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MMPI-2 predictors of Gray's two-factor reinforcement sensitivity theory

Pilar Segarra [a,*], Scott R. Ross [b], M. Carmen Pastor [a], Susana Montañés [a], Rosario Poy [a], Javier Moltó [a]

[a] *Department of Psychology, Jaume I University, Campus de Riu Sec, s/n, Castellón 12071, Spain*
[b] *Department of Psychology, DePauw University, Greencastle, IN 46135, USA*

Abstract

This study examined the utility of the MMPI-2 to predict Gray's BIS/BAS dimensions in a sample of 193 Spanish undergraduates. Although the MMPI-2 is composed of numerous scale indices, we focused on the clinical, content, and the Personality Psychopathology-Five (PSY-5) scales. Overall, findings confirmed hypothesized associations between BIS/BAS factors and MMPI-2 indices. BIS scores demonstrated strong, positive relationships with numerous indices of anxiety, neuroticism, and negative affect, whereas BAS scores were positively related to indices of impulsivity, positive affect, disinhibition, extraversion, and anger. Multiple regression analyses further highlighted PSY-5 Negative Emotionality/Neuroticism scale and content scales of Low Self-esteem and Anxiety as predictors of BIS activity. By contrast, BAS activity was predicted by PSY-5 Positive Emotionality/Extraversion scale, the content scale of Type A Behavior, and the clinical scale of Hypomania. As expected, PSY-5 Constraint scale was a potent predictor of both BIS (positively) and BAS (negatively). Of particular interest, PSY-5 Aggressiveness scale predicted BIS and not BAS activity. Implications of these multivariate formulas for the assessment of BIS and BAS dimensions using the MMPI-2 are discussed.
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Keywords: Behavioral inhibition system; Behavioral activation system; MMPI-2; Reinforcement sensitivity theory

* Corresponding author. Tel.: +34 964 729 566; fax: +34 964 729 267.
  E-mail address: segarra@psb.uji.es (P. Segarra).

1. Introduction

Biological models of motivation and emotion are drawing increased attention from researchers in personality. Gray's (1970, 1982, 1987) reinforcement sensitivity theory (RST) is now one of the most influential biological theories of personality (Smillie & Jackson, 2006). The original RST posits two major systems of emotion underlying two orthogonal personality dimensions: The Behavioral Inhibition System (BIS) responds to signals of punishment and signals of non-reward, but also to high intensity, innate fear or novel stimuli, and is proposed as the causal basis of anxiety; the Behavioral Approach System (BAS) responds to signals of reward and signals of non-punishment, and is related to impulsivity. Although the theory was born of basic animal learning research and not at all concerned with personality, Gray's model is attractive because it provides a "plausible way of accounting, in terms of brain functioning, for several sorts of psychopathology" (Carver & White, 1994, p. 320). To this extent, we have recently examined the relationships between BIS/BAS and MMPI-2 Personality Disorder Scales in a non-clinical sample of Spanish college students (Pastor et al., 2007). Our findings confirmed the relationship between BIS and Cluster C (characterized by "anxious fearful behavior"), and showed that the BAS is related to Cluster B (characterized by "erratic behavior").

Using multiple putative measures of BIS and BAS, this study extends these findings examining the relationships between Gray's personality dimensions and clinical/personality indices derived from the Minnesota Multiphasic Personality Inventory-2 (MMPI-2; Butcher, Dahlstrom, Graham, Tellegen, & Kaemmer, 1989). Given the popularity of both Gray's model and the MMPI-2, an examination of the representation of Gray's dimensions in the MMPI-2 seems timely.

1.1. Gray's RST and psychopathology

There is growing interest in relating normal personality traits to psychological disorders (e.g., Costa & Widiger, 1994). In this area, RST has clear implications because abnormal functioning of BIS and BAS systems is believed to underlie a broad range of adult psychopathologies (e.g., Fowles, 1988). Indeed, Gray (1970) was among the earliest to suggest that individuals characterized by an overactive BIS are prone to develop anxiety and negative feelings, with several studies supporting this link to increased neuroticism and negative affect in anxiety disorders (Fowles, 1988; Mineka, Watson, & Clark, 1998). Conversely, an underactive BIS has been linked to primary psychopathy (Gray, 1987; Lykken, 1995; Newman, MacCoon, Vaughn, & Sadeh, 2005). An overactive BAS, however, has been linked to extraversion (Newman, Widom, & Nathan, 1985), mania (Meyer, Johnson, & Carver, 1999), and secondary psychopathy (Lykken, 1995; Newman et al., 2005). Although the authors concur on the psychopathologies just named, they diverge regarding the source of other disorders. For example, depression has been linked to an underactive BAS and low levels of positive affect (Henriques, Glowacki, & Davidson, 1994; Pinto-Meza et al., 2006), but also to an overactive BIS (Johnson, Turner, & Iwata, 2003; Meyer et al., 1999).

1.2. Gray's RST and MMPI-2 indices

The MMPI-2 remains the most widely used instrument in clinical assessment (Pope, Butcher, & Seelen, 1999). Furthermore, the breadth of the MMPI-2 in assessing psychopathology and per-

sonality bode well for representing Gray's personality dimensions. For example, core features of BIS overactivity (i.e., anxiety, neuroticism, and negative affect) are reflected in a number of MMPI-2 indices, including clinical scales of Psychasthenia, Depression and Social Introversion, and content scales of Anxiety, Fears, Depression, and Obsessiveness (Butcher et al., 1989). In contrast to the BIS, the BAS reflects a more heterogeneous manifestation of personality characteristics, such as positive affect (Davidson, 1992), disinhibition (Lykken, 1995), extraversion (Smillie & Jackson, 2006), and anger (Carver, 2004). Additionally, some studies have demonstrated a direct link between depression and self-reported BAS underactivity (Pinto-Meza et al., 2006). Of the clinical scales, Hypomania (positively, reflecting impulsivity), in addition to Depression and Social Introversion (negatively, reflecting lack of positive affect and extraversion) should be good indicators of overall BAS activity. Similarly, many of the content scales also reflect individual differences in BAS activation, such as Antisocial Practices (reflecting disinhibition), Social Discomfort (reflecting extraversion), as well as Anger, Cynicism, and Type A Behavior (reflecting anger and irritability).

Moreover, the MMPI-2 Personality Psychopathology-Five (PSY-5) scales also show promise in the measurement of Gray's factors. On the heels of the five-factor model of normal personality, Harkness, McNulty, and Ben-Porath (1995) developed the PSY-5 as a new dimensional system for representing abnormal personality in the MMPI-2. Although relationships among the PSY-5 dimensions and the BIS and BAS have not been explicitly tested, some theoretical support exists for differentially linking most PSY-5 dimensions to the BIS and BAS constructs. Thus, PSY-5 Negative Emotionality/Neuroticism scale entails a broad affective disposition to experience a wide range of unpleasant emotions, particularly anxiety (i.e., high BIS activation). By contrast, the PSY-5 Positive Emotionality/Extraversion scale reflects a global disposition to experience positive affects (i.e., high BAS activation). PSY-5 Constraint, indexing low impulsivity and disinhibition, has been shown to be negatively related to extraversion and positively to neuroticism (Trull, Useda, Costa, & McCrae, 1995), suggesting associations with both BIS (+) and BAS (−). Finally, recent research has demonstrated that anger-out and aggression are positively related with BAS and negatively to BIS, (Smits & Kuppens, 2005), it thus being plausible to expect that PSY-5 Aggressiveness scale would be related to both BAS (+) and BIS (−).

1.3. Current study

Given the popularity of Gray's constructs in characterizing individual differences in normal and abnormal personality, our study aimed to determine the relationship between Gray's dimensions and indices from the MMPI-2. Because no clear consensus has been reached about how to assess these dimensions (Caseras, Ávila, & Torrubia, 2003), we used factor analysis, employing multiple measures of BIS and BAS, to represent Gray's dimensions of anxiety and impulsivity, respectively.

Despite a plethora of MMPI-2 indices, we focused on the clinical, content, and PSY-5 scales to examine the utility of these scales in assessing BIS and BAS dimensions. Consistent with previous findings, we expected that the BIS would be positively related to MMPI-2 clinical scales of Psychasthenia, Depression, and Social Introversion, as well as content scales of Anxiety, Fears, Obsessiveness, Depression, and Low Self-esteem (reflecting anxiety, neuroticism, and negative affect). Additionally, PSY-5 scales of Negative Emotionality/Neuroticism and Constraint should also

show a positive association with BIS activity, representing increased sensitivity to punishment and apprehensiveness. In contrast, PSY-5 Aggressiveness scale should be negatively related to BIS factor.

The BAS factor, in contrast, should demonstrate positive correlations with MMPI-2 clinical scales of Hypomania and Psychopathic Deviate (reflecting impulsivity), and also should show negative associations with Depression (reflecting positive affect) and Social Introversion (reflecting extraversion). Similarly, we hypothesized that MMPI-2 content scales of Antisocial Practices (positively, reflecting impulsivity), as well as Anger, Cynicism, and Type A Behavior (positively, reflecting anger and disinhibition), Depression and Social Discomfort (negatively, reflecting low positive affect and extraversion, respectively) would be related to BAS activity. Moreover, PSY-5 scales of Positive Emotionality/Extraversion and Aggressiveness should be positively related to the BAS, whereas PSY-5 Constraint should be negatively related to this factor. No hypotheses about specific associations of PSY-5 Psychoticism with BIS and BAS factors were posed, given the lack of the related literature to support them.

In addition to testing the unique predictive power of individual MMPI-2 scales, we derived multivariate formulas based on the PSY-5, content, and clinical scales for representing individual differences in BIS and BAS activity. We believed that regression analyses could prove useful in furthering the investigation of the BIS and BAS dimensions in psychopathology.

2. Method

2.1. Participants and procedure

A total of 208 students from the Jaume I University (Castellón, Spain) participated in this study. This sample is the same reported in Pastor et al. (2007). All participants completed Spanish adaptations of the STAI-T, SPSRQ, BIS/BAS, and MMPI-2, in that order. To eliminate invalid test profiles, we employed the following exclusionary criteria for the MMPI-2: Cannot Say > 30, VRIN or TRIN > 80 T, F > 100 T, Fb > 110 T and <30 T greater than F, and Fp > 100 T (Butcher et al., 2001). This procedure excluded 15 participants of the initial sample. Thus, the final sample was composed of 79 male (41%) and 114 female (59%) students with an average age of 20.1 (SD = 2.7) years.

Participants were solicited from undergraduate courses across multiple disciplines. In small group sessions ranging from 20 to 40 students, volunteers were informed of their rights as research participants and gave written consent prior to receiving measures. To minimize the potential influence of response biases, anonymity was emphasized by a random code appearing at the top of each measure. Participants were given monetary remuneration (12 €) for their time.

3. Measures

The Behavioral Inhibition and Activation Scales (BIS/BAS; Carver & White, 1994) is a 24-item Likert scaled (4 points) self-report measure of Gray's behavioral inhibition (BIS) and activation

systems (BAS). The BIS/BAS is composed of four scales, one for measuring individual differences in BIS activation (BIS-CW; 7 items), and three scales for assessing BAS functioning: Drive (BAS-DR; 4 items), Fun-Seeking (BAS-FS; 4 items), and Reward Responsiveness (BAS-RR; 5 items). Studies support the reliability and validity of these scales in North-American samples (e.g., Carver & White, 1994; Ross, Millis, Bailley, & Bonebright, 2002). In our sample, internal consistency (coefficient alpha) was .74 for BIS-CW, .68 for BAS-DR, .66 for BAS-FS, and .54 for BAS-RR.

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia, Ávila, Moltó, & Caseras, 2001) is a 48-item yes/no self-report measure also developed to assess individual differences in Gray's dimensions. The SPSRQ is composed of two scales: The Sensitivity to Punishment (SP) scale assesses differences in the anxiety dimension following Gray's description of the BIS, and includes 24 questions about habitual behaviors in response to punishment and signals of non-reward and novel stimuli. The Sensitivity to Reward (SR) scale was created to measure individual differences in Gray's impulsivity dimension, and includes 24 items describing situations in which people could do something (reflecting instrumental learning) to obtain rewards. These scales have demonstrated good reliability and construct validity in both Anglo-Saxon and Spanish samples (e.g., Brebner, 1998; Caseras et al., 2003; Torrubia et al., 2001). In the current study, coefficient alpha was .86 for SP and .77 for SR.

The Trait Anxiety Scale (STAI-T) from the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) is a 20-item Likert scaled (4-point) self-report questionnaire that measures anxiety as a general personality trait. The North-American and Spanish (Seisdedos, 1982) manuals of this measure provide detailed information supporting the reliability and validity of this scale in both countries. In our sample, coefficient alpha was .85.

Minnesota Multiphasic Personality Inventory-2 (MMPI-2; Butcher et al., 1989) is a 567-item true/false self-report measure of psychopathological and clinically relevant personality traits. The authorized Spanish adaptation was developed by Ávila and Jiménez (2000), and this process carefully followed the internationally accepted rules for translation. The MMPI-2 is composed of numerous scales, but here we focused on the clinical, content, and PSY-5 scales. The use of the clinical scales for assessing personality and psychopathology in North-American and Spanish populations is supported by a host of studies, although these scales lack discriminant validity (Greene, 2000). However, the content scales have less item overlap than the clinical scales, offering better construct validity (Jackson, Fraboni, & Helmes, 1997). Indeed, fifteen content scales (see Table 1 for the scale names) were precisely developed using both rational and statistical methods to group items in order to provide relevant data on traits, behaviors or symptoms not available from clinical scales (Butcher, Graham, Williams, & Pen-Porath, 1990). Finally, the Personality Psychopathology Five (PSY-5; Harkness et al., 1995) is a set of MMPI-2 scales to measure five personality constructs that the authors believe are relevant to psychopathology: Aggressiveness, Psychoticism, Constraint, Negative Emotionality/Neuroticism, and Positive Emotionality/Extraversion. There is adequate support for the convergent and discriminant validity of these scales in clinical and normal samples (e.g., Harkness et al., 1995; Trull et al., 1995). For the MMPI-2 scales used in this study, internal consistencies (Cronbach's alphas) ranged from .55 (Paranoia) to .87 (Schizophrenia) for clinical scales, from .59 (Type A Behavior) to .84 (Cynicism) for content scales, and from .61 (Aggressiveness) to .77 (Negative Emotionality/Neuroticism) for PSY-5 scales.

Table 1
Relationships for MMPI-2 clinical, content, and PSY-5 scales with factors of behavioral inhibition and behavioral activation

MMPI-2 indices	Behavioral inhibition factor	Behavioral activation factor
Clinical scales		
Hypochondriasis	.48**	.12
Depression	.60**	−.24*
Hysteria	.26**	−.07
Psychopathic deviate	.30**	.31**
Paranoia	.36**	.15
Psychasthenia	.74**	.12
Schizophrenia	.43**	.25*
Hypomania	−.01	.55**
Social introversion	.52**	−.34**
Content scales		
Anxiety	.66**	.18
Fears	.47**	−.06
Obsessiveness	.64**	.07
Depression	.65**	.16
Health concerns	.44**	.16
Bizarre mentation	.15	.34**
Anger	.21*	.42**
Cynicism	.09	.38**
Antisocial practices	−.14	.50**
Type A behavior	.14*	.45**
Low self-esteem	.64**	.02
Social discomfort	.11	−.29**
Family problems	.25*	.25**
Work interference	.61**	.07
Negative treatment indicators	.47**	.12
PSY-5 scales		
Negative Emotionality/Neuroticism	.67**	.24**
Positive Emotionality/Extraversion	−.31**	.32**
Aggressiveness	−.33**	.45**
Psychoticism	.20	.37**
Constraint	.40**	−.52**

Note: Correlations that differed significantly ($p < .01$) according to Steiger's (1980) test for dependent samples are given in italics.
* $p < .01$.
** $p < .001$.

4. Data analysis

Multi-measure representations of BIS and BAS dimensions were derived using common factor analysis with varimax rotation. Details of this analysis are given in Pastor et al. (2007). The BIS factor was composed of the STAI-T, SP, and BIS-CW; the BAS factor was composed of the SR, BAS-FS, BAS-DR, and BAS-RR scales. Using regression-based factor scores, zero-order corre-

lations were computed for the BIS and BAS factors with clinical, content, and PSY-5 scales from the MMPI-2. Finally, two multiple regression equations were performed to determine MMPI-2 predicted scores representing the BIS and BAS factors, respectively. For these analyses, the PSY-5 personality scales were entered together in step 1, to determine the collective contribution of all PSY-5 scales in predicting BIS and BAS dimensions. In order to bolster MMPI-2 prediction of Gray's dimensions, we included theoretically-related content and clinical scales in subsequent steps (2 and 3). Content scales were entered before clinical scales because the former have greater construct specificity than the clinical scales (Greene, 2000).

5. Results

5.1. Relationship of BIS and BAS factors and MMPI-2 clinical and content scales[1]

Zero-order correlations among MMPI-2 clinical and content scales with derived BIS and BAS factor scores are given in Table 1. Of the clinical scales, Psychasthenia was the most highly associated with BIS, with Hypochondriasis, Hysteria, and Schizophrenia showing modest to moderate associations. For the BAS, Hypomania demonstrated the strongest (positive) association. Depression and Social Introversion (scales reflecting negative affect as well as decreased extraversion) were positively correlated with the BIS, and negatively correlated with the BAS factor. Steiger's (1980) *t* test for dependent correlations indicated a strong pattern of divergence for clinical scales by BIS and BAS factors. Notable exceptions were the Psychopathic Deviate, Paranoia, and Schizophrenia scales, which did not show significant differences between their correlations with BIS and BAS factors.

The vast majority of content scales demonstrated a strong pattern of divergence with the BIS and BAS factors. As expected, Anxiety, Fears, Obsessiveness, and Low Self-esteem scales showed positive and strong correlations with the BIS, consistent with the role of anxiety and neuroticism in behavioral inhibition. In contrast, Anger, Cynicism, Antisocial Practices, and Type A Behavior scales showed positive and moderate correlations with the BAS factor, highlighting an impulsive, aggressive, and competitive lifestyle. Also as expected, the Social Discomfort scale was negatively related to the BAS, providing additional evidence for the relationship between extraversion and the BAS. Importantly, the Depression scale showed a positive and strong correlation with the BIS, and was unrelated to the BAS.[2]

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[1] Scores in both clinical and content scales for our student sample were highly similar to Spanish normative data, with T-scores ranging from 46 to 55 (all within ±.5 SD about the mean). Data were collapsed across gender in all analyses because an examination of correlations with gender partialled out revealed an identical pattern of relationships between BIS and BAS factors and MMPI-2 indices (mean difference in *rs* < .05). Futhermore, when the differences between genders were analyzed with *r*-to-*z* test, only 1 of the 58 comparisons emerged as significant at the .05 level.

[2] Moreover, the content scales of Health Concerns, Work Interference, and Negative Treatment Indicators showed strong correlations only with BIS factor, probably reflecting neuroticism.

5.2. Relationship of BIS and BAS factors to MMPI-2 PSY-5 scales

Table 1 also shows the correlations of the PSY-5 scales with BIS and BAS factors. Not surprisingly, Negative Emotionality/Neuroticism scale was more related to the BIS than to the BAS. Also as expected, Constraint was moderately correlated with both BIS (positively) and BAS (negatively). Positive Emotionality/Extraversion and Aggressiveness scales, interestingly, were moderately correlated with both BIS (−) and BAS (+) factors. Finally, Psychoticism showed a modest correlation with the BAS factor.

5.3. Multivariate assessment of BIS and BAS activity

In order to determine the PSY-5 contribution to BIS and BAS, two hierarchical multiple regression analyses were conducted including all PSY-5 scales in the first block. Additionally, to increase prediction and representation of Gray's constructs in multivariate models, we included theoretically-relevant content and clinical scales in second and third blocks, respectively. To test for the additive power of content and clinical scales over the PSY-5, stepwise entry was used on the second and third blocks. Although stepwise procedures can lead to spurious findings in multiple regression (Thompson, 1995), the potential set of predictors were chosen based on a priori grounds for linking these MMPI-2 indices to Gray's model. Table 2 displays the final coefficients of the variables included in these two regression analyses.

In the first regression, we examined the MMPI-2 scales in predicting the BIS factor. Although the clinical scale of Psychasthenia was strongly related to this factor, we dropped it from this analysis to avoid problems of multicolinearity with other variables (e.g., Obsessiveness, Low Self-esteem, and Depression; $rs > .75$). When PSY-5 scales were entered simultaneously in the first step, they accounted for 66% of the variance in BIS scores ($F(5,187) = 72.37$, $p < .0001$, $R = .81$). Additionally, in the second step, content scales of Anxiety, Fears, Obsessiveness, and Low Self-esteem were allowed to enter if they improved prediction. Only Anxiety and Low Self-Esteem entered into the equation, adding significantly to prediction ($R^2\Delta = .06$, $p < .0001$). In the third step, clinical scales of Depression and Social Introversion similarly were allowed to enter but did not significantly add to prediction. The final model resulted in a cumulative R^2 of .72 ($R = .85$) and retained significance ($F(7,185) = 67.63$, $p < .0001$). PSY-5 scales of Negative Emotionality/Neuroticism, Constraint and Aggressiveness, and the content scales of Low Self-esteem and Anxiety were retained as significant predictors of BIS scores.

For the BAS, the PSY-5 scales were entered together in the first step, the content scales of Anger, Cynicism, Antisocial Practices, and Type A Behavior were entered in the second step, and the clinical scales of Hypomania, Psychopathic Deviate, and Depression were entered in the third step. In order to avoid an overrepresentation of the extraversion construct, neither the content scale of Social Discomfort nor the clinical scale of Social Introversion were entered in the regression analysis. The resulting equation was significant ($F(7,185) = 26.16$, $p < .0001$) and accounted for 50% of the variance ($R = .71$), with content ($R^2\Delta = .019$, $p < .01$) and clinical scales ($R^2\Delta = .020$, $p < .01$) significantly adding to model prediction. PSY-5 scales of Positive Emotionality/Extraversion and Constraint, the content scale of Type A Behavior, and the clinical scale of Hypomania were retained as significant predictors of BAS scores (see Table 2).

Table 2
Hierarchical multiple regression analyses with PSY-5, clinical, and content scales of MMPI-2 predicting BIS and BAS constructs

Model predictors	B	β	t	p
BIS factor				
Block 1 (PSY-5 scales)				
Negative Emotionality/Neuroticism	.07	.39	5.68	.000
Positive Emotionality/Extraversion	−.01	−.05	−1.23	.219
Aggressiveness	−.05	−.15	−2.93	.004
Psychoticism	−.02	−.08	−1.56	.120
Constraint	.05	.25	5.32	.000
Block 2 (content scales)				
Low self-esteem	.06	.29	5.10	.000
Anxiety	.04	.19	2.83	.005
Constant	−1.79		−5.19	.000
BAS factor				
Block 1 (PSY-5 scales)				
Negative Emotionality/Neuroticism	.01	.08	1.19	.236
Positive Emotionality/Extraversion	.05	.23	4.03	.000
Aggressiveness	−.01	−.03	−.36	.720
Psychoticism	.02	.07	.10	.319
Constraint	−.07	−.35	−5.37	.000
Block 2 (content scales)				
Type A behavior	.05	.21	2.87	.005
Block 3 (clinical scales)				
Hypomania	.04	.21	2.72	.007
Constant	−1.58		−3.69	.000

6. Discussion

The strong associations between BIS scores and the clinical scale of Psychasthenia, the content scales of Anxiety, Fears, Obsessiveness, and Low Self-esteem, and PSY-5 Negative Emotionality/ Neuroticism firmly support Gray's hypothesis that the BIS is related to anxiety and negative affect. By contrast, the fact that BAS scores were strongly associated with indicators of impulsivity and disinhibition (clinical scale of Hypomania, the Antisocial Practices content scale, and PSY-5 Constraint), extraversion (clinical scale of Social Introversion), and anger (content scales of Anger and Type A Behavior) evidenced that impulsivity is a heterogeneous construct. Regarding indices of Depression, our findings suggested that both clinical and content depression scales assessed more general negative affect than absence of positive emotionality, consistently with Johnson et al. (2003).

Comparison of the magnitude of relationships for the BIS and BAS with MMPI-2 indices further highlights the differential role of BIS and BAS in the manifestation of psychopathology. Specifically, 22 of 29 comparisons were significantly different (see Table 1), supporting the discriminant validity of these factors vis-à-vis psychopathology.

Additionally, the MMPI-2 better represented the BIS ($R = .85$) than the BAS ($R = .71$), consistent with the predominance of neuroticism in psychopathology (see Greene, 2000). Multiple regression supported the depiction of high BIS scorers as being anxious, vulnerable, constrained, and prone to negative affect. In contrast, high BAS scorers were higher in hypomanic activation and positive affect, but less constrained. Multivariate associations with impatience, irritable and critical tendencies were also consistent with previous findings pointing to increased anger and BAS activity (Carver, 2004). Interestingly, PSY-5 Aggressiveness was a significant negative predictor of BIS, but not BAS, being consistent with Smits and Kuppens's (2005) findings, who found that aggressiveness is primarily due to low inhibitory activation instead of strong approach-motivating activity.

It is also important to note that the content scale of Anxiety, but not Fears, predicted BIS activity, supporting the Gray and McNaughton's (2000) distinction between fear and anxiety and their hypothesis regarding BIS relation to the anxiety state (see also Corr, 2004; McNaughton & Corr, 2004).

Despite generally positive findings for the MMPI-2 vis-à-vis Gray's dimensions, the current study was limited by the use of a single method (i.e., self-report) to assess BIS and BAS activity. Additionally, our sample was composed solely of college students. Although appropriate to use a normal sample in assessing Gray's BIS/BAS dimensions, the MMPI-2 was developed on clinical samples that evidence extremes of behavior and maladaptive functioning. Consequently, the inclusion of only undergraduates could have restricted the range of correlations observed. If so, our design likely favoured Type II error and attenuation of observed effect sizes. Nonetheless, given the growing application of Gray's RST model to psychopathology, the inclusion of clinical samples with anxiety (i.e., "internalizing") disorders, and those with impulsive (i.e., "externalizing") disorders, would extend the current findings. Future research should address this issue to better understand how normal personality trait dimensions may represent and further inform investigators about the etiology of psychopathologies. To this end, the multivariate formulas derived in this study may facilitate research on the BIS/BAS in psychopathology, given the frequent use of the MMPI-2 in the assessment of clinical disorders. Although future studies examining the generalizability of these formulas are needed, they provide clinicians with existing MMPI-2 databases for a provisional method of determining individual differences in BIS and BAS activity.

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