought to underlie differences in personality. In particular, studies showed that BAS reactivity was associated with extraversion, impulsivity, sensation seeking, anger and hostility, FFFS reactivity with neuroticism and fearfulness, whereas BIS reactivity was associated with worry proneness, neuroticism and anxiety (Beck et al., 2009; Corr and McNaughton, 2008; Dissabandara et al., 2011; Harmon-Jones, 2003; Keiser and Ross, 2011; Quilty and Oakman, 2004; Segarra et al., 2014). Moreover, RST systems are also particularly helpful to understand and explain a broad range of psychopathologies (see Bijttebier et al., 2009, for review). For example, substance abuse was found to be significantly associated with high BAS sensitivity (Franken and Muris, 2006; Johnson et al., 2003), whereas depression was associated with high BIS and low BAS sensitivity (Campbell-Sills et al., 2004; Kasch et al., 2002; McFarland et al., 2006).

Several self-report questionnaires have been developed to assess individual differences in RST systems. One of the most commonly used is the Behavioural Activation System / Behavioural Inhibition System scales (BIS/BAS scales; Carver and White, 1994). BIS/BAS scales were not developed to assess FFS/FFFS reactivity, they only measure BIS and BAS reactivity as depicted in the original RST (Gray, 1982, 1987). This twenty-item questionnaire comprises four interrelated scales, one of them tapping BIS reactivity and the remaining three tapping different aspects of BAS reactivity. BAS scales include the Drive scale, assessing the persistent pursuit of desired goals, the fun seeking (FS) scale, reflecting a desire for new rewards and a willingness to approach potentially rewarding events, and the reward responsiveness (RR)

scale, tapping positive responses to the occurrence or anticipation of reward (Carver and White, 1994). Support for this four-factor structure was reported in several studies (Campbell-Sills et al., 2004; Cogswell et al., 2006; Cooper et al., 2007; Demianczyk et al., 2014; Franken et al., 2005; Heubeck et al., 1998; Knyazev et al., 2004; Leone et al., 2001; Müller and Wytykowska, 2005; Ross et al., 2002), although suboptimal fit indices were often observed and refinements (e.g. adding cross-loadings, dropping items) frequently needed in order to achieve adequate fit to the data (see e.g. Campbell-Sills et al., 2004; Cogswell et al., 2006; Demianczyk et al., 2014; Franken et al., 2005; Knyazev et al., 2004). Other studies provided support for a two-factor (BIS and BAS) rather than for a four-factor solution (e.g. Jorm et al., 1998; Strobel et al., 2001; Yu et al., 2011).

Although they did not originally comprise a FFFS scale, re-examinations of the structure of BIS/BAS scales suggests that items of the BIS scale may be used to differentiate between BIS and FFFS as depicted in the rRST (Gray and McNaughton, 2000). For example, Johnson et al. (2003) showed that two items of the BIS scale, i.e. “Even if something bad is about to happen to me, I rarely experience fear or nervousness” and “I have very few fears compared to my friends” loaded on a separate factor interpreted as FFFS, whereas the remaining items loaded on another factor interpreted as a BIS-anxiety. More recently, Heym and colleagues (2008) suggested the inclusion of a third item i.e. “If I think something unpleasant is going to happen I usually get pretty worked up”, as an additional indicator of the FFFS factor. Thus, these studies suggest that a five-factor solution comprising the three original BAS factors, a BIS-anxiety and a FFFS factor may better reflect the structure of the BIS/BAS scales than a four-factor solution.

The BIS/BAS scales were translated into several different languages, including Russian (Knyazev et al., 2004), Polish (Müller and Wytykowska, 2005), Italian (Leone et al., 2001),

Dutch (Smits and Boeck, 2006), Sinhalese (Dissabandara et al., 2012), Spanish (Segarra et al., 2014), German (Strobel et al., 2001) and French (Caci et al., 2007). More specifically, with regards to the German translation, the first evaluation of the psychometric characteristics of the questionnaire showed that the Carver and White's four-factor structure did not adequately fit to the data, and that a two-factor solution, i.e. one BAS factor and one BIS factor achieved a better fit. A more recent examination of this translation (Müller et al., 2013) compared the fit of two-, four- and five-factor solutions. The five-factor solution proposed by Johnson and colleagues (2003) yielded the best goodness of fit although it was not optimal as it did not meet the conventional standards of fit. With regard to the French translation of the BIS/BAS scales, Caci and colleagues (2007) found a mediocre fit in the original four-factor solution. Exploratory factor analysis restricted to four factors revealed that only fifteen items loaded on the expected factors, whereas five items (25%) did not load on any factor, or had cross-loadings. As noted by the authors, a major limitation of this study was that the sample size ($N = 144$) may not be sufficient to compute factor analysis. They stated that a closer look at the structure of BIS/BAS scales was needed, as well as possibly some structural refinements, in order to achieve a better measurement of the underlying constructs.

Using a large and representative sample of French- and German-speaking Swiss young males, the aim of the present study was to investigate the factorial structure and the psychometric properties of the French and German versions of the BIS/BAS scales. More specifically, fit statistics of different factor solutions proposed in previous studies (i.e. two-, four-, five-factor solutions) will be compared in order to identify the most adequate factor structure. If none of the model tested achieve the conventional standards of fit, exploratory approach will be adopted in

order to specify an adequate fitting model. Convergent validity and factor loading invariance of French and German versions will be examined.

Methods

Study design and participants

We analyzed data from the Cohort Study on Substance Use Risk Factors (C-SURF). C-SURF is a longitudinal study designed to investigate risk and protective factors of substance use in emerging adulthood. Research protocol (15/07) was approved by the ethics committee for clinical research of Lausanne University Medical School. Participants were enrolled in three of six army recruitment centres, covering twenty-one of twenty-six Swiss cantons. As army recruitment is mandatory in Switzerland for 20-year-old males, virtually all young males of this age were eligible for participation. Army recruitment centres were used to inform and enrol participants but the study was independent of the army. Questionnaires were completed at home, thus, participants were not influenced by army procedures when filling out questionnaires. More information on enrolment procedure has been described in previous studies (Studer et al., 2013a; Studer et al., 2013b).

A total of 7,557 participants gave written consent to participate and, among them, 5,987 (79.2%) completed the baseline questionnaire between September 2010 and March 2012 and 6,021 (79.7%) completed the follow-up questionnaire between March 2012 and April 2013. A total of 5,479 (91.5% of baseline respondents) responded to both baseline and follow-up questionnaires.

BIS/BAS scales were only assessed in the follow-up questionnaire. Only participants with complete data ($N = 5,872$, 97.5% of the follow-up respondents) on the BIS/BAS scales were selected to examine the factorial structure and group invariance of the questionnaire. Convergent

validity analyses were conducted on respondents to baseline and follow-up questionnaires, as some variables of interest were assessed only in the baseline questionnaire and others only in the follow-up questionnaire. Missing values were listwise deleted ($N = 4,927$, 89.9% of respondents to baseline and follow-up).

Instruments

French (Caci et al., 2007) and German (Strobel et al., 2001) translations of the BIS/BAS scales (Carver and White, 1994) were used to assess individual differences in BIS and BAS reactivity. This self-report questionnaire comprised 24 items, including four filler items, evaluated on a four-point scale ranging from 1-“very true for me” to 4-“very false for me”. Items were recoded in such a way that high values were indicative of a higher level of endorsement of the item.

French and German versions of the shortened Zuckerman-Kuhlman Personality Questionnaire (ZKPQ-50-cc; Aluja et al., 2006) were used to assess individual differences in Aggression/Hostility and Anxiety/Neuroticism traits at baseline. Each personality trait was evaluated using ten items in a true/false format. Summary scores ranging from 0 to 10 were computed. This was used to examine the convergent validity of the BIS/BAS scales. Consistent with previous studies, it is expected that Anxiety/Neuroticism will be positively related to BIS and FFFS (Beck et al., 2009; Keiser and Ross, 2011; Segarra et al., 2014), whereas Aggression/Hostility will be positively related to BAS, in particular to the Drive and FS scales (Harmon-Jones, 2003).

The French and German translations of the eight-item Brief Sensation Seeking (BSSS; Hoyle et al., 2002) were used to assess individual differences in sensation seeking (SS) at baseline. Each item was evaluated on a five-point scale ranging from 1-“strongly disagree” to 5-

“strongly agree”. A summary score ranging from 8 to 40 was computed. Consistent with previous studies (Dissabandara et al., 2011; Keiser and Ross, 2011; Quilty and Oakman, 2004), SS is expected to correlate positively with BAS scales.

The eleven criteria for alcohol use disorders (AUD) according to the fifth edition of the diagnostic and statistical manual of mental disorders (DSM-5; American Psychiatric Association, 2013) were used to assess AUD at follow-up. Questions, adapted from the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Hesselbrock et al., 1999; Knight et al., 2002), included the following criteria: (1) tolerance; (2) withdrawal symptoms; (3) using larger amounts and for longer periods than intended; (4) desire to cut down alcohol use, without success; (5) spending a great deal of time obtaining, consuming alcohol, or recovering from the effects of alcohol; (6) giving up important activities because of drinking; (7) continued drinking despite awareness that alcohol had repeatedly caused anxiety, depression or health problems; (8) drinking in hazardous situations; (9) failure to fulfill major role obligations at work/school/home; (10) continued use despite persistent or recurrent social or interpersonal problems due to drinking. At the time of the development of the questionnaire, no item for (11) cravings and urges to consume alcohol was available for a DSM-5 version. Thus, the question regarding cravings and urges was adopted from the Composite International Diagnostic Interview Short Form (CIDI SF; Kessler et al., 1998). Participants were asked whether they experienced each criterion in the previous twelve months. A summary score of AUD (range: 0-11) was constructed. The Cannabis Use Disorder Identification Test (CUDIT; Adamson and Sellman, 2003) was used to assess cannabis use disorders (CUD) at follow-up. This is a ten-item assessment tool asking participants about symptoms of cannabis use disorder during the previous twelve months, yielding score of CUD ranging from 0 to 40. The Fagerström Test for Nicotine Dependence

(FTND; Heatherton et al., 1991) was used to assess nicotine dependence (ND) at follow-up. This is a six-item questionnaire yielding a continuous score of ND ranging from 0 to 9. Substance use disorders will be used to assess convergent validity. Consistent with previous studies (Franken and Muris, 2006; Keough and O'Connor, 2014; O'Connor et al., 2009; Voigt et al., 2009), positive correlations are expected between BAS and substance use disorders, in particular the Drive and FS scales.

The Major Depressive Inventory (MDI) was used at follow-up to assess levels of depression (Bech et al., 2001; Olsen et al., 2003). This is a twelve-item questionnaire covering symptoms of depression according to DSM-IV (American Psychiatric Association, 1994) and ICD-10 (World Health Organization, 1993). Participants were asked to indicate how much of the time the symptoms have been present during the past fourteen days on a six-point scale from 0 (never) to 5 (all the time). A summary score of major depression severity (MDS) was computed with ten criteria (two criteria use two items and take the higher score of any of these two, see Bech et al., 2001; Olsen et al., 2003). MDS will be used to assess convergent validity. Consistent with results of previous studies (Campbell-Sills et al., 2004; Kasch et al., 2002; McFarland et al., 2006; Meyer et al., 1999), MDS is expected to correlate positively with BIS and negatively with BAS scales, in particular with the RR scale.

Socio-demographic variables including age, language and highest completed level of education were assessed. Highest completed level of education consisted of three categories of schooling: primary schooling (9 years); vocational training (>9–12); post secondary schooling (thirteen years or more including high school which can be only twelve years in some cantons). Furthermore, participants were distinguished according to their preferred language, i.e. French or German.

Statistical analyses

A series of confirmatory factor analyses (CFA) using weighted least squares means and variance adjusted (WLSMV) estimation was first conducted to assess the fit of different factorial structures of the BIS/BAS scales previously reported in the literature. A two-factor model was first tested, with BIS and BAS items loading on two distinct correlated factors (Model 1). Model 2 examined a four-factor model, as proposed by Carver and White (1994), with one BIS and three BAS (i.e. RR, FS, Drive) correlated factors. Then, two five-factor models were tested, i.e. the model proposed by Heym and colleagues (2008), with one BIS-anxiety (four items), one FFFS (three items) and three BAS correlated factors (model 3) and the model proposed by Johnson and colleagues (2003) including one BIS-anxiety (five items), one FFFS (two items) and three BAS correlated factors (model 4). Model adequacy was assessed using the root mean square error of approximation (RMSEA), i.e. the square residuals between observed and estimated input matrices of the population approximation, (Hair et al., 1995) and the comparative fit index (CFI), i.e. the overall amount of the covariation among the observed variables that can be accounted for by the hypothesized model. For RMSEA, values close to .06 or lower, are generally considered as indicating a good fit (Hu and Bentler, 1999), although some authors suggested that values in the range of .06–.08 indicate fair fit (Browne and Cudeck, 1993). For CFI, values close to .95 or higher indicate good fit (Hu and Bentler, 1999), but values greater than .90 are generally considered as acceptable (Kline, 2011).

As all the models failed to reach acceptable model adequacy, an exploratory approach was then adopted. The 5,872 participants with complete data on the BIS/BAS scales were randomly split into an exploration sample and a validation sample of equal size ($N=2,936$). First, a series of one-to-eight-factor exploratory factor analyses (EFA) using geomin rotation with

unstandardized least squares estimation was conducted on the exploration sample. The number of factors retained was determined according to eigenvalues (i.e. eigenvalue > 1). Then, items with low loadings (<.45) as well as those loading on factors other than expected were excluded (Comrey and Lee, 1992). The solution obtained was then cross-validated in the validation sample using CFA. Then multigroup CFA was conducted to assess invariance of factor loadings between French- and German-speaking participants. The difference in fit between the two groups was evaluated according to the difference in CFI ($|\Delta\text{CFI}|$) and RMSEA ($|\Delta\text{RMSEA}|$) between a model constraining item loadings to be equal between groups and a model where item loadings were freely estimated in each group. According to Chen (2007) $|\Delta\text{CFI}|$ value greater than or equal to 0.010 supplemented by $|\Delta\text{RMSEA}|$ greater than or equal to 0.015 indicate the non-invariance of factor loadings between groups.

Finally, convergent validity of the BIS/BAS scales was examined by computing correlations of BIS/BAS scales with Aggression/Hostility, Anxiety/Neuroticism, and SS traits and with AUD, ND, CUD, and MDS scores. Due to the large sample size ($N = 4,927$ completed cases) correlations as low as $|r| = .03$ were statistically significant. However, such low correlations are not necessarily meaningful (Cumming, 2012). As a consequence, we only considered correlations close to $|r| = .10$ or higher to be meaningful, in that they are indicative of at least a small but not trivial effect size (Cohen, 1988). Mplus 7.11 (Muthén and Muthén, 1998-2012) was used for factor analysis and SPSS 22 was used for descriptive characteristics of the sample, reliability and convergent validity analyses.

Results

Descriptive characteristics of the sample

The mean age of participants was 21.38 years ($SD = 1.30$). Three thousand four hundred and nineteen (58.2%) participants were French-speaking, whereas 2,453 (41.8%) were German-speaking. Four hundred and seventy-five participants (8.1%) reported primary schooling as their highest completed level of education, whereas 2,754 participants (46.9%) reported vocational training, and 2,643 participants (45.0%) reported post secondary schooling.

Structure of the BIS/BAS scales

Fit indices of the different factorial structures of the BIS/BAS, based on suggestions in the literature, are reported in table 1. Results indicate that among four models tested, the five-factor model proposed by Johnson and colleagues (2003) was the best fitting solution. However, the fit indices highlight that this model was far from adequately fitting the data, as were the other tested models. Therefore, the exploration sample was used to run a series of EFA. A four-factor solution was retained as the first four eigenvalues were greater than 1 (5.33, 2.78, 1.81, 1.04, 0.97). Loadings of this four-factor solution are reported in table 2. The first factor comprised two items of the RR scale and two items of the Drive scale. Factor 2 reflects BIS as all BIS items had loadings higher than 0.45, except the two items supposed to form the separate FFFS factor according to Johnson and colleagues (2003). Factor 3 and factor 4 correspond to the Drive and FS scales, respectively, as items with loadings higher than 0.45 were expected to load on these factors. Seven items did not show loadings of 0.45 or higher on any factor. These items were not retained in the shortened solution. Similarly, the two Drive items loading on factor 1 were excluded, so that factor 1 corresponded to RR scale.

To confirm the adequacy of this shortened four-factor solution (i.e. BIS comprising five items; RR, FS, Drive comprising each two items), a CFA with a WLSMV estimation was conducted in the validation sample. Fit indices for this model (RMSEA = 0.074; CFI = 0.936)

suggested that the fit was acceptable. Factor loadings of this model and correlations between factors are reported in table 3. Small positive correlations were observed between BIS and Drive. Moderate correlations were found between BIS and FS, RR and BIS, RR and Drive, and RR and FS, whereas FS and Drive correlated strongly. All correlations were statistically significant (all $p < .001$, except for the correlation between BIS and Drive, which was significant at $p = .017$). The correlations between the original BIS/BAS scales developed by Carver and White (1994) and those of the shortened version validated here were large (i.e. $r = .923$ for BIS; $r = .824$ for Drive; $r = .805$ for RR; $r = .866$ for FS).

Multigroup analysis

Multigroup CFA were conducted on the total sample to test whether factor loadings varied between French- and German-speaking participants. Results showed that $|\Delta\text{CFI}|$ between the unconstrained model (CFI = 0.930) and the model constraining equal factor loadings between the two groups (CFI = 0.921) did not exceed 0.010 ($|\Delta\text{CFI}| = 0.009$), and that $|\Delta\text{RMSEA}|$ (RMSEA = 0.077 for unconstrained model; RMSEA = 0.079 for constrained model) was far below 0.015 ($|\Delta\text{RMSEA}| = 0.002$). In line with Chen (2007), this result suggests that the null hypothesis of invariance should not be rejected.

Convergent validity of the BIS/BAS scales

Correlations between BIS/BAS and Sensation Seeking, Neuroticism/Anxiety, AUD, ND, CUD, and MDS are reported in table 4. SS and Aggression/Hostility traits were positively associated with BAS (except for the association between Aggression/Hostility and RR that was close to zero), with stronger correlations for Drive and FS than for RR scales, and almost unrelated with BIS (coefficients close to zero, although significant with Aggression/Hostility trait). The Neuroticism/Anxiety trait was positively related with BIS and negatively with BAS

total, Drive and RR scales, although the coefficients of the latter correlations were very small. AUD was positively associated essentially with FS, and to a lesser extent with BAS total, Drive and BIS scores. ND was positively associated essentially with FS, to a lesser extent with BAS total and Drive scores, and negatively related with RR and BIS, although the size of the coefficients of the latter association were very small. CUD was positively associated with FS, and to a lesser extent with BAS total scores. MDS was positively associated with BIS, to a lesser extent with FS, and negatively associated with RR.

Discussion

The aim of the present study was to examine the factorial structure and the psychometric properties of the BIS/BAS scales (Carver and White, 1994) in a large sample of French- and German-speaking Swiss young men. The fit of factorial structures proposed in previous researches, i.e. two-factor (Jorm et al., 1998; Yu et al., 2011), four-factor (Carver and White, 1994), and five-factor solutions (Heym et al., 2008; Johnson et al., 2003) was tested using CFA.

In line with previous studies examining the factor structure of the BIS/BAS scales (Beck et al., 2009; Müller et al., 2013; Poythress et al., 2008), the five-factor solution as proposed by Johnson and colleagues (2003), (i.e. two items for FFFS, five items for BIS, five items for RR, four items for Drive, four items for FS) obtained better fit statistics than the two- and four-factor structures. However, the five-factor solution (as well as the two- and the four-factor solutions) clearly did not meet the conventional standards of fit. Thus, the application of previously proposed factor structure may be questionable when using the French and German versions of the BIS/BAS scales because it may not reflect the structure of the observed data properly.

Results of the EFA conducted on the exploration sample provided support for a four-factor structure, but nine items were found to be problematic. Two items expected to load on the

Drive factor were found to load on the RR factor. These items, namely “When I want something I usually go all-out to get it” and “If I see a chance to get something I want I move on it right away”, were already found as problematic in earlier examination of the French and German versions of the BIS/BAS scales (Caci et al., 2007; Strobel et al., 2001). Additionally, seven items had poor loadings on any of the four factors extracted. This was the case for the two items of the original BIS scale (i.e. “Even if something bad is about to happen to me, I rarely experience fear or nervousness” and “I have very few fears compared to my friends”) that were found to belong to the FFFS factor by Johnson and colleagues (2003) and that were already found to be problematic by Cogswell et al. (2006). This finding suggests that these two items tap constructs other than BIS reactivity. However, we found no evidence that these two items form a single factor tapping FFFS reactivity, as proposed by Johnson and colleagues (2003). Thus, further studies should focus on the development of a valid and reliable measure of FFFS sensitivity. The two items “I’m always willing to try something new if I think it will be fun” and “I crave excitement and new sensations”, expected to tap FS, also had low loadings. They were also found to be problematic by Knyazev et al. (2004). Three items assumed to load on the RR scale, namely “When I see an opportunity for something I like, I get excited right away” found to be problematic by Jorm et al. (1998), “When good things happen to me, it affects me strongly” found to be problematic by Caci et al. (2007), and “It would excite me to win a contest”, found to be problematic by Franken et al. (2005) also had poor loadings in the EFA. These nine items were excluded and the remaining items were submitted to a CFA in the validation sample to cross-validate a shortened four-factor version of the BIS/BAS scales, with one BIS factor comprising five items and one RR, one Drive and one FS factor, each comprising two items.

Fit statistics suggested that this model adequately reflects the structure of the observed data and that the reliability of the scales was acceptable. Correlations between Carver and White (1994) BIS/BAS scales and the shortened version were higher than .80, suggesting that constructs assessed by shortened BIS/BAS scales are very similar to those assessed by the original scales. Convergent validity analyses showed that, consistent with previous studies (Beck et al., 2009; Keiser and Ross, 2011; Segarra et al., 2014), BIS was positively related with the Neuroticism/Anxiety trait. By contrast, BAS scales (in particular the Drive and FS scales) were positively related to SS and Aggression-Hostility traits (Dissabandara et al., 2011; Harmon-Jones, 2003; Quilty and Oakman, 2004). BIS and BAS scales were also related with psychopathologies. Consistent with previous studies (Franken and Muris, 2006; Johnson et al., 2003), positive associations were found between BAS (in particular with the FS scale) and substance use disorders. Major depression severity was positively related with BIS and negatively related with BAS RR scale, as previously shown (McFarland et al., 2006; Meyer et al., 1999).

Moreover, results of multigroup CFA provided support for invariance of factor loadings between the French and the German versions of the questionnaire, suggesting that shortened BIS/BAS scales can be used in international studies conducted in French- as well as in German-speaking samples as they measure the same constructs in both languages. In countries where other languages are spoken, other shortened versions have also been proposed, such as a 14-item (Demianczyk et al., 2014) and a 16-item (Cogswell et al., 2006) in the U.S., and a 14-item version in Russia (Knyazev et al., 2004). All the items retained in the present study were also retained in the above-mentioned shortened versions, except for two items. The first, i.e. “When I go after something I use a no holds barred approach”, originally loading on the Drive scale was not retained in any of the three other shortened versions. The second, i.e. “I feel worried when I

think I have done poorly at something important”, originally loading on the BIS scale was not retained in the version of Demianczyk et al. (2014). Thus, as most of the items retained in the present study were also retained in other shortened versions validated in countries where other languages than French and German are spoken, the shortened BIS/BAS scales proposed in the present paper is also likely to reliably assess BIS/BAS sensitivity in an international context beyond French- and German-speaking countries. However, this should be confirmed in further studies.

Taken together, this suggests that the shortened BIS/BAS scales constitute a valid and reliable measure of individual differences in BIS and BAS reactivity that can be used in both French- and German-speaking populations. However, the present study is not without limitation. One limitation is that although it is representative, the sample only comprised young males. Therefore, further studies are needed in order to establish whether our findings can be extended to women and older participants. Another shortcoming is the cross-sectional design, which prevented us from exploring the stability of the factor solution over time and from assessing test-retest reliability. The use of personality traits (i.e. SS, Aggression/Hostility, Neuroticism/Anxiety) that were assessed about 15 month (i.e. at baseline) before BIS/BAS sensitivity (assessed at follow-up) to test convergent validity may also be seen as a limitation. However, this should not have strongly influenced the correlations observed in the convergent validity analysis, since personality traits are assumed to reflect the expression of genetically-determined systems (Eysenck, 1990) that are relatively stable over time (McCrae and Costa, 1994). In addition, our analyses did not support the existence of a FFFS factor based on the items of the BIS/BAS scales. Further studies are needed to develop a valid measure to assess individual differences in FFFS reactivity.

To conclude, psychometric evaluation of the French and German versions of the BIS/BAS scales showed that the fit of previously proposed two- four- and five-factor structures was not adequate, suggesting that the use of these models should be avoided. A satisfactory four-factor shortened solution was obtained after many modifications were made to the original factor structure (removing items with inadequate loadings). This shortened version of the BIS/BAS scales could be particularly suitable for large scale surveys where the length and number of questions in a questionnaire is a common issue. It is also recommended that researchers who are interested in assessing individual differences in BIS and BAS reactivity in French- and German speaking individuals use this shortened version rather than previous versions, at least in samples of young adults. Using this shortened version may increase the validity and reliability of the scales and provide a better understanding of the BIS and BAS and their relations to other personality measures and psychopathologies.

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Table 1. Fit indices of CFA models (N = 5,872)

	RMSEA	CFI
Model 1 (two factors)	0.137	0.541
Model 2 (four factors)	0.127	0.613
Model 3 (five factors, Heym et al., 2008)	0.127	0.626
Model 4 (five factors, Johnson et al., 2003)	0.097	0.779

Note. RMSEA = root mean square error of approximation; CFI = comparative fit index.

Table 2. Exploratory factor analysis of the BIS/BAS scales conducted on the exploration sample (N=2,936)

Item	Expected factor ^a	Standardized loadings			
		Factor 1	Factor 2	Factor 3	Factor 4
Even if something bad is about to happen to me, I rarely experience fear or nervousness	BIS	-0.443	0.307	-0.056	0.018
I go out of my way to get things I want	Drive	-0.040	0.025	0.711	0.018
When I'm doing well at something I love to keep at it	RR	0.771	0.088	-0.025	-0.185
I'm always willing to try something new if I think it will be fun	FS	0.408	-0.053	0.109	0.328
When I get something I want, I feel excited and energized	RR	0.548	0.155	0.175	0.074
Criticism or scolding hurts me quite a bit	BIS	-0.071	0.628	0.085	-0.025
When I want something I usually go all-out to get it	Drive	0.615	0.007	-0.057	0.032
I will often do things for no other reason than that they might be fun	FS	0.104	0.005	0.003	0.649
If I see a chance to get something I want I move on it right away	Drive	0.584	-0.065	-0.024	0.263
I feel pretty worried or upset when I think or know somebody is angry at me	BIS	0.008	0.673	0.020	-0.015
When I see an opportunity for something I like I get excited right away	RR	0.362	0.355	-0.062	0.260
I often act on the spur of the moment	FS	-0.084	0.071	0.278	0.532
If I think something unpleasant is going to happen I usually get pretty “worked up”	BIS	-0.001	0.639	0.016	0.064
When good things happen to me, it affects me strongly	RR	0.083	0.376	0.317	0.083

Table 2. (continued)

Item	Expected factor ^a	Standardized loadings			
		Factor 1	Factor 2	Factor 3	Factor 4
I feel worried when I think I have done poorly at something important	BIS	0.278	0.622	0.024	-0.094
I crave excitement and new sensations	FS	0.169	0.011	0.270	0.419
When I go after something I use a “no holds barred” approach	Drive	0.021	-0.045	0.786	-0.006
I have very few fears compared to my friends	BIS	-0.384	0.230	-0.286	0.009
It would excite me to win a contest	RR	0.433	0.241	0.034	0.048
I worry about making mistakes	BIS	-0.004	0.686	-0.152	-0.001

Note. BIS = behavioural inhibition system; RR = reward responsiveness; FS = fun seeking. ^aExpected factor following Carver and White (1994). In bold, loadings $\geq .45$.

Table 3. Factor structure of the shortened BIS/BAS scales (N=2,936)

	BIS	Drive	RR	FS
Item loadings				
I go out of my way to get things I want	-	0.719	-	-
When I'm doing well at something I love to keep at it	-	-	0.551	-
When I get something I want, I feel excited and energized	-	-	0.918	-
Criticism or scolding hurts me quite a bit	0.595	-	-	-
I will often do things for no other reason than that they might be fun	-	-	-	0.595
I feel pretty worried or upset when I think or know somebody is angry at me	0.676	-	-	-
I often act on the spur of the moment	-	-	-	0.645
If I think something unpleasant is going to happen I usually get pretty “worked up”	0.655	-	-	-
I feel worried when I think I have done poorly at something important	0.694	-	-	-
When I go after something I use a “no holds barred” approach	-	0.808	-	-
I worry about making mistakes	0.652	-	-	-
Correlations				
Drive	0.056	-	-	-
RR	0.396	0.309	-	-
FS	0.251	0.636	0.477	-
Mean (SD)	13.23 (2.87)	4.55 (2.30)	6.73 (1.16)	5.05 (1.33)

Note. BIS = behavioral inhibition system; RR = reward responsiveness; FS = fun seeking; SD = standard deviation. All factor loadings were significant at $p < .001$. All correlations between BIS, Drive, RR and FS were significant (all $p < .001$, except for the correlation between BIS and Drive, $p = .017$).

Table 4. Convergent validity of the shortened BIS/BAS scales ($N = 4,927$)

	Mean (SD)	BIS	BAS total	BAS Drive	BAS RR	BAS FS
Personality						
Sensation seeking	24.37 (6.93)	-.016	.305***	.256***	.098***	.286***
Neuroticism/anxiety	1.97 (1.99)	.286***	-.037**	-.031*	-.065***	.011
Aggression/hostility	4.13 (2.21)	.034*	.138***	.124***	-.002	.160***
Substance use disorders						
Alcohol use disorders	1.21 (1.62)	.083***	.089***	.051***	-.004	.139***
Nicotine dependence	0.88 (1.64)	-.045**	.063***	.061***	-.035*	.099***
Cannabis use disorders	1.83 (4.43)	.019	.063***	.014	-.007	.127***
Major depression severity	7.85 (7.13)	.217***	-.023	.001	-.113***	.046**

Note. BIS = behavioural inhibition system; BAS = behavioural activation system; RR = reward responsiveness; FS = fun seeking; SD = standard deviation. * $p < .05$, ** $p < .01$, *** $p < .001$.