



## BEHAVIORAL INHIBITION SYSTEM FUNCTIONING IN ANXIOUS, IMPULSIVE AND PSYCHOPATHIC INDIVIDUALS

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**Summary**—Behavioral inhibition system (BIS) functioning (Gray, *The psychology of fear and stress*. Cambridge University Press, 1987) was assessed by measuring whether approach responses were emitted more slowly when a cue for punishment was present. Experiment 1 compared high- and low-anxious as well as high- and low-impulsive university students. As predicted by Gray's model (Gray, *The neuropsychology of anxiety*. New York: Oxford University Press, 1982), high-anxious subjects responded more slowly than low-anxious subjects on cue-present vs cue-absent displays. Experiment 2 compared incarcerated psychopaths and nonpsychopaths subdivided into high- and low-anxious groups. Consistent with weak BIS models of psychopathy (Fowles, *Psychophysiology*, 17, 87-104, 1980; Gray, *The psychology of fear and stress*, Cambridge University Press, 1987), psychopaths displayed less inhibition than controls on cue-present trials, but this effect was limited to comparisons involving high-anxious psychopaths and controls.

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Meeting one's goals typically involves a plan of action for operating on the environment. Associated with goal-directed behavior, there is enhanced allocation of attentional resources to relevant behavioral and environmental stimuli. However, goal-directed behavior will tend to be ineffective and even maladaptive if it is not coupled with careful monitoring of other (i.e. peripheral) environmental cues (Kahneman, 1973). Such cues are essential for anticipating potential problems and altering response strategies that would otherwise result in aversive outcomes (e.g. punishment, omission of expected rewards). Thus, coordinating goal-directed activity with attention to peripheral environmental cues may be necessary for successful interactions with the environment (see Wallace, Bachorowski & Newman, 1991).

Cognitive-behavioral theories of self-regulation emphasize the role of *controlled information processing* for monitoring, evaluating, and revising perceptions, interpretations, and response strategies that individuals regard as inappropriate. Kanfer and Gaelick (1986), for instance, state that the onset of self-regulation involves "a qualitatively different mode of cognitive functioning, called controlled processing" (p. 287). Although controlled processing may be necessary while a person is actively striving to "deautomatize troublesome behavior patterns" (p. 288), the use of controlled processing resources to evaluate behavior on an *ongoing* basis would be exhausting and inefficient, and, thus, unlikely. In fact, there appears to be general agreement that most information processing, as well as most behavior, is highly automatized (see Gilbert, Krull & Pelham, 1988; Hollon & Garber, 1990; Kanfer & Gaelick, 1986). If cognitive processing and behavior typically proceed in a relatively automatic fashion, then there must be a relatively autocratic mechanism for checking behavior and cognition so that they may be interrupted when controlled processing and self-regulation are required.

The neuropsychological model of anxiety put forward by Gray (1987a, b) provides a useful framework for considering the processes that mediate the automatic checking of goal-directed behavior and the shift to controlled processing. In particular, Gray has described a hypothetical behavioral inhibition system (BIS) that "responds to signals of punishment, signals of frustrative nonreward, and novel stimuli by inhibiting ongoing behaviour, increasing readiness for action (arousal level), and increasing attention to environmental stimuli" (p. 262). According to Gray,

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"the chief function of the behavioural inhibition system is to monitor ongoing behaviour, checking continuously that outcomes coincide with expectations. In this role, it scans incoming sensory information for threatening or unexpected events and, if they occur, brings all other behaviour to a halt so as to evaluate the nature of the threat" (p. 368). In essence, then, the BIS represents a mechanism for effecting the relatively automatic shift to controlled processing and initiation of self-regulation.

A number of investigators have noted the potential relevance of BIS activity for personality and psychopathology. Gray (1982), for instance, equates anxiety with activity in the BIS and has proposed a biologically-based personality dimension of anxiety, with low anxiety being associated with a weak BIS and high anxiety being associated with a strong BIS. Gray (1981) has related his model to H. J. Eysenck's personality model of extraversion and neuroticism (Eysenck, 1981). Gray's anxiety dimension is anchored by neurotic introverts (strong BIS) on one end and by stable extraverts (weak BIS) on the other. According to Gray's conceptualization, neurotic introverts and other trait anxious individuals are differentially predisposed to interrupt ongoing behavior and redirect attention in response to cues for punishment, nonreward, and novelty.

In Gray's model, the personality dimension of 'impulsivity' is orthogonal to the anxiety dimension and is anchored by neurotic extraverts at the high impulsivity end and by stable introverts at the low impulsivity end. Gray relates impulsivity to the absolute strength of his behavioral approach system (BAS) which determines sensitivity to reward/approach cues (cf. Wallace *et al.*, 1991). Although impulsivity is theoretically independent of BIS functioning, impulsive subjects may be less likely to interrupt ongoing behavior and redirect attention to punishment cues owing to their stronger approach responses (see Gray, 1991; Newman & Wallace, 1993).

Other investigators have proposed that psychopaths and other 'disinhibited individuals' (Gorenstein & Newman, 1980) are characterized by a weak BIS (Fowles, 1980) or by related problems that render the BIS ineffective (Newman, Widom & Nathan, 1985; Patterson & Newman, 1993; Quay, 1993). Individuals with a weak or ineffective BIS would be less responsive to cues for punishment and nonreward and thus, be hampered in their ability to monitor and adjust ongoing behavior automatically in accord with changing environmental contingencies (Newman, 1987).

In light of its potential importance for explaining inhibitory (e.g. anxiety disorders) as well as disinhibitory (e.g. psychopathy) psychopathology, a direct method for assessing BIS activity would facilitate research on these problems. After reviewing numerous studies which examined psychophysiological responding in approach and avoidance situations, Fowles (1980, 1988) proposed that BAS and BIS activity may be indexed by heart rate and skin conductance responding, respectively. Preliminary evidence relating to this proposal is encouraging (e.g. Fowles, Fisher & Tranel, 1982) but, regardless of its validity, it would be useful to have multiple measures of BIS functioning and it would be especially useful to have a behavioral as well as a psychophysiological assessment device.

Toward this end, we have developed a face valid, behavioral measure of BIS functioning. First, subjects complete a 150 trial pretreatment during which they must inhibit behavior (button presses) in the presence of a particular stimulus (the letter 'Q') in order to avoid punishment. The purpose of this pretreatment is to establish the letter Q as a cue for punishment (i.e. as an input to the BIS). Second, subjects perform a visual search task in which the Q is irrelevant but is presented on 50% of the trials to measure its effect on performance. By subtracting a subject's mean response time on Q-absent trials from their mean response time to Q-present trials, it is possible to measure the degree to which the Q elicited *behavioral inhibition*.

The purpose of this investigation was to: (a) examine the validity of our measure of BIS functioning by contrasting the performance of high- and low-anxious subjects; (b) assess the discriminant validity of the measure by contrasting the performance of high- and low-impulsive subjects; and (c) evaluate the hypothesis that low-anxious psychopaths are characterized by weak BIS functioning.

## EXPERIMENT 1

Experiment 1 was designed to assess the validity of our measure of BIS functioning by contrasting the performance of neurotic introverts and stable extraverts. According to Gray, neurotic introverts

are characterized by a strong BIS and high trait anxiety whereas stable extraverts are characterized by a weak BIS and low trait anxiety. Given our assumption that responding more slowly on Q-present than on Q-absent trials relates to BIS functioning, neurotic introverts should slow down significantly more (i.e. display greater behavioral inhibition) than stable extraverts. Although our primary hypotheses relate to the behavior of neurotic introverts and stable extraverts who epitomize high and low BIS functioning, respectively (Gray, 1981; Wallace *et al.*, 1991), supplementary analyses were conducted using the trait form of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushene, 1970) because it is a more widely used measure of trait anxiety. Finally, we report comparisons involving neurotic extraverts and stable introverts to evaluate whether there is an association between Gray's impulsivity dimension and our measure of BIS functioning.

## METHODS

### *Subjects*

Subjects were 76 male undergraduates who volunteered to participate in this study in order to gain experience and earn extra credit points for introductory psychology courses at the University of Wisconsin-Madison. Only male subjects were tested to facilitate comparison with the male prisoners used in Experiment 2.

All subjects completed the EPQ (Eysenck & Eysenck, 1975) and the STAI (Spielberger *et al.*, 1970). Subjects were divided into extraverts and introverts according to whether their extraversion scores were above or below the median of 15.5. The median neuroticism score was 8.5. This procedure yielded 16 stable introverts (SIs), 23 neurotic introverts (NIs), 19 stable extraverts (SEs), and 18 neurotic extraverts (NEs).

### *Procedure*

Subjects reported to a waiting room and completed the personality questionnaires before being escorted to a laboratory room where they were tested individually. Subjects were seated at a table in front of a computer monitor and response box with a row of four response buttons mounted on the top side. From left to right, the buttons were labeled 1, 2, 3, and 4. Presentation of stimuli and recording of responses were controlled by PC-based, Micro-Experimental Laboratory software (Schneider, 1988). All subjects were tested by one of two male experimenters.

*Pretreatment.* During the pretreatment phase, two 75 trial segments separated by a 1 min rest period were used to establish the letter 'Q' as a cue for punishment. Each trial was initiated by a 1000 msec signal ('Get ready'), followed by a 1000 msec fixation point to focus attention (\*\*), and then a string of four or six letters presented for 2000 msec. Only the letters N, P, R, S, T, V, W, X, Z were used because they are easily discriminated from the letter Q and from the numerals 1-9 (see below). After each trial, subjects received a 1000 msec feedback display: 'Correct Response! You win x points' (where x was equal to 1, 2, or 3 points) and 'Wrong Response! You lose 5 points' after correct and incorrect responses, respectively or 'Correct!' and 'Wrong!' after correct abstentions and misses, respectively.

Subjects were instructed to 'Press the right hand button unless the letter 'Q' appears in the string. If the letter 'Q' appears in the string, do NOT press the button.' The instructions also informed subjects that they would win one, two, or three points depending upon how fast they responded and that they would lose five points if they pressed when a Q was present. The Q was programmed to appear on a random 50% of the trials. Regardless of the number of punished errors committed, we reasoned that this procedure would establish the Q as a cue for punishment because subjects are systematically trained to detect the Q so that they may avoid punishment by inhibiting responses when the Q is present.

*Test trials.* Following the pretreatment, instructions for the next phase were presented followed by 145 test trials without break. During test trials, the stimulus display contained four letters (or three letters and one number) arranged so that each character appeared in one corner of an imaginary rectangle that was 2.2cm wide and 1.9cm high at the outside border of the characters. Subjects were instructed to 'Press the right hand button if the symbols are all letters but if one of the symbols is a number do not press the button'. In addition, the instructions indicated that subjects

Table 1. Experiment 1 personality and interference scores for stable introverts (SI), neurotic introverts (NI), stable extraverts (SE), and neurotic extraverts (NE)

	SI (n = 16)		NI (n = 23)		SE (n = 19)		NE (n = 18)		Total (n = 76)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Extraversion	12.43	(2.68)	10.78	(3.90)	19.00	1.41	18.50	1.50	15.01
Neuroticism	4.63	(2.53)	12.83	(3.04)	4.32	2.08	13.11	3.53	9.04
Baseline RT	568	(98)	551	(75)	548	91	568	114	558
Interference-1	31	(60)	31	(64)	-17	69	9	68	14
Interference-2	-6	(68)	31	(68)	2	83	14	79	12
Interference-3	43	(72)	1	(52)	-5	67	-17	62	4
Interference-T	23		21		-7		2		10

Note: SD, standard deviation; Interference-1, Block 1 interference (in msec); Interference-2, Block 2 interference (in msec); Interference-3, Block 3 interference (in msec); Interference-T, total interference (in msec).

would win three, four, or five points for correct responses depending upon the speed of their response and that they would lose five points if they responded incorrectly (i.e. when a number was present). Timing of the trials was the same as in the pretreatment.

Randomization procedures were used to approximate 60% 'no go' trials (i.e. those with a number) and 40% 'go' trials (i.e. all letters). Following a block of 25 'neutral' trials (i.e. no Q's were presented), the Q was programmed to appear on 50% of the go trials. Although the particular trials and location in which the Qs were presented were randomized, the expected number of go trials containing the letter Q was 24. Test trials differed importantly from pretreatment trials in that the Q had no special relationship to task requirements during this phase of the experiment task.

## RESULTS AND DISCUSSION

### Pretreatment

To evaluate the extent to which the pretreatment was successful in training subjects to notice and inhibit responding to the Q, we conducted a 2 (introvert, extravert)  $\times$  2 (neurotic, stable) ANOVA using the number of times that subjects failed to inhibit a response to the Q as the dependent variable. Overall, subjects committed 4.92 errors. This analysis yielded no significant main effects or interactions. A one-way ANOVA involving the high-, medium-, and low-anxious subjects as identified by the STAI was also nonsignificant. Thus, it appears that pretreatment experience with the letter Q was comparable across groups.

### Test trials

Test trials were divided into three blocks of five Q-present and five Q-absent, 'go' trials (reaction times to 'no go' trials can not be analyzed). Because prior research with related tasks showed that a subject's reaction to the Q might extinguish rapidly, our a priori comparisons involved only the first block of trials. However, as noted below, the effects of Q on performance did not change significantly during the task, so we present comparisons collapsed across trial block as well as the planned comparisons.

*Response times.* Planned comparisons\* were used to test the hypothesis that NIs would respond more slowly on Q-present than on Q-absent trials relative to SEs during the first trial block. NIs responded 31 msec slower on Q-present than on Q-absent trials whereas SEs responded 17 msec faster,  $t(40) = 3.26, p < 0.005$ . Across all three blocks, NIs responded 21 msec slower and SEs 7 msec faster on Q-present trials,  $t(40) = 1.86, p < 0.10$  (see Table 1).

A parallel comparison was used to assess group differences along the impulsivity dimension. NEs responded 9 msec slower on Q-present than on Q-absent trials, whereas SIs responded 31 msec slower. This difference did not approach statistical significance,  $t(32) = 1.35, p > 0.20$ . Across all

\*The *t*-tests were calculated using the *MS error* from the Block  $\times$  Trial type interaction component of the ANOVA for comparisons involving Block 1 and the *MS error* from the Trial type component of the ANOVA for comparisons that collapsed across Block. For all analyses reported in this manuscript, the two error terms were quite similar. Degrees of freedom were based on the number of subjects included in the specific comparison.

three blocks, NEs responded 2 msec slower and SIs 23 msec slower on Q-present trials,  $t(32) = 1.26$ ,  $p > 0.20$ .

Results for omnibus ANOVA are reported to place the planned comparisons in context. The ANOVA revealed a significant main effect for Trial type ( $F(1,72) = 4.50$ ,  $p < 0.05$ ), indicating that subjects responded more slowly on Q-present than Q-absent trials, but this effect was qualified by a significant Extraversion  $\times$  Trial type interaction ( $F(1,72) = 7.02$ ,  $p < 0.01$ ), with introverts showing greater behavioral inhibition than extraverts. There was also a significant Neuroticism  $\times$  Trial type  $\times$  Block interaction ( $F(2,144) = 3.02$ ,  $p = 0.05$ ). Inspection of the means suggests that subjects with high neuroticism scores displayed more behavioral inhibition than low scorers during the first two blocks of trials but less behavioral inhibition on the last block of trials.

### *Supplementary analyses*

Data were reanalyzed using STAI scores to divide subjects into high-, medium-, and low-anxious groups (i.e. thirds). The cutting scores were 32.5 and 41.5 and yielded 27 high-anxious, 23 medium-anxious, and 25 low-anxious subjects. For the first trial block, high-anxious subjects responded 29 msec slower and low-anxious subjects responded 13 msec *faster* on Q-present than on Q-absent trials,  $t(50) = 3.13$ ,  $p < 0.005$ . Across all three blocks, high-anxious subjects responded 25 msec slower and low-anxious subjects 6 msec faster on Q-present trials,  $t(50) = 2.30$ ,  $p < 0.05$ .

The ANOVA again revealed a main effect for Trial type ( $F(1,72) = 4.44$ ,  $p < 0.05$ ) which was qualified by the Anxiety  $\times$  Trial type interaction ( $F(1,72) = 3.97$ ,  $p < 0.05$ ), indicating that behavioral inhibition was greater for high-anxious subjects than for low-anxious subjects. Subjects with mid-range anxiety scores displayed intermediate levels of behavioral inhibition.

Using two different methods for classifying high- and low-anxious subjects, the results of Experiment 1 supported our hypothesis that high-anxious subjects would respond more slowly than low-anxious subjects on Q-present vs Q-absent trials. Moreover, the fact that high- and low-impulsive subjects were not differentiated on this putative measure of BIS functioning provides preliminary evidence for the discriminant validity of the measure.

## EXPERIMENT 2

In contrast to trait-anxious individuals who appear to be excessively responsive to punishment cues, the psychopaths' failure to learn from experience (Cleckley, 1976) and poor passive avoidance learning (i.e. learning to inhibit punished responses; Lykken, 1957; Newman & Kosson, 1986; Schmauk, 1970) suggest that they are insufficiently attentive to potential punishments (e.g. Hare, 1978; Trasler, 1978). Moreover, psychopaths typically display less electrodermal activity in anticipation of aversive events (Hare, 1978). Based on these and other findings, Fowles (1980) proposed that psychopaths may be characterized by a weak BIS (see also, Gorenstein & Newman, 1980; Patterson & Newman, 1993).

The purpose of Experiment 2 was to test whether psychopaths would be less responsive to cues for punishment on our putative measure of BIS functioning. Toward this end, we selected groups of psychopathic and nonpsychopathic offenders using the Psychopathy Checklist-Revised (PCL-R; Hare, 1991) and subdivided the groups using the Welsh Anxiety Scale (WAS; Welsh, 1956).

The rationale for subdividing subjects on the WAS is three-fold. First, investigators have traditionally drawn a distinction between primary and secondary (or neurotic) psychopaths (see Blackburn, 1983; Hare, 1970). In contrast to the primary psychopath, whose behavior problems are thought to reflect a deficiency in affective or cognitive processing, those of the secondary psychopath are regarded as a product of their high levels of negative affect. Second, laboratory assessments of passive avoidance and other indices of behavioral inhibition have consistently found differences between low-anxious (primary) psychopaths and controls whereas high-anxious (secondary) psychopaths typically perform more like controls (Arnett, Howland, Smith & Newman, 1993; Kosson, Smith & Newman, 1990; Newman, Kosson & Patterson, 1992; Newman, Patterson, Howland & Nichols, 1990; Newman, Schmitt & Voss, in press; Newman *et al.*, 1985; Schmauk, 1970). Third, owing to the association between anxiety and behavioral inhibition/sensitivity to punishment cues,

it is important to control for level of anxiety when comparing psychopaths and controls (Arnett, Smith & Newman, in press).

The most common method for distinguishing primary and secondary psychopaths involves using self-report measures of negative affect such as the WAS and the Taylor (1953) Manifest Anxiety Scale (see Newman & Brinkley, in press; Watson & Clark, 1984). In distinguishing between high- and low-anxious subjects, we are not proposing that high-anxious psychopaths are not true psychopaths. At present, there is insufficient information to determine whether high anxiety moderates psychopathy or serves to identify a distinct psychopathic type. Thus, we do not use the term 'secondary psychopath' to describe this group. In this regard, it is also worth noting that some investigators appear to regard high-anxious psychopathy as an oxymoron. However, numerous investigations involving the PCL-R suggest that psychopathy and anxiety/negative affect are close to statistically independent indicating that psychopaths may, indeed, be high- as well as low-anxious.

Thus, as a test of the weak BIS hypothesis, we predicted that low-anxious psychopaths would slow down less than low-anxious controls on Q-present vs Q-absent trials.

## METHODS

### *Subjects*

Forty-eight incarcerated white males\* meeting the inclusion criteria for the study completed the BIS task. File information was used to exclude men who were older than 39, currently psychotic or taking psychotropic medication, or whose reading level was below the fourth-grade level. The remaining subjects were invited to participate. Following a description of the project which emphasized its voluntary nature, subjects were interviewed for approximately 1–1.5 hr (see Kosson *et al.*, 1990). Interviewers then classified inmates using the 20-item Psychopathy Checklist (PCL-R; Hare, 1991). There is abundant evidence that the PCL-R provides a reliable and valid indicator of psychopathy, especially when used with incarcerated white offenders (Hare, 1991; Kosson *et al.*, 1990). Although reliability was not evaluated in this study, prior assessments involving the same raters revealed reliability estimates approximating 0.90 (see Hare, Harpur, Hakstian, Forth, Hart & Newman, 1990). Subjects receiving a score of 30 or above were classified as psychopaths and subjects scoring at or below 22 were classified as nonpsychopaths. Subdividing the groups using the median WAS score resulted in 11 low-anxious controls, 13 high-anxious controls, 15 low-anxious psychopaths and nine high-anxious psychopaths.

*Procedure.* The task was identical to the one used in Experiment 1 except that money (i.e. cents) was used instead of points as the incentive.

## RESULTS AND DISCUSSION

### *Pretreatment*

Number of incorrect responses was analyzed using ANOVA to determine whether there were group differences in inhibiting button presses to the letter Q. Neither the main effects nor the Psychopathy  $\times$  Anxiety interaction approached statistical significance. Thus, it appears that pre-treatment experience with the letter Q was comparable across groups. Overall, subjects committed 3.68 errors.

### *Test trials*

*Response times.* A planned comparison was used to test the hypothesis that, relative to low-anxious psychopaths, low-anxious controls would respond more slowly on Q-present than on Q-absent trials during the first block of trials. Low-anxious psychopaths responded 21 msec faster and

\*To date, evidence supporting the validity of the PCL and PCL-R is based almost entirely on white male offenders. Although we are committed to rectifying this problem by conducting studies with female and nonwhite subjects (e.g. Kosson *et al.*, 1990), we believe that such studies are most relevant when they employ established as opposed to untested paradigms. Moreover, there is preliminary evidence that the laboratory correlates of psychopathy may be weaker in black than in white inmates (Kosson *et al.*, 1990; Newman *et al.*, 1997; Thornquist & Zuckerman, 1995).

Table 2. Experiment 2 personality scores and interference scores by group

	Low-anxious controls ( <i>n</i> = 11)		High-anxious controls ( <i>n</i> = 13)		Low-anxious psychopaths ( <i>n</i> = 15)		High-anxious psychopaths ( <i>n</i> = 9)		Total ( <i>n</i> = 48)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
PCL-R scores	17.64	6.74	17.54	3.33	34.07	2.62	32.67	1.80	25.38
Welsh Anxiety	4.54	1.97	17.85	6.73	4.36	2.06	17.56	8.14	10.66
Interference-1	6	56	27	117	-21	133	-94	141	-16
Interference-2	-13	87	38	128	-28	147	-19	121	-5
Interference-3	-33	98	30	80	-1	79	-17	116	-3
Interference-4	-19	71	-1	149	-4	114	-65	114	-18
Interference-T	-15		23		-13		-49		-10

Note. SD, standard deviation; PCL-R, psychopathy checklist-revised; Interference-1, Block 1 interference (in msec); Interference-2, Block 2 interference (in msec); Interference-3, Block 3 interference (in msec); Interference-4, Block 4 interference (in msec); Interference-T, total interference (in msec).

low-anxious controls responded 6 msec slower on Q-present than on Q-absent trials, but this difference did not approach statistical significance,  $t(24) < 1.0$ . Across all four blocks,\* low-anxious psychopaths responded 13 msec faster and low-anxious controls responded 15 msec faster on Q-present trials. This difference was also nonsignificant,  $t(24) < 1.0$  (see Table 2).

Although there were no a priori hypotheses concerning high-anxious subjects, we report the data because of its relevance to the weak BIS hypothesis. During the first trial block, high-anxious psychopaths responded 94 msec faster on Q-present trials whereas high-anxious controls responded 27 msec slower,  $t(20) = 3.50$ ,  $p < 0.005$ . Across all four blocks, high-anxious psychopaths responded 49 msec faster and high-anxious controls responded 23 msec slower on Q-present trials,  $t(20) = 2.04$ ,  $p = 0.05$ .†

The omnibus ANOVA revealed a significant effect for Block ( $F(3,132) = 3.43$ ,  $p < 0.05$ ) and a Block  $\times$  Anxiety interaction ( $F(3,132) = 4.68$ ,  $p < 0.01$ ), indicating that low-anxious subjects responded more slowly with each trial block, whereas high-anxious subjects responded slowly initially and remained relatively consistent throughout the task. There was also a significant Psychopathy  $\times$  Trial type interaction ( $F(1,44) = 4.37$ ,  $p < 0.05$ ) which was qualified by a significant Psychopathy  $\times$  Anxiety  $\times$  Trial type interaction ( $F(1,44) = 4.66$ ,  $p < 0.05$ ). These interactions indicate that psychopaths displayed less behavioral inhibition than controls but that this difference was specific to high-anxious psychopaths and controls.

## GENERAL DISCUSSION

The purpose of this study was to develop a behavioral measure to assess BIS functioning. Toward this end, we trained a cue for punishment and then measured the extent to which it interrupted goal-directed (i.e. BAS-driven) behavior.‡ Consistent with the model put forward by Gray (1987a, b), (a) high-anxious undergraduates displayed significantly greater behavioral inhibition than low-anxious undergraduates in response to the cue for punishment; whereas (b) high- and low-impulsive groups were not differentiated supporting the proposal that this task constitutes a relatively specific measure of BIS functioning.

In fact, the results of both experiments were fairly consistent in demonstrating stronger inhibition in high-anxious than in low-anxious subjects. Collapsing across blocks, high-anxious undergraduates and prison controls averaged 21 msec and 23 msec of behavioral inhibition respectively, whereas the comparable figures were 7 msec and 15 msec *faster* for the low-anxious undergraduates and prison

\*Although Experiments 1 and 2 employed the same number of trials, the number of valid trials (i.e. correct 'go' responses) was higher in Experiment 2 than in Experiment 1. Whereas including all four trial block in Experiment 1 would have resulted in substantial loss of subjects, all of the subjects in Experiment 2 had four full blocks of data.

†This contrast was also justified by the significant Psychopathy  $\times$  Anxiety  $\times$  Trial Type interaction obtained in the overall ANOVA.

‡In light of the small number of errors committed during the pretreatment phase, readers may question whether the Q did, in fact, become a cue for punishment. We do not feel that it is necessary for subjects to experience such pairings for the Q to signal potential loss of reward and the need to inhibit responding. The expectation that a stimulus or response will lead to punishment is, in all likelihood, sufficient to trigger fear and behavioral inhibition.

controls. Moreover, none of the three low-anxious groups in this study averaged more than 0 msec of behavioral inhibition across blocks or more than 6 msec during the first block of trials.

Moreover, the uniformly low levels of behavioral inhibition displayed by low-anxious subjects probably underlies the lack of support for our prediction that low-anxious psychopaths would show less behavioral inhibition than low-anxious controls. Contrary to expectation, low-anxious psychopaths and controls displayed comparably low levels of behavioral inhibition. In spite of their low level of anxiety, the lack of behavioral inhibition displayed by low-anxious prison controls in Experiment 2 was unexpected. Studies of passive avoidance learning that compare low-anxious psychopaths and controls typically find significantly better passive avoidance learning in low-anxious controls (e.g. Newman *et al.*, 1990; Schmauk, 1970). As passive avoidance learning is theoretically mediated by the BIS, we expected that low-anxious controls would also display greater behavioral inhibition in the presence of cues for punishment. The reason for this apparent contradiction could relate to the experimental contingencies. In contrast to passive avoidance tasks in which responding in the presence of punishment cues is punished, our measure of BIS functioning involved no such contingency. Thus, a potential explanation for the weak inhibition displayed by low-anxious controls is that they are responsive to relevant punishment cues but minimally responsive to irrelevant threat cues.

In contrast to low-anxious controls, low-anxious psychopaths may be relatively unresponsive to punishment cues regardless of their relevance. Whereas low-anxious psychopaths and controls may often perform similarly owing to their comparably low levels of anxiety (and weak BIS), the deficient passive avoidance learning of low-anxious psychopaths may reflect another, more disabling, psychobiological process. For instance, Patterson and Newman (1993) have proposed that low-anxious psychopaths may be less adept at response modulation than low-anxious controls; that is, they are less likely to suspend reward seeking behavior in order to process peripheral, but potentially relevant, information such as cues for punishment. Such a deficit might explain why low-anxious psychopaths would appear similar to other low-anxious groups when punishment cues are irrelevant but, unlike low-anxious controls, fail to adjust behavior on tasks requiring subjects to suspend goal-directed behavior and accommodate the information (e.g. on passive avoidance tasks). Further research is needed to address this speculation.

Another aspect of the present results meriting discussion concerns the performance of high-anxious psychopaths. The present results are fairly consistent in demonstrating that high-anxious groups responded more slowly, and low-anxious groups responded more quickly, on Q-present trials. Unlike the other high-anxious groups, however, high-anxious psychopaths displayed frank facilitation as opposed to inhibition. Though admittedly *post hoc*, it may be that their response facilitation reflects the combination of the two independent processes described above. That is, the performance of high-anxious psychopaths may reflect (1) strong sensitivity to punishment cues owing to their high level of anxiety combined with (2) poor response modulation stemming from their status as psychopaths. Wallace *et al.* (1991) have proposed that heightened sensitivity to certain types of cues leads to heightened arousal in the presence of such cues which, in turn, leads to accelerated responding in the absence of behavioral inhibition (see also the discussion of drive summation in Gray, 1987a, b).

A final consideration concerns the relation between the pretreatment and test phases of this experiment. Both phases involved presenting cues for punishment but responding to punishment cues in the pretreatment resulted in loss of money whereas the cues were irrelevant during the test phase. In other words, the pretreatment involved an explicit instrumental contingency whereas reaction to the punishment cues during the test phase relied on a conditioned or relatively automatic (i.e. involuntary) response. The absence of significant group differences during the pretreatment appears to indicate that psychopaths and low-anxious subjects are as able as nonpsychopaths and high-anxious subjects in using punishment cues to avoid punishment when there is an explicit punishment contingency. Though psychopaths are generally regarded as deficient in passive avoidance, we (Newman *et al.*, 1990; Newman & Wallace, 1993) have noted that this deficit is relatively specific to avoidance contingencies that are 'latent' and, thus, require response modulation.

The results of this investigation provide preliminary support for a new approach to assessing the BIS. Regardless of whether anxiety was assessed using Gray's (Gray, 1981) dimension of anxiety running from the neurotic introversion to the stable extraversion quadrant of Eysenck's (Eysenck,

1981) two-dimension space, the trait form of the STAI (Spielberger *et al.*, 1970), or the Welsh (1956) anxiety scale, high-anxious subjects responded more slowly on Q-present than on Q-absent trials, whereas low-anxious subjects displayed the reverse. The only exception to this pattern was the behavior of high-anxious psychopaths which could be explained by the moderating influence of psychopathy on high anxiety.

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