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From BIS/BAS to the Big Five†

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Abstract

Gray (1987) proposed two systems that underlie much of our behaviour and personality. One system relates to avoidance or withdrawal behaviour, called the Behavioural Inhibition System (BIS), whereas the other system relates to approach behaviour, called the Behavioural Approach System (BAS). In two samples, it was investigated whether individual differences in surface of personality as described by the Big Five can be explained by BIS/BAS. Neuroticism and Extraversion could be explained well by BIS/BAS, but also for Agreeableness and Conscientiousness consistent findings were obtained.
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Key words: *Behavioural Inhibition System; Behavioural Activation System; Big-Five Personality Factors; Neuroticism; Extraversion*

Several theorists have argued that there are two core systems in the regulation of behaviour (e.g. Depue & Iacono, 1989; Fowles, 1980; Gray, 1987). One system deals with aversive motivation and avoidance or withdrawal behaviour, whereas the other system deals with appetitive motivation and approach behaviour. Gray (1987, 1990, 1991, 1994) referred to the first system as the Behavioural Inhibition System (BIS), and to the latter as the Behavioural Approach System (BAS). He argued that both systems are part of the neurobiological underpinnings of behaviour and affect. The specific neuro-biological basis of BIS and BAS are described in detail in Depue and Iacono (1989), Gray (1990, 1994) and Sutton and Davidson (1997).

The primary purpose of BIS is preventing or stopping behaviour that is expected to lead to punishment or the cessation/loss of reward. As such, BIS activity is closely related to trait anxiety (Arnett & Newman, 2000; Carver & White, 1994; Gray, 1982, 1987, 1990; Hagopian & Ollendick, 1994) and vulnerability to anxiety (Carver & White, 1994;

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Gomez & Gomez, 2002). In a recent revision of his theory, Gray & McNaughton (2000) state that BIS becomes active when approach–avoidance, avoidance–avoidance or approach–approach conflicts are experienced. Its primary function is inhibiting ongoing behaviour, but it can also motivate risk assessment behaviour or behavioural caution, and increase the attention and arousal. Another important distinction is between BIS and the flight/freezing/Fight system (FFFS, McNaughton & Corr, 2004). The latter system copes with an explicit danger that can be escaped or avoided in an explicit way. Panic and fear are emotions associated with that system. However, as the FFFS is not our focus of interest, it will not be discussed here any further.

BAS—also called the behavioural facilitation system (Depue & Collins, 1999; Depue & Iacono, 1989) or the behavioural activation system (Fowles, 1980)—is activated by stimuli of reward, or by opportunities to avoid or stop punishment (McNaughton & Corr, 2004). For example Depue & Iacono (1989) suggested that BAS activation energizes behaviour directed at acquiring rewards or eliminating punishment.

As Gray's model provides a behaviourally and physiologically based explanation for personality, it is not surprising that the BIS/BAS system has been related to dimensions of several personality theories. From the framework of Eysenck's dimensional theory, links between BIS and Neuroticism and between BAS and Extraversion have been reported (e.g. Diaz & Pickering, 1993; Gomez, Cooper, & Gomez, 2000; Gray, 1970, 1987; Heubeck, Wilkinson, & Cologon, 1998; Jackson, 2002, 2003; Jorm et al., 1999). Carver and White (1994) and Zelenski and Larsen (1999) have linked the BIS/BAS system also to the four dimensions of the personality theory of Cloninger (1986, 1991): Harm Avoidance relates positively to BIS and negatively to BAS, Reward Dependence relates positively to BIS and BAS, Persistence relates positively to BAS and Novelty Seeking primarily relates to the impulsivity related part of BAS.

Another major personality theory, besides the ones of Eysenck and Cloninger, is the theory of the Big Five in which it is assumed that the surface of personality can be described with five dimensions: Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness (e.g. Costa & McCrae, 1989, 1992, 1995; Digman, 1990; Goldberg, 1992; McCrae & Costa, 1997). This theory can be conceived of as a lexically based description of the surface of personality, i.e. at the level of person perception (e.g. Digman, 1990), in contrast with the BIS/BAS system, as they can be conceived as biological precursors to personality. Investigating to which extent the Big-Five personality traits can be explained by the BIS/BAS system is the major aim of the current study.

To measure individual differences in BIS and BAS activity, the BIS/BAS questionnaire of Carver and White (1994) will be used. This questionnaire measures the dispositional sensitivities to BIS and BAS at a cognitive level. Consequently, the BIS/BAS questionnaire focuses mainly on the consequences of BIS/BAS activity and not on the BIS/BAS activity itself (Carver & White, 1994; Leone, Perugini, Bagozzi, Pierro, & Mannetti, 2001). The questionnaire comprises one BIS scale and three BAS scales. The BIS scale attempts to measure concerns regarding the possible occurrence of negative events and the sensitivity to such events when they do occur (Jorm et al., 1999). The BAS part of the questionnaire is divided into three subscales: drive, fun seeking and reward responsiveness. The drive scale (BASD) comprises items that 'pertain to the persistent pursuit of desired goals', the fun seeking scale (BASF) comprises items that 'reflect both a desire for new rewards and a willingness to approach a potentially rewarding event on the spur of the moment', and the reward responsiveness scale (BASR) comprises items that 'focus on positive responses to the occurrence or anticipation of

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reward' (Carver & White, 1994, p. 322). Several authors (e.g. Heubeck et al., 1998; Leone et al., 2001) found that responses to the three BAS scales are positively correlated as would be expected since they all are assumed to reflect the same emotional system.

Notwithstanding the shared emotional system, the BAS scales also reflect a certain differentiation. Taking a close look to the items of the BAS scales, one can see that two scales, BASD and BASF, refer to *actions* people take, either because they strive for a goal or because they want to experience fun. In contrast, the BIS scale and the BASR scale contain items that express a *sensitivity* towards events that occurred or are expected. They imply a dependency of one's effect on the external world and events that are part of that world. This interpretation can explain why Cloninger (1986, 1991) found that the Reward Dependence dimension from his theory correlates positively with both BIS and BAS. In line with this interpretation, BASR, but not BASD and BASF, was often found to be positively correlated with BIS (Harmon-Jones, 2003; Heubeck et al., 1998; Johnson, Turner, & Iwata, 2003; Ross, Millis, Bonebright, & Bailey, 2002). Moreover, in three out of the four just cited studies, the correlation between BASD and BASF was higher than the correlation between BASF and BASR or between BASD and BASR (Harmon-Jones, 2003; Heubeck et al., 1998; Johnson et al., 2003).

Explaining the Big-Five personality dimensions by BIS/BAS

Prediction of Neuroticism

We expect that BIS can predict Neuroticism to a large extent, because BIS and Neuroticism share the feature of negative emotional *sensitivity* (Larsen & Ketelaar, 1991; Leen-Feldner, Zvolensky, Feldner, & Lejuez, 2004). Our hypothesis is in line with findings of Heubeck et al. (1998), Jorm et al. (1999) and Zelenski and Larsen (1999), that there is a strong positive association between BIS and Neuroticism from Eysenck's system.

The correlation of the BAS scales with Neuroticism is less clear. On the one hand BASR shares its sensivity with Neuroticism, but BASD and BASF, unlike Neuroticism refer to actions people take in a positive direction, which may be expected from emotionally stable persons. On the basis of our conceptual analysis, we expect a small positive effect of BASR on Neuroticism, and a small negative effect of BASD and BASF on Neuroticism. However contrary to our predictions, some authors found no correlation between the BAS scales and Neuroticism (Carver & White, 1994) or only a small positive correlation between Neuroticism and BASR, but no significant correlation between Neuroticism and BASD or BASF (Jorm et al., 1999; Heubeck et al., 1998).

Relations with Extraversion

Taking a close look to the items of the BAS scales, one can see that they all imply positive evaluations and positive emotionality, either in anticipation (BASD, BASF) or in reaction (BASR) to an event. Our conjecture is that Extraversion can be predicted by BAS to a large extent, because Extraversion primarily implies an approach tendency (Depue & Collins, 1999; Elliot & Thrash, 2002; Gomez, Cooper, & Gomez, 2000; Gray, 1987) and positive emotionality (Carver, Sutton, & Scheier, 2000; Clark & Watson, 1999; Eysenck, 1987; Gable, Reis, & Elliott, 2000; Larsen & Ketelaar, 1989, Meyer & Shack, 1989). Positive feelings may also stem from BIS when the basis of a negative evaluation vanishes or is avoided (Carver, 2003), but this does not detract from the core feature of negative evaluation, because positive feelings such as relief require a negative evaluation to begin with. In a similar way, BAS may lead to negative feelings such as anger when prevented to

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actually reach the positive (Carver, 2004; Corr, 2002; Harmon-Jones, 2003). In agreement with our hypotheses that BAS is positively related to Extraversion, several authors found a positive association between the BAS scales and Extraversion from Eysenck's system (e.g. Carver & White, 1994; Heubeck et al., 1998; Jorm et al., 1999; Zelenski & Larsen, 1999).

Our predictions of the effects of the BIS/BAS scales on Conscientiousness, Openness and Agreeableness are more tentative (for Conscientiousness), or we do not have any (for Agreeableness and Openness), because there are no direct empirical findings available. The three dimension in a question are not included in the personality theories, which were linked previously to BIS/BAS (Eysenck's and Cloninger's theory).

Relations with Conscientiousness

Gray assumed that individual differences in BAS underlie a dimension of impulsivity (Gray, 1994). In a recent study, Quilty and Oakman (2004) found that global impulsivity measures were related to BAS. In the same vein, Zelenski and Larsen (1999) found that BASF is highly correlated to an impulsivity dimension. Whiteside and Lynam (2001) made a comprehensive review of such impulsivity measures and found they could be reduced to four factors. Two of them (Pre-meditation and Perseverance) were found to be negatively associated with Conscientiousness. Because impulsivity at least partly contrasts with Conscientiousness, we expect that Conscientiousness can be predicted by BASF, in the negative sense, and to a moderate degree. For the other BIS/BAS scales, we have no specific hypotheses.

Relations with Openness and Agreeableness

As we have not found any related literature from which we could derive specific associations of these two-personality dimension with BIS/BAS, we have no hypotheses about them. This part of the study is therefore explorative.

First, the structure of the BIS/BAS questionnaire will be investigated in two samples. Second, the predictive effects of BIS, BASR, BASD and BASF for the Big-Five personality dimensions will be determined in the same two independent samples. The reason for using two samples is to check whether our results are robust or not.

METHOD

Participants

The first sample consisted of 390 Dutch speaking first year psychology students. The sample consists of 66 males and 324 females, which reflects the proportion of the two genders among psychology students. The average age was 18.6 (SD = 2.73).

The second sample consisted of 260 Dutch speaking first-year psychology students (55 males and 205 females); the mean age was 18.5 (SD = 3.07). These data were collected one year later than the one for the previous sample. Participation in both studies was a partial fulfilment of a requirement to participate in research.

Procedure

Because our participants are Dutch speaking, we needed a Dutch translation of the original BIS/BAS questionnaire. Therefore, three translators translated the items of the original

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BIS/BAS questionnaire independently in Dutch. For item translations that were different across the translators (only six items), the three translators were asked to generate at least three alternative translations. For a translation to be accepted, it had to occur among the alternatives of all three translators. The quality of this translation was checked with a backtranslation by three other persons. Finally, we asked a native English speaker to rate the backtranslated items on similarity in meaning with the original BIS/BAS items on a 5-point scale (1 = totally different meaning, 2 = different meaning, 3 = similar meaning, 4 = almost the same meaning and 5 = exactly the same meaning). Twenty-two of the 24 backtranslated items (92%) received a rating of 4 or higher. Two items received a rating of 3 for all three backtranslations, which means that their meaning was still similar to the original items. The final questionnaire in Dutch can be obtained from the authors upon request. Apart from the translation method and the assessment based on the rating we just reported, also an investigation of the factorial structure can throw light on the validity of our translation.

The measures of the Big-Five personality dimensions and the BIS/BAS measures were collected in two separate sessions. The first session in which the Big-Five personality measures were collected, took place in the first semester, whereas the BIS/BAS measures were collected in a second session that took place in the second semester. The participants were assured that the research was anonymous. In order to combine the data from both sessions, the participants received a reference number at the beginning of the academic year which they had to bring to all sessions that were organized. This reference number contained no information that could be used to retrieve the identity of a participant. In the first sample, for 281 participants (41 males and 240 females) both measures (BIS/BAS and Big Five) were available, whereas in the second sample, for 220 participants (50 males and 170 females) both measures (BIS/BAS and Big Five) were available.

Materials

To assess individual differences in BIS sensitivity and BAS sensitivity, the Dutch translation of Carver and White's (Carver & White, 1994) BIS/BAS questionnaire was administered. Similar to the original BIS/BAS questionnaire, the responses were collected using a four point scale (1 = strongly agree to 4 = strongly disagree). In order to obtain scale scores, all items other than item 2 and item 22 are reversed coded and summed per scale.

The Big Five personality factors (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness) were assessed with the authorized Dutch translation of the NEO-FFI, a short version of form S of the Revised NEO Personality Inventory (Costa & McCrae, 1992, Hoekstra, Ormel, & de Fruyt, 1996, McCrae & Costa, 2004). In total, the NEO-FFI has 60 items, 12 per factor. Participants indicated their responses on a scale from 1 (strongly disagree) to 5 (strongly agree).

RESULTS

The two general BIS/BAS scales demonstrated sufficient reliability (for Cronbach's alpha, see the diagonals of Table 1), although for two of the BAS subscales the reliability was only moderate (BASF and BASR). Also in other studies, the reliability of the BASR scale

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Table 1. Descriptive statistics and correlations for BIS/BAS scales in Sample 1 (first line) and Sample 2 (second line)

	Mean	SD	BIS	BAS	BASD	BASF	BASR
BIS	21.37	3.81	0.82				
	21.92	3.88	0.84				
BAS	38.85	4.51	−0.06	0.73			
	38.83	5.06	−0.07	0.78			
BASD	10.44	2.32	−0.14	0.77	0.75		
	10.30	2.48	−0.23	0.79	0.79		
BASF	11.66	1.94	−0.19	0.71	0.31	0.55	
	11.82	2.17	−0.15	0.79	0.44	0.65	
BASR	16.75	1.93	0.19	0.70	0.29	0.27	0.54
	16.71	2.03	0.28	0.69	0.28	0.36	0.59

Note: Cronbach's alphas are mentioned on the diagonal. All correlations are significant at the 0.01 level, except for the correlations between BIS and BAS, which are not significant.

and the BASF scale was lower than the reliability of the other scales (Carver & White, 1994, Heubeck et al., 1998). The reliability of the BIS scale and the BASD scale were reasonably high, taking into account the small number of items. Moreover, they were similar to the reliabilities as obtained in other studies (Heubeck et al., 1998, Jorm et al., 1999, Leone et al., 2001).

The BAS scales were all three significantly correlated ($r = 0.27$ to 0.31, $p < 0.001$ for Sample 1; $r = 0.28$ to 0.44, $p < 0.001$ for Sample 2). The BIS scale and the total BAS scale were unrelated ($r = -0.06$, $p > 0.10$ for Sample 1; $r = -0.07$, $p > 0.10$ for Sample 2), but each of the BAS subscales correlated significantly to BIS ($p < 0.01$). Two of the BAS scales were negatively correlated to the BIS scale (−0.14 for BASD and −0.19 for BASF, Sample 1; −0.23 for BASD and −0.15 for BASF, Sample 2;) and one was positively correlated to the BIS scale (0.19 for BASR, Sample 1;.28 for BASR, Sample 2). The correlations can be found in Table 1, together with the means and the standard deviations for all BIS/BAS scales. The correlations were similar across the two samples and also across the two genders.

Structure of BIS/BAS questionnaire

The structure of the BIS/BAS scales is important for a decision on whether the three BAS scales should be treated as differential variables or not. Therefore, two competing models were fitted with LISREL 8.70 (Jöreskog & Sörbom, 2004): (1) a two-factor model with one BIS and one BAS factor, the two personality dimensions postulated by Gray (1987), and (2) a four-factor model with BIS, BASD, BASF and BASR as latent factors. The two-dimensional model was used to test whether the composite of the three BAS subscales can be used as a homogeneous general measure of BAS activity without any further differentiation as is sometimes done (e.g. Harmon-Jones, 2003; Gable, Reis, & Elliott, 2000; Gomez & Gomez, 2002; Gomez & McLaren, 1997, O'Gorman & Baxter, 2002).

The indicators we used for both models were each a composite of two or three items. Such indicators are called item parcels. For example, the two indicators of BASR were obtained by splitting the five items of the BASR scale (items 4, 7, 14, 18 and 23) into two sets: the first two items (items 4 and 7) and the last three items (items 14, 18 and 23). In

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order to test whether our results depend on the specific grouping of the items, we tried out different groupings of the items into parcels. All different groupings led to similar conclusions about the structure of the BIS/BAS questionnaire.

The model with item parcels as indicators has been called the partial disaggregation model (Bagozzi & Heatherton, 1994; Leone et al., 2001) to distinguish it from the total disaggregation model in which all individual items load on their factors and from the total aggregation model where all items are averaged or summed. It might be argued that the total disaggregation model would be more informative, but such a model requires more parameters to be estimated, and therefore it needs larger samples. Moreover, single items are more vulnerable to measurement error and sample specificity (Leone et al., 2001). As the partial disaggregation reduces the number of observed variables and parameters, it permits modelling with smaller sample sizes and reduces the likelihood of computational problems. In addition, it reduces measurement error in the observed indicators (see e.g. Bagozzi, 1993; Bentler, 1989; Leone et al., 2001). In our application, the aggregation was also useful to obtain a more continuous-like variable (8- and 12-point scales instead of the original 4-point scale).

The models were estimated with a maximum likelihood approach. Missing data were handled by listwise deletion (casewise deletion led to similar results). To determine the fit of the Confirmatory Factor Analysis (CFA) models, we used the approach and the cut-off criteria as proposed by (Hu & Bentler, 1998, 1999), meaning that a model fits the data if its standardized-root-mean-squared residual (SRMR) is lower than 0.09 and the comparative fit index (CFI) is higher than 0.95.

Two-factor solution

The two-factor model was tested first. It comprised three indicators for the BIS factor and six indicators for the BAS factor (two indicators per BAS subconcept). The SRMS was equal to 0.10 and 0.12, and the CFI was equal to 0.99 and 0.99 for the samples 1 and 2, respectively. From the SRMS values, it can be concluded that the two-factor model does not sufficiently fit our data in none of both samples, so that constructing a general BAS measure by summing over the three BAS subscales may yield interpretation problems.

Four-factor solution

This model comprised of three indicators for the BIS factor, and two indicators for each BAS factor. Every indicator loaded on its (sub)scale factor. This model fitted our data well (SRMR = 0.04, CFI = 0.99 for Sample 1; SRMR = 0.03, CFI = 0.99 for Sample 2), confirming the adequacy of the four-dimensional structure as proposed by Carver & White (1994). For both samples, the factor loadings are given in Table 2 and the correlations between the factors are given in Table 3. Note, that the inter-factor correlations are larger than the inter-scale correlations (Table 1) because the correlations between the latent factors are corrected for unreliability.

When the total disaggregation model was used, similar conclusions about the best fitting model were obtained. Because of this result, the relations with the Big-Five personality dimensions should be investigated while treating the BAS scales as separate variables.

Explaining the Big-Five personality Surface by the BIS/BAS Scales

Note that simply correlating both sets of variables or regressing the BIS/BAS scales on the NEO-FFI scales will not give us a clear answer to the question which part of the Big Five can be explained by BIS and BAS. First, the sum scores of the NEO-FFI scales

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Table 2. Factor loadings of the four-factor model for Samples 1 and 2

	Sample 1					Sample 2				
	BIS	BASD	BASF	BASR	Error variance	BIS	BASD	BASF	BASR	Error variance
BIS1	0.75				0.45	0.73				0.46
BIS2	0.83				0.31	0.84				0.29
BIS3	0.77				0.41	0.80				0.36
BASD1		0.65			0.58		0.66			0.56
BASD2		0.91			0.17		0.92			0.15
BASF1			0.70		0.51			0.57		0.68
BASF2			0.45		0.80			0.85		0.29
BASR1				0.58	0.67				0.53	0.72
BASR2				0.64	0.59				0.71	0.49

Note: All factor loadings are significant at the 0.01 level.

are correlated in our samples (e.g. Neuroticism and Extraversion correlated −0.28 in Sample 1 and −0.37 in the Sample 2) and this is not exceptional (e.g., Gosling, Rentfrow, & Swann Jr., 2003; McCrae & Costa, 2004), so that correlations between BIS/BAS and Big-Five variables will be contaminated by the correlations between the Big-Five variables when separate multiple regressions would be done. Second, both the BIS/BAS scales and the NEO-FFI scales are just markers of the underlying traits. Their unreliability suppresses the inter-correlations and the regression coefficients, when the predictive structure is investigated at the manifest level.

Therefore, we opted for a Structural Equation Model (SEM) approach, in which the BIS/BAS variables are measured with the same item parcels as before and in which each of the Big-Five variables is measured with item parcels of three items, so that each Big-Five variable has four indicators. In correspondence with the fact that the Big Five should be five orthogonal dimensions, no correlations were allowed between the latent Big-Five variables other than those induced by the latent predictor variables (left part of Figure 1). Finally, the latent Big-Five variables were regressed on the latent BIS/BAS variables. See Figure 1 for a graphical representation of the structural part of this model.

This model fitted our date reasonably well (SRMR = 0.07, CFI = 0.99 for Sample 1; SRMR = 0.09, CFI = 0.99 for Sample 2). However; when exploring the correlations between the latent variables, it was noticed that the latent BAS variables were

Table 3. Factor correlations of the four-factor model for Sample 1 (first line) and Sample 2 (second line)

	BIS	BASD	BASF	BASR
BIS	1			
BASD	−0.19	1		
	−0.30			
BASF	−0.24	0.54	1	
	−0.16	0.58		
BASR	0.31	0.39	0.59	1
	0.42	0.43	0.55	

Note: All correlations are significant at the 0.01 level.

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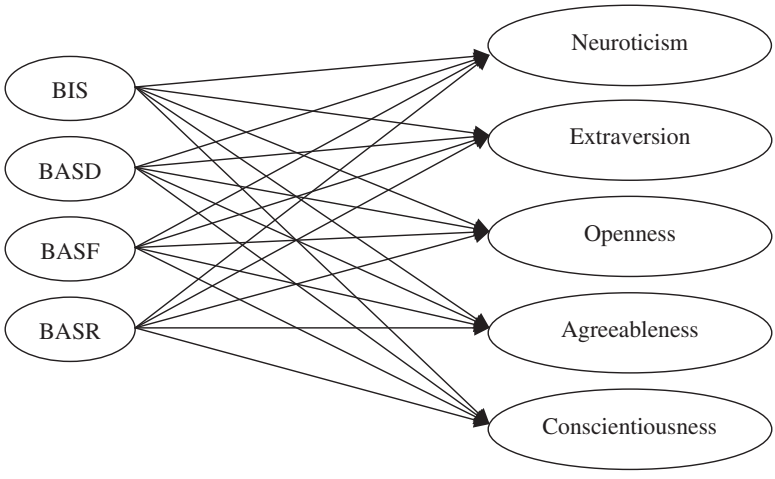


Figure 1. Structural model for regressing the Big Five on BIS/BAS.

highly correlated. For example in Sample 1 BASR correlated 0.69 with BASF and 0.64 in Sample 2. This finding is not unexpected given the inter-factor-correlations mentioned in Table 3. Second, some R^2 values were unreasonably high given the correlations between the predictors and the dependent latent Big-Five variable, which suggest that suppressor effects are present. By consequence, neither the regression coefficients nor the R^2 can be interpreted due to multicollinearity. Therefore, two additional SEMs were fitted without a regression between the latent variables, but with only correlations instead. In the first SEM, the correlations among the latent Big-Five variables (the unexplained part) were restricted to zero (Model 1), whereas in the second SEM, correlations were allowed between all latent variables including the latent Big-Five variables (Model 2). It was necessary for Model 1 to fit that three groups of error covariances were introduced: between indicators of Neuroticism and Extraversion, between indicators of Extraversion and Openness and between indicators of Agreeableness and Conscientiousness. Note that one cannot implement similar error covariances in Model 2 because it would lead to an unidentified model.

Model 1 displays the relations between BIS/BAS and the Big Five, and these relations are not contaminated by the relations between the latent Big-Five variables (SRMR = 0.09, CFI = 0.95 for Sample 1; SRMR = 0.09, CFI = 0.99 for Sample 2). Model 2 shows the same relations between the BIS/BAS scales and the NEO-FFI scales, but now with correlations between the latent Big-Five variables indeed (SRMR = 0.07, CFI = 0.99 for Sample 1; SRMR = 0.08, CFI = 0.99 for Sample 2). For both models, the correlations are corrected for unreliability, because they are correlations between latent variables. In order to estimate the amount of variance of the Big Five which is explained by the BIS/BAS and at the same time avoiding suppressor effects, stepwise regression were performed with the factor scores of the latent BIS/BAS variables as predictors of the factor scores of the latent Big-Five variables. The factor scores were computed in LISREL by an extension of a formula given by Anderson & Rubin (1956). When all predictors were introduced, suppressor effects were found with an effect on R^2. The stepwise procedure is an improvement because it does not yield any aberrant R^2 (too high in comparison with the

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correlations), but a disadvantage is that it may depend on small differences in the correlations which predictors are selected. Furthermore, the R^2 are not corrected for unreliability anymore, as they are not part of the SEM, but estimated in a separate analysis. The correlations (Model 1 and Model 2) and the R^2 values (of the stepwise regressions) are given in Table 4. From the regression analysis, we report only the values of R^2, but not the regression weights, because of the earlier mentioned disadvantage.

In the following, we will use a conservative strategy in interpreting our results, by requiring replication across samples and across models, so that our findings are neither due to specific features of one sample, nor to the empirically found relations between the NEO-FFI scales. For relations that do not generalize over samples or models, further evidence is needed before they can be considered reliable findings.

First, a general finding is that the correlational pattern is very similar across both samples and also across both models. Second, primarily Neuroticism and Extraversion can be predicted well from BIS/BAS. The predictive power of BIS/BAS for the other three Big-Five variables is lower, but not negligible.

Neuroticism related primarily to BIS, BASD and BASF. A positive relation was found with BIS, whereas the relation with BASD and BASF was found to be negative. The expected low positive correlation with BASR was not found. Individual differences in *Extraversion* can almost equally well be explained from BIS/BAS. In agreement with our hypothesis, Extraversion related positively to all BAS scales. In addition, a negative correlation was found between Extraversion and BIS. For both dimensions, the predictive value of BIS/BAS was rather high.

Table 4. Correlations between latent variables for BIS/BAS and Big Five for Sample 1 (first line) and Sample 2 (second line) for Model 1 (no correlations between latent Big-Five) and Model 2 (correlations between latent Big-Five)

		BIS	BASD	BASF	BASR	R^2
Model 1	Neuroticism	0.68**	−0.24**	−0.43**	−0.08	0.51**
		0.76**	−0.36**	−0.28**	0.11	0.59**
	Extraversion	−0.30**	0.16**	0.69**	0.36**	0.45**
		−0.29**	0.43**	0.59**	0.25**	0.36**
	Openness	−0.09	−0.06	0.11	−0.11	0
		−0.05	−0.06	0.23**	0.13	0.12**
	Agreeableness	0.33**	−0.29**	−0.26**	0.13	0.20**
		0.35**	−0.40**	−0.29**	−0.02	0.21**
	Conscientiousness	0.19**	0.21**	−0.28**	0.16	0.32**
		0.15**	0.02	−0.25**	0.04	0.14**
Model 2	Neuroticism	0.67**	−0.25**	−0.36**	−0.10	0.55**
		0.76**	−0.32**	−0.25**	0.10	0.62**
	Extraversion	−0.20**	0.10	0.67**	0.41**	0.53**
		−0.24**	0.31**	0.53**	0.23**	0.30**
	Openness	−0.22**	−0.03	0.16	−0.14	0.05
		0.07	−0.04	0.26**	0.11	0.13**
	Agreeableness	0.21**	−0.22**	−0.03	0.21**	0.15**
		0.31**	−0.28**	0.05	0.10	0.15**
	Conscientiousness	0.00	0.27**	−0.21**	0.18**	0.38**
		0.06	0.06	−0.23**	0.03	0.13**

*significant at $p < 0.05$; **significant at $p < 0.01$

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The other three Big-Five dimensions are predicted by BIS/BAS to a smaller extent (lower R^2). For *Openness*, a significant negative relation between Openness and BASF was found, but only in Sample 2. In Sample 1, this correlation was also positive, but not significant. *Agreeableness* was positively related to BIS and negatively to BASD and BASF in Model 1. In Model 2 where the latent Big-Five scales were allowed to correlate, the association with BASF disappears, but the other two correlations remain significant. Finally, *Conscientiousness* was predicted to a moderate degree by BIS/BAS in Sample 1, but less well in Sample 2. As expected, Conscientiousness was negatively related to BASF, significantly so in the both samples, but in addition also a significant positive correlation with BASD was found in Sample 1. These results were similar across both models. Only when the latent Big-Five variables are not allowed to correlate (Model 1) a positive correlation was found between Conscientiousness and BIS.

DISCUSSION AND CONCLUSIONS

In both samples, the structure of the BIS/BAS scales turned out to be four-dimensional: one dimension for the BIS scale and one for each of the three BAS scales. These results were confirmed by differential relations of the BIS scale and the three BAS scales with the Big-Five scales. Also Carver & White (1994), Heubeck et al. (1998), Jorm et al. (1999), Leone et al. (2001) and Ross et al. (2002) found that four dimensions are needed. Our results generalize this finding to a non-English speaking population. The fact that we found the expected four-dimensional structure for the translated BIS/BAS questionnaire also supports the validity of the translation.

Sometimes, BAS activity is measured as the sum of the three BAS scales (e.g. Harmon-Jones, 2003, Gable et al., 2000, Gomez & Gomez, 2002, Gomez & McLaren, 1997, O'Gorman & Baxter, 2002). Because the four-factor structure has a better fit than the two-factor structure, we conjecture that it pays off to look at the separate subscales for a more differentiated view on the BAS scores. This was confirmed by the differential relational pattern of the BIS/BAS latent variables with the Big-Five personality dimensions.

Several authors assume, although sometimes implicitly, that BIS/BAS underlies part of the surface of personality as described for example by the Big-Five (e.g. Corr, 2001; Gray, 1970; Matthews & Gilliland, 1999). In our study, two out of the Big-Five variables (N and E) could be predicted quite well based on BIS/BAS as measured by the BIS/BAS inventory of Carver & White (1994). This finding supports the theory of Gray (1970, 1981) that the Neuroticism and Extraversion dimensions are a rotation of the BIS and BAS dimensions. However, the relation between Neuroticism and Extraversion seems more complicated than Neuroticism and Extraversion just being a 45° rotation of the BIS/BAS structure (Gray, 1981), as according to our findings Neuroticism and Extraversion need to be rotated to a smaller degree and in opposite directions (see Table 4). The other three Big-Five personality dimensions are not part of this theory.

In accordance with our hypotheses and earlier findings, *Neuroticism* is highly positively related with BIS and negatively with several BAS measures (See e.g. Heubeck et al., 1998; Jackson & Smillie, 2004; Jorm et al., 1999). Our results are not surprising, but they can nevertheless shed light on the meaning of the personality factor Neuroticism. In the literature Neuroticism is defined in different ways: as emotional control (Fiske, 1949), negative emotionality (Tellegen, 1985), as negative affect and disturbed thoughts and behaviours that accompany emotional distress (McCrae & Costa, 1987), as anxiety (Cattell, 1957), and as emotional (in)stability (Guilford, 1975; Hofstee, Raad, & Goldberg, 1992; Lorr, 1986). The

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positive relation between BIS and Neuroticism suggests that Neuroticism can be understood in its original meaning of emotional instability, meaning that one's emotions depend strongly on external and therefore varying circumstances. BIS reflects a *reaction* towards events that occurred or are expected, and hence a sensitivity to these events. Emotional Stability, on the other hand, is in agreement with more stable and personality related forces in the person. The link of Neuroticism with negative affect can be understood assuming that the basic affective tone is positive (as one may assume it is for most people). Deviations from it, and therefore instability, would be mainly induced by negative events or circumstances and with negative affect as a consequence. The sensitivity interpretation is in agreement with the fact that recently several authors argued that BIS activity, which is highly correlated with Neuroticism, can be responsible for positive as well as for negative emotions: Although BIS activity or avoidance behaviour is strongly associated with negative emotionality (Elliot & Thrash, 2002), it can also cause positive emotions such as reactions of relief for example when an expected punishment fails to occur (Carver, 2003). The sensitivity/reactivity interpretation can also explain why not also BASR is negatively correlated with Neuroticism, like the other two BAS scales. Also BASR implies a reaction and sensitivity, but related to positive events. However, contradictory to our interpretation, the correlation between BASR and Neuroticism was not consistently positive, and when positive, it was not significant.

In line with our hypotheses, *Extraversion* was positively related to all BAS scales, although one correlation is not significant. Moreover, Extraversion was also negatively related to BIS. Similar relations between BIS, BAS and Extraversion are obtained by several authors (Heubeck et al., 1998; Jackson & Smillie, 2004; Jorm et al., 1999) when relating BIS/BAS to the personality dimensions of Eysenck.

Openness is hardly predicted at all by BIS/BAS. Only BASF had a positive effect on Openness in one sample (Sample 2). This finding can be explained based on the description of Openness, as openness to feelings and new ideas, flexibility of thought and readiness to indulge in fantasy (Costa & McCrae, 1985). As BASF reflects a desire for new rewards, it is not surprising that this variable relates positively to Openness. However, this was not a consistent finding and would need replication to draw conclusions.

The results for *Agreeableness* are stronger and more consistent. Agreeableness was positively related to BIS and negatively to BASD. When the Big-Five were treated as uncorrelated variables, a negative relation was found between Agreeableness and BASF in both samples. The consistent positive association between Agreeableness and BIS is plausible as activation of BIS can favour agreeable behaviour because it stops behaviours in which punishment or cessation of reward is expected, including social punishment or social rewards. That a negative correlation was found with pursuing one's goals in a persistent way (BASD) makes also sense because BASD implies that one gives priority to one's own goals instead of trying to please others. The negative relation between Agreeableness and BASF, which is more tentative as it was only found with Model 1, but not with Model 2, can be explained as based on impulsivity, a close correlate of BASF (Zelenski & Larsen, 1998), and found to be negatively associated with Agreeableness (e.g. Blackburn & Coid, 1998: Nigg, 2002).

Finally, *Conscientiousness* was predicted to a reasonable extent by BIS/BAS in one sample, but to a lower extent in the other sample. A consistent finding was its negative correlation with BASF. The positive correlation with BASD was found only in one sample, so that the possibility exists that it is not a general finding but due to a specific characteristic of the sample in question. A plausible explanation for the negative relation between Conscientiousness and BASF is that BASF is highly related to impulsivity

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(Zelenski & Larsen, 1999), which on its turn can be contrasted with Conscientiousness (Markon, Krueger, & Watson, 2005). In correspondence with this hypothesis, when allowing for correlations among the Big-Five scales, Neuroticism, which comprises the facet impulsivity, was slightly negatively related to Conscientiousness in both samples ($r = -0.30$ in Sample 1 and $r = -0.16$ in Sample 2). The positive correlation with BASD can be explained as stemming from persistence and consistency, which are aspects of both.

The major correlations other than those with Neuroticism and Extraversion are correlations with Agreeableness and Conscientiousness, the combination of which contributes to the negative pole of Eysenck's Psychoticism factor (Eysenck, 1992a, 1992b; Markon et al. 2005). From our results, it may be derived that Agreeableness and Conscientiousness are both positively correlated with BIS and negatively with BASF. Therefore, one may expect Psychoticism to be negatively correlated with BIS and positively with BASF. This expectation is confirmed in the study by Jorm et al. (1999). In addition, Jorm et al. (1999) found a positive correlation between BASD and Psychotism. This correlation is not so easy to explain from our results. BASD seems negatively related to Agreeableness, but in one study it seems also positively related to Conscientiousness. The positive correlation between BASD and Psychotism as found by Jorm et al. (1999) may therefore be based primarily on the lack of Agreeableness aspect of Psychotism, and not so much on a lack of Conscientiousness aspect. The association of BASD with Conscientiousness seems less robust, as it was significant in only one of both studies.

When consistency over samples *and* models is used as a strict criterion for inference, it must be concluded that Agreeableness is related to the combination of BIS and the absence of BASD, whereas Conscientiousness seems to be associated with the absence of BASF. This implies that the relation with BIS/BAS would depend on which aspect of Psychoticism is concerned.

In sum, Neuroticism and Extraversion can be predicted well by BIS/BAS, but also for Agreeableness and Conscientiousness consistent findings were obtained. The current findings extend earlier findings in which primarily the Neuroticism–BIS, Extraversion–BAS association was prominent. Also two other Big-Five dimensions seem to have a clear link to BIS/BAS, although BIS/BAS is certainly not a sufficient explanation for all individual differences in those dimensions.

Finally, although the results are in line with a view that suggests some causality, the correlational nature and the lack of longitudinal data, is too weak a basis to corroborate causal speculation.

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