



Sensitivity of Gray's Behavioral Inhibition System in clinically anxious and non-anxious children and adolescents

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ABSTRACT

The child version of the Carver and White (1994) BIS/BAS-scales (Muris et al., 2005) was used to assess sensitivity of the Behavioral Inhibition and the Behavioral Activation System in clinically anxious and non-anxious youth ($n = 175$, ages 8–18 years, 70 boys). Results supported the hypothesis that clinical anxiety is associated with overactivity in the BIS (Gray, 1982). Consistent with the revised Reinforcement Sensitivity Theory (Gray & McNaughton, 2000) the BIS-scale consists of two subscales, one measuring BIS_Anxiety and one measuring FFFS_Fear. BIS-scores were higher in the anxious sample than in the non-anxious sample. BAS-scores were equal. Higher levels of BIS-activity were related with an increase in symptoms of anxiety and depression. BIS-scores were higher in girls than in boys, there were no gender differences in BAS-scores.

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1. Introduction

Gray's Reinforcement Sensitivity Theory (RST; 1982) postulates how behavior follows from activity in two major brain systems: the Behavioral Approach (BAS) and the Behavioral Inhibition System (BIS). Both systems function independently from one another and are sensitive to different types of reinforcement. The BIS constitutes sensitivity to punishment and conditioned aversive stimuli, the BAS involves responsiveness to reward and other appetitive stimuli. Activity in both systems is related with different emotional and behavioral consequences. BIS-activity leads to feelings of anxiety and initiates behavioral inhibition. BAS-activity is linked with positive feelings and triggers approach behavior.

In addition to its involvement in normal behavior, activity in both systems is thought to underlie different types of psychopathology (e.g., Gray, 1982; Kimbrel, 2008; Quay, 1988). Overactivity of the BIS is assumed to be a vulnerability factor for internalizing problems. Underactivity of the BIS and overactivity of the BAS (or a combination) are thought to be risk factors for externalizing problems. Empirical studies provide evidence for the association of BIS and BAS with various psychopathological symptoms in adults (for review, Bijttebier, Beck, Claes, & Vandereycken, 2009). For example, overactivity in the BAS is found to be associated with

Attention Deficit Hyperactivity Disorder and psychopathy (e.g., Mitchell & Nelson-Gray, 2006; Uzieblo, Verschueren, & Crombez, 2007), while high BIS is associated with symptoms of anxiety and depression (e.g., Kimbrel, Nelson-Gray, & Mitchell, 2007). Research on the role of BIS/BAS-sensitivity in youth psychopathology is based on work by Quay (1988, 1997) who developed a theoretical framework for internalizing and externalizing behavior in children, based on Gray's model. Consistent with the assumptions in adult psychopathology research, Quay linked childhood emotional and behavioral problems to inadequate activation of the BIS, the BAS or both systems. Evidence for the role of BIS and BAS in childhood psychopathology is provided by studies using performance based measures as indices of BIS/BAS-activity. For example, overactivity of the BAS in children with conduct disorder and comorbid ADHD is found in studies using reward contingency tasks (e.g., Matthys, Van Goozen, De Vries, Cohen-Kettenis, & Van Engeland, 1998). Evidence for increased BIS-activity in clinically anxious children has been found using an anxiety-specific version of the stop task (Vervoort et al., submitted for publication).

Several studies used parental rating scales to explore the role of BIS and BAS in internalizing and externalizing behavior in community samples of non-selected children and adolescents (Blair, 2003; Colder & O'Connor, 2004). Studies with self-report questionnaires show that children can provide valid indices for BIS/BAS-sensitivity (e.g., Muris et al., 2005; Slobodskaya, Knyazev, Saffronova, & Wilson, 2003). The BIS/BAS-scales by Carver and White (1994) are

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the most extensively used self-report BIS/BAS-measures. The original questionnaire, developed for adults, contained 20 items and 4 scales: a BIS-scale (with 7 items, e.g., “I worry about making mistakes”) and three BAS-scales. When the original adult version of the BIS/BAS-scales was administered to a community sample of children between 6 and 14 years, meaningful relations between BIS/BAS-scores and symptoms of anxiety and depression have been found (Coplan, Wilson, Frohlick, & Zelenski, 2006). Although this suggests that the adult version of the BIS/BAS-scales can be used with young participants, Muris et al. (2005) developed an age downward version of the questionnaire. Factor analysis showed that this child version contained two factors: one for BIS-sensitivity and one for BAS-sensitivity. In community samples, BIS-scores were positively correlated with Neuroticism and negatively with Extraversion. BAS-scores were positively related to both Neuroticism and Extraversion. High BIS-scores were associated with more emotional problems, whereas high BAS-scores were related with more externalizing problems (Bjørnebekk, 2009; Muris et al., 2005; Sportel, Nauta, de Hullu, Hartman, & de Jong, in preparation).

Despite the relevance of the BIS/BAS-model for childhood psychopathology, there are no studies validating the Carver and White (1994) BIS/BAS-scales in clinical youth samples. Although studies in community samples suggest that extreme BIS/BAS-scores are risk factors for psychological disorders (Sportel et al., in preparation), knowledge of BIS/BAS-profiles in youth who already have developed psychopathology is still limited. Therefore, the current study used the child version of the BIS/BAS-scales (Muris et al., 2005) to compare BIS/BAS-sensitivity between clinically anxious and non-anxious children and adolescents. We expected BIS-scores, but not BAS-scores, in the clinical sample to be higher than in the non-anxious sample. Additionally, we examined associations between BIS/BAS-sensitivity and emotional problems. We expected high BIS-scores to be associated with an increase in emotional symptoms (both anxiety and depression). BAS-scores were expected not to be correlated with anxiety, but to be negatively associated with depression symptoms.

Although the core assumption regarding the relation between BIS and anxiety disorders (i.e. anxiety involves hyperactivity in the BIS) still holds, Gray's original model (1982) has been revised several times. One adaptation involves the relation between BIS and BAS. Gray stated that both systems were independent from one another (i.e. the separable subsystems hypothesis, Pickering, 1997). Since there was only limited support for two orthogonal systems, Corr (2001, 2002) suggested that, under normal conditions, the BIS and BAS might be interdependent and have a joint influence on behavior. Consistent with this so-called joint subsystems hypothesis, BIS and BAS-scores were correlated in community samples of children and adolescents (Bjørnebekk, 2009; Muris et al., 2005). In extreme cases, as in the presence of anxiety disorders, however, Corr expected both systems to act independently as separate systems, since the overactive BIS disproportionately suppresses the influence of the BAS. We will test whether BIS and BAS will jointly predict anxiety symptoms.

Another adaptation to the model (Gray, 1987; Gray & McNaughton, 1996, 2000) relates to its focus on a third system, the Fight-Flight-Freeze System (FFFS), which is activated by conditioned and unconditioned aversive stimuli and initiates escape behavior. Similarly to the proposed involvement of BIS in feelings of anxiety, the FFFS is thought to underlie emotions of fear and panic. While overactivity in the BIS is assumed to be an underlying factor in all anxiety disorders, overactivity in the FFFS is assumed to be related to panic disorder, social phobia and specific phobia (Gray & McNaughton, 2000; Kimbrel, 2008; Zinbarg & Lira Yoon, 2008). Empirical research on this third system is still scarce (Bijttebier et al., 2009), in part because most existing measures to test Gray's theory are based on the original BIS/BAS-model and do not yield

separate scores for BIS and FFFS-sensitivity (Carver & White, 1994; Muris et al., 2005; for exception see Jackson, 2009). However, BIS-items in the Carver and White BIS/BAS-scales might tap both systems (Corr & McNaughton, 2008). Indeed, the BIS-scale seems to incorporate two oblique subscales: BIS-Anxiety (4 items, e.g., “I worry about making mistakes”) and FFFS-Fear (3 items, e.g., “I have few fears compared to my friends”) (Heym, Ferguson, & Lawrence, 2008). We will test whether this two-factor structure can also be extracted from the BIS-scale in our youth sample and we hypothesized that BIS-Anxiety would be associated with all anxiety disorder symptoms, whereas FFFS-Fear would be mostly associated with symptoms of panic disorder and social phobia.

2. Method

2.1. Participants

Participants were 175 children and adolescents (aged 8–18 years old, $M = 13.11$, $SD = 2.53$). Sixty participants (20 boys), recruited in a secondary school in a Dutch urban region, were included in the control group (CON) if no (sub-)clinical internalizing problems were reported by the parents on the Child Behavior Checklist ($T < 65$; which corresponds to the bottom 93% of the general population; Achenbach & Rescorla, 2001; Verhulst & van der Ende, 2001) and if they had no treatment history.

One hundred and fifteen anxiety disordered children and adolescents (50 boys) were included in the clinically anxious group (ANX). All were referred to one of two outpatient child psychiatric units in the Netherlands (de Bascule, Amsterdam and Accare, Groningen). Anxiety diagnoses according to the DSM-IV-criteria were based on a semi-structured diagnostic interview, the Anxiety Disorders Interview Schedule for DSM-IV – Child and Parent Version (ADIS-IV:C/P, Siebelink & Treffers, 2001; Silverman & Albano, 1996). Based on parent and child interviews, a clinical diagnosis with clinician severity rating (CSR, ranging between 1 and 8) was provided. Children were included in the ANX-group when the CSR was 4 or higher (indicative for clinical anxiety diagnosis) on at least one anxiety disorder. Primary diagnoses included Social Phobia (SP, 33.3%), Separation Anxiety Disorder (SAD, 13.9%), Specific Phobia (20.4%), Generalized Anxiety Disorder (GAD, 22.2%) and Panic Disorder with or without Agoraphobia (PD, 10.2%). There was considerable anxiety comorbidity: 68.4% of the anxious participants received two or more anxiety diagnoses (75.7%), an additional mood disorder diagnosis (18.6%), or a comorbid ADHD diagnosis (5.7%). All participants were free of anxiolytic medication and they had not received cognitive behavioral therapy for their anxiety disorder in the last 6 months prior to inclusion in the study. Before treatment, children and parents were asked to participate in a study on mediators and moderators of CBT for anxiety. Participants filled out the questionnaires during a 1-h individual test session, in the presence of one experimenter leader. After this test session, participants in the ANX-group received CBT.

The study design was approved by the medical ethics committee of both participating clinics. Written informed consent was obtained from both children (aged 12 and older, $n = 108$) and their parents.

2.2. Questionnaires

2.2.1. BIS/BAS-scales

Sensitivity of the Behavioral Inhibition and the Behavioral Activation System was indexed by the child version of Carver and White (1994) BIS/BAS-scales (Muris et al., 2005). Twenty items are scored on a 4-point scale (0 = not true, 1 = somewhat true, 2 = true, 3 = very true). Seven items make up the BIS-scale and in-

clude statements as “I am very fearful compared to my friends”). Thirteen items make up the BAS-scale, and include statements such as “I often do things for no other reason than that they might be fun”. In community samples, BIS and BAS-scores were meaningfully related to personality indices and symptoms of psychopathology (Bjørnebekk, 2009; Muris, Meesters, & Schouten, 2002; Muris et al., 2005; Sportel et al., in preparation). Internal reliability of the BIS ($\alpha = .80$) and BAS-scores ($\alpha = .85$) in the present study was good.

2.2.2. Revised Child Anxiety and Depression Scale – short version (RCADS25)

Self-reported symptoms of DSM-IV anxiety and depression diagnoses were measured with the Dutch short version of the Revised Child Anxiety and Depression Scale (RCADS, Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000; RCADS25, Muris et al., 2002). The RCADS25 consists of 25 items that have to be rated on a 4-point scale (0 = never, 1 = sometimes, 2 = often, 3 = always). There are 4 scales referring to anxiety disorders (SP = Social Phobia, SAD = Separation Anxiety Disorder, PDA = Panic Disorder (with agoraphobia), GAD = Generalized Anxiety Disorder) and one to Major Depressive Disorder (MDD). A total anxiety score (RCADS25-ANX) is calculated by summing across all anxiety scales. Eleven RCADS-forms were missing. Internal reliability in the present study was good ($\alpha = .89$ for anxiety; $\alpha = .75$ for depression).

3. Results

3.1. Distinguishing between BIS_Anxiety and FFFS_Fear in the BIS-scale

Confirmatory factor analysis (CFA), run with the sem-package of R (R Development Core Team, 2009), was used to test the Heym et al. (2008) two-factor model. Items and item variances were specified as free, factor variances were fixed at 1. Values for root mean square error of approximation (RMSEA) between .05 and .10 and fit indices greater than .9 indicate good fit (Hu & Bentler, 1999; Stevens, 1996). The model showed acceptable fit to the data (RMSEA = .08, Bentler's Comparative Fit Index CFI = .95, Bentler-Bonnet's Normed Fit Index NFI = .95, Tucker-Lewis Non-Normed Fit Index NNFI = .93). Internal reliability of the BIS_Anxiety-scores ($\alpha = .76$) and FFFS_Fear-scores ($\alpha = .61$) was low.

Table 1

Descriptive statistics for all questionnaires as a function of group and gender.

	ANX				CON			
	Boys		Girls		Boys		Girls	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)
BIS	9.10	(4.02)	11.58	(4.09)	5.14	(3.44)	9.49	(4.58)
BIS_Anxiety	4.04	(2.89)	5.74	(2.78)	2.67	(2.31)	5.26	(2.98)
FFFS_Fear	5.06	(1.88)	5.85	(1.86)	2.48	(1.60)	4.23	(1.94)
BAS	16.36	(8.17)	14.57	(5.76)	15.90	(5.59)	19.15	(6.45)
RCADS25-ANX	13.53	(8.75)	19.28	(10.47)	4.79	(4.14)	11.39	(7.16)
SP	4.55	(3.24)	6.48	(3.51)	2.79	(2.32)	5.19	(3.00)
PAD	2.41	(2.18)	3.92	(3.24)	0.37	(0.60)	1.52	(1.96)
SAD	3.22	(3.18)	4.37	(3.35)	0.58	(1.02)	1.26	(1.50)
GAD	3.35	(2.97)	4.51	(3.91)	1.05	(1.58)	3.42	(3.15)
RCADS25-MDD	3.16	(2.29)	4.54	(2.87)	1.79	(1.40)	3.03	(2.48)

Note: BIS: Behavioral Inhibition System, BAS: Behavioral Activation System; RCADS25: Revised Child Anxiety and Depression Scale (short version), ANX: Anxiety Scale, SP: Social Phobia, PAD: Panic Disorder, SAD: Separation Anxiety Disorder, GAD: Generalized Anxiety Disorder, MDD: Major Depressive Disorder.

Table 2

Correlations with age and between scores on the BIS/BAS-scales and anxiety questionnaires.

	BIS	BIS_Anx	FFFS_Fear	BAS
Age	.26***	.26***	.19*	-.11
BIS		.92***	.84***	.11
BIS_Anxiety			.55***	.21*
FFFS_Fear				-.07
RCADS25-Anx	.70***	.61***	.63***	.11
SP	.73***	.73***	.53***	.04
PAD	.56***	.47***	.54***	-.00
SAD	.45***	.33***	.48***	.04
GAD	.46***	.37***	.44***	.23**
RCADS25-MDD	.55***	.44***	.54***	.08

Note: BIS: Behavioral Inhibition System, BAS: Behavioral Activation System; RCADS25: Revised Child Anxiety and Depression Scale (short version), ANX: Anxiety Scale, SP: Social Phobia, PAD: Panic Disorder, SAD: Separation Anxiety Disorder, GAD: Generalized Anxiety Disorder, MDD: Major Depressive Disorder.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

3.2. Descriptive statistics and correlations

Table 1 shows the descriptive statistics for all scales, separately for each group and for boys and girls. Table 2 shows correlations of BIS/BAS-scores with age and with the other scale scores. To control for the effects of age on BIS-scores, partial correlations are reported for the BIS-scales. Bivariate correlations describe relations of BAS-scores with RCADS25-scores.

3.3. Group and gender differences

To test for group and gender differences in the three BIS-scores, 2 (group: ANX vs. CON) \times 2 (gender: boy vs. girl) ANCOVAs with age as covariate was conducted. After controlling for the significant effect of age, there was a significant main effect of group on all three BIS-scale scores (BIS: $F(1, 170) = 37.40$, BIS_Anx: $F(1, 170) = 10.27$, FFFS_Fear: $F(1, 170) = 74.39$, all $ps < .001$), and a significant main effect of gender, (BIS: $F(1, 170) = 19.86$, $p < .001$, BIS_Anx: $F(1, 170) = 10.27$, $p < .01$, FFFS_Fear: $F(1, 170) = 12.42$, $p < .001$). The interaction between group and gender was not significant for the total BIS-score, $F(1, 170) = 3.55$, $p = .06$, and the BIS_Anx-score, $F(1, 170) = 1.72$, $p = .19$. For FFFS_Fear-scores, there

Table 3
Predicting anxiety symptoms (RCADS25_Anx) with BIS and BAS.

	ANX				CON			
	<i>B</i>	<i>SE(B)</i>	β	<i>p</i>	<i>B</i>	<i>SE(B)</i>	β	<i>p</i>
Constant	5.51	4.38		.21	7.97	7.95		.32
Age	−0.50	0.33	−.14	.13	−0.82	0.57	−.11	.16
BIS	1.54	0.21	.64	<.001	1.26	0.12	.82	<.001
BAS	0.09	0.12	.06	.45	0.15	0.08	.15	.06
Model statistics	$R^2 = .61, F(3, 113) = 21.50, p < .001$				$R^2 = .86, F(3, 49) = 43.76, p < .001$			

was a significant interaction between group and gender, $F(1, 170) = 4.55, p = .03$.

For BAS-scores, a 2 (group: ANX vs. CON) \times 2 (gender: boy vs. girl) ANOVA revealed non-significant main effects of group, $F(1, 171) = 3.53, p = .06$ and gender, $F(1, 171) = 0.44, p = .51$, but a significant interaction, $F(1, 171) = 5.26, p = .02$.

3.4. Separate vs. joint subsystems

A linear regression analysis with age, BIS and BAS-scores as predictors and RCADS25-Anx-scores as outcome variable was performed separately for each group (Table 3). In the CON-group, both BIS and BAS predicted anxiety scores, although the effect of BAS was only marginally significant. In the ANX-group, only BIS, not BAS-scores predicted anxiety scores.

4. Discussion

The present study examined BIS/BAS-sensitivity in clinically anxious and non-anxious children and adolescents using the child version of the Carver and White (1994) BIS/BAS-scales (Muris et al., 2005). Factor analysis showed that in the BIS-scale two subscales could be distinguished: a BIS_Anxiety-scale and a FFFS_Fear-scale. Participants in the ANX-group scored higher on BIS-scales than in the CON-group and girls had higher BIS-scores than boys. BAS-scores were equal in both samples, and for boys and girls. BIS-scores increased with age, but there was no age effect on BAS. BIS-scores were meaningfully related to indices emotional problems.

The current study adds to the evidence for Gray's Reinforcement Sensitivity Theory (1982) by showing that stronger activity in the BIS is indeed related to higher levels of anxiety. BIS-scores in the clinically anxious sample were higher than in the non-anxious sample and than in the community sample of the Muris et al. (2005) study. In community samples BIS-sensitivity, but not BAS-sensitivity, is associated with anxiety symptoms (e.g., Børnebekk, 2009; Muris et al., 2002, 2005). The present study extends these findings by showing that, in a sample of clinically anxious youth, high levels of BIS indeed are associated with more self-reported anxiety symptoms, whereas BAS-levels in anxious and non-anxious youths are equally moderate. Like Heym et al. (2008), we were able to distinguish a separate BIS_Anxiety and FFFS_Fear factor in the original BIS-scale consistent with recent RST revisions (Gray & McNaughton, 2000). As far as we know, the present study is the first in which both BIS as a total scale and BIS_Anxiety and FFFS_Fear as separate subscales are studied in children and adolescents. Other than Heym et al. (2008) who associated the subscales with personality dimensions, we studied relations between subscale scores and emotional symptoms. Consistent with the idea that BIS_Anxiety is related with all types of anxiety, BIS_Anxiety-scores were significantly related to all anxiety-related RCADS25-subscales. The correlations involving FFFS_Fear were strongest for panic disorder and social anxiety disorder. Contrary to the idea

that depression is associated with high levels of BIS in combination with low levels of BAS, BAS-scores in the present sample were not related to the RCADS25-depression measure. This is inconsistent with previous studies reporting negative correlations between BAS-sensitivity and depression in both community samples and clinically depressed patients (e.g., Kasch, Rottenberg, Arnow, & Gotlib, 2002; Kimbrel et al., 2007). However, it is consistent with Corr's (2002) idea that extremely high BIS-sensitivity in a clinically anxious sample might overrule the effects of BAS-sensitivity. In the present non-depressed sample, BAS-scores seem not extreme enough to overcome this BIS-dominance. The exact relationship between BIS and BAS-sensitivity and psychopathological symptoms in samples of clinically anxious children with and without comorbid (ADHD or depressive) problems awaits further examination.

Other than in the Muris et al. (2005) community sample, BIS and BAS-scores were unrelated to one another in the present study. This seems to suggest that BIS and BAS are separate systems. When investigating the influence of BIS and BAS in the prediction of anxiety symptoms, however, a more fine-grained picture emerges. In non-anxious individuals BIS and BAS both predict anxiety. In clinically anxious individuals, BIS has a unique influence on anxiety symptoms, independent of BAS. The findings that BIS and BAS have a joint influence in normal situations, but are independent in extreme cases (as in clinical samples) are consistent with Corr's (2001, 2002) revision of Gray's Reinforcement Sensitivity Theory (1982) in terms of the distinction between joint and separable subsystems hypotheses. It seems that, in community samples, both BIS and BAS have an influence on behavior, but if one of the systems is overactive (i.e. the BIS in anxiety disorders), it overrules the activity of the other system.

Results of the present study should be interpreted in light of several limitations. One might argue that the present sample size is too small for conducting factor analysis, since sample sizes of at least 300 participants are frequently advocated (e.g., Comrey & Lee, 1992; Tabachnick & Fidell, 2001). Other authors, however, state that 5–15 participants per variable are needed (e.g., Kass & Tinsley, 1979; Nunnally, 1978). Following these more liberal rules, the present sample size was large enough, given the 7 items that make up the original BIS-scale. More recently, Kline (2005) considered between 100 and 200 subjects as a minimum, and following his guidelines, the present sample can be considered "medium-sized". Moreover, we added Tucker–Lewis NNFI as model fit index, because it is independent of sample size. Future research could replicate the study in larger samples.

As with other cross-sectional studies, it is impossible to draw causal conclusions from the present results. The study was correlational, and aimed at replicating and extending previous findings on the relationships between BIS-activity and anxiety. In order to get insight into the exact nature of this link, however, longitudinal studies are needed.

Another limitation of the present study relates to its exclusive focus on the BIS dimension of Gray's Reinforcement Sensitivity Theory (1982). This restriction was driven by the fact that we wanted to investigate the role of Gray's BIS-concept in childhood

and adolescent anxiety as a part of a major research project on cognitive behavioral therapy for youths with anxiety disorders. Other studies did investigate BIS and BAS-sensitivity in youngsters. For example, Muris et al. (2005), tried to fit a four-factor structure to the BIS/BAS-scales (one BIS-factor and three BAS-factors: Drive, Fun Seeking and Reward Responsiveness), but they concluded that there were only two factors: one for BIS and one for BAS. Apart from that, the most notable revision of Gray's model involves the description of role of the FFFS-component in anxiety (Gray & McNaughton, 2000), but this was never before tested in childhood clinical anxiety. Therefore, we choose to focus our investigations on BIS and FFFS in emotional problems. A test of the full theory, investigating both BIS and BAS-sensitivity (and their factors) in internalizing and externalizing disorders would be more comprehensive. Moreover, it would be interesting to follow Bijttebier et al.'s (2009) other recommendations, and not only take into account RST revisions as we did in the present study, but also to adopt a developmental perspective, to study different models of the relationship between BIS/BAS-sensitivity and psychopathology (e.g., direct vs. indirect relations), and to investigate potential mediators and moderators of this link (e.g., cognitive processes, attachment style). Once there is clarity established on the link between BIS/BAS-sensitivity and childhood psychopathology, this knowledge can be introduced in studies on the role of RST-related concepts in psychotherapy.

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