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AUTONOMIC RESPONSIVITY DURING PASSIVE AVOIDANCE IN INCARCERATED PSYCHOPATHS

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Summary—Autonomic response to rewards and punishments was assessed in incarcerated psychopaths and nonpsychopaths during passive avoidance learning. Based on behavioral evidence that psychopaths are less likely to suspend approach behavior following punishment and that approach behavior is associated with increased heart rate (HR), we hypothesized that, in comparison to HR following reward, psychopaths would display greater HR following punishment than nonpsychopaths. A significant Psychopathy × Feedback interaction ($P < 0.05$) revealed that psychopaths displayed lower HR following punishment feedback than controls ($P < 0.10$) but group differences in HR were moderated by level of anxiety and seconds following feedback. A marginally significant Psychopathy × Feedback interaction for skin conductance responses (SCRs) revealed that psychopaths exhibited fewer SCRs following punishment than controls. There were no group differences in passive avoidance learning. That psychopaths displayed lower HR and fewer SCRs than controls following punishment is inconsistent with our hypothesis and indicates that psychopaths were relatively unresponsive to punishment feedback in this study. Alternative explanations for this finding are discussed within the context of psychopaths' difficulty learning from punishment.

Passive avoidance learning—learning to inhibit behaviors that lead to punishment—has been studied intensively in psychopaths due to its presumed importance in the socialization process (Trasler, 1978). Most experimental investigations have shown psychopaths to be poor at passive avoidance learning (Lykken, 1957; Newman & Kosson, 1986; Siegel, 1978). These studies complement clinical descriptions of psychopaths' failure to inhibit behaviors that result in punishment (Cleckley, 1976).

Although a variety of explanations for psychopaths' poor passive avoidance has been posited (Gorenstein & Newman, 1980; Mawson & Mawson, 1977; Quay, 1965; Schachter & Latane, 1964), most have focused on pychopaths' poor fear conditionability (Fowles, 1980; Hare, 1970, 1978). The relationship of poor fear conditionability to poor passive avoidance has been explained using Mowrer's (1947, 1960) two-process theory of avoidance learning (Hare, 1965; Lykken, 1957), Lacey's (1967) intake–rejection theory coupled with research on orienting and defensive responses (Hare, 1978), and Gray's (1975) two-factor learning theory (Fowles, 1980). All of these theories rely on physiological evidence from classical conditioning and quasi-conditioning paradigms. Relative to nonpsychopaths, psychopaths display less electrodermal activity (Hare, 1978) and similar (Hare & Quinn, 1971; Tharp, Maltzman, Syndulko & Ziskind, 1980) or greater (Hare & Craigen, 1974; Hare, Frazelle & Cox, 1978) heart rate (HR) acceleration in response to conditioned stimuli (CSs) for punishment.

Despite widespread acceptance of the significance of autonomic conditioning data for passive avoidance learning in psychopaths, only one study has examined psychopaths' autonomic response to punishment *within the context* of a passive avoidance learning paradigm. Schmauk (1970) measured skin conductance (SC) while *S*s performed a modified version of Lykken's (1957) passive avoidance task under one of three conditions. In comparison to controls, primary (i.e. low-anxious) psychopaths showed significantly lower SC in anticipation of a lever press that could result in physical (shock) and social (the experimenter says "wrong") punishment, but not in a condition involving loss of money. Learning results paralleled the SC findings with low-anxious psychopaths

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performing significantly worse than controls in the physical and social punishment conditions but not in the loss of money condition.

Schmauk's (1970) study, while important, has a number of shortcomings that we sought to remedy in the current study. First, Schmauk (1970) identified incarcerated psychopaths using a self-report measure (the Psychopathic Deviate scale of the Minnesota Multi-phasic Personality Inventory, MMPI) that has questionable validity for identifying psychopaths in an offender population (Hare, 1985a; Hare & Cox, 1978) and, unlike the psychopaths, control *S*s were not incarcerated. In contrast, we employed an offender control group and identified psychopaths using a clinical interview and the Revised Psychopathy Checklist (PCL-R; Hare, 1985b). Second, whereas Schmauk (1970) examined anticipatory responding without regard to the outcome of the response, we examined responses to correct (i.e. rewarded) and incorrect (i.e. punished) trials separately. Third, Schmauk (1970) only measured SC, whereas we measured both SC and HR. Several other procedural differences reflect our interest in measuring psychopaths' physiological reaction to reward and punishment *feedback* rather than their *anticipatory response* to the consequences of selecting a particular lever.

Our hypotheses were based on an integration of two models. The first model is derived from work by Gray (1977, 1982) and Fowles (1980) and consists of three arousal systems: (a) the behavioral activation system (BAS), (b) the behavioral inhibition system (BIS), and (c) the nonspecific arousal system (NAS). The BAS initiates behavior in response to CSs for reward (approach) or active avoidance and Fowles has proposed that activity in the BAS is associated with HR increase. The BIS is viewed as an anxiety system and inhibits behavior in response to cues for punishment (passive avoidance) or frustrative nonreward (extinction). Fowles proposed that electrodermal activity (EDA) is indicative of BIS activation. In addition, the BAS and BIS are mutually inhibitory and have positive inputs to the NAS.

The second model involves a four-stage mechanism for passive avoidance learning proposed by Patterson, Kosson and Newman (1987). In this model (see also Newman, 1987), when psychopaths and other disinhibited individuals are provided with an opportunity to obtain reward, they adopt a response set that is resistant to interruption (Stage 1). When confronted with an unexpected environmental event (such as punishment), psychopaths, like controls, experience an increment in nonspecific arousal (Stage 2). This increased arousal results in pausing to accommodate the new information in controls but leads to facilitation of ongoing behavior in psychopaths (Stage 3). Finally, because psychopaths maintain their readiness to respond rather than pausing to process response feedback, they are less likely than controls to learn the cues that are associated with punishment and that are necessary for passive avoidance learning (Stage 4). According to Newman and his colleagues (Newman, Kosson & Patterson, in press; Newman, Patterson, Howland & Nichols, 1990), the passive avoidance deficit of psychopaths relates to Stage 3 of the model.

Using the terminology of the Gray/Fowles model, it is predicted from the Patterson *et al.* (1987) model that nonpsychopaths will display an increase in BIS and NAS activity and a decrease in BAS activity following punishment feedback relative to their response following reward. Psychopaths will also display an increase in BIS and NAS activity but, unlike controls, will display no decrease in BAS activity. In other words, Patterson *et al.* (1987) regard psychopaths and controls as equally sensitive to punishment feedback but hold that psychopaths are less likely to suspend a dominant response set for reward to process punishment feedback.

Assuming that HR indexes BAS activity as proposed by Fowles (1980), we predicted that, in comparison to HR following reward feedback, psychopaths would display greater HR following punishment than controls. It might be predicted that the increased vigilance of controls following punishment would result in HR decrease. However, pilot work revealed that this task produced a characteristic HR acceleration to feedback followed by gradual recovery to baseline HR in nearly all *S*s. In light of this characteristic response, we predicted that group differences would be manifested in the degree of HR acceleration, with psychopaths showing greater HR than controls. Psychopaths and controls were not expected to differ in response to reward feedback, however, analyzing *S*s HR to punishment relative to reward provides a more precise index of their reaction to the punishment aspect of the feedback. That is, if we only examined HR response to punishment, it would be unclear whether any observed group differences reflected response to punishment or response to feedback in general. In addition, in examining *S*s' behavioral reaction to punishment, we uniformly have evaluated response time following punishment *relative to* response time following reward. Thus, it seemed important to use an analogous strategy for analyzing the psychophysiological data.

In contrast to our predictions for HR, no group differences were predicted for measures of EDA (i.e. BIS activity). This expectation is based on behavioral evidence suggesting that psychopaths are no less sensitive than controls to monetary punishment (Newman & Kosson, 1986; Schmauk, 1970). Although it is not possible to test the null-hypothesis, alternative models of psychopathy (e.g. weak BIS model of Fowles, 1980) predict group differences on this measure.

To explore our hypotheses, we employed a modified version of the passive avoidance task developed by Chesno and Kilmann (1975) and adapted by Newman and Kosson (1986). Whereas the Newman and Kosson (1986) task was designed to be fast-paced, the current version employed a long and variable (8 to 14 secs) intertrial interval (ITI) to enable the recording of autonomic physiology in response to reward and punishment feedback uncontaminated by motor responding. Given that an enforced ITI of 5 sec has been shown to eliminate impulsive responding in psychopaths (Newman, Patterson & Kosson, 1987), this investigation should not be regarded as an attempt to replicate the behavioral findings reported by Newman and Kosson (1986) or Patterson *et al.* (1987).

Finally, recent studies indicate that anxiety mediates the relationship of psychopathy to performance on tasks employing reward and punishment incentives (e.g. Newman *et al.*, 1990, in press) and on standardized measures of neuropsychological functioning (Smith, Arnett & Newman, 1992). In particular, group differences have been specific to low-anxious psychopaths and controls. Therefore, we tested enough *S*s to incorporate anxiety as a factor and still have approx. 15 *S*s per cell.

METHOD

Subjects

*S*s were 63 White male inmates at a minimum security state correctional facility in southern Wisconsin. Potential *S*s were selected by identifying every fifth name on the institution roster. *S*s were excluded from eligibility for participation if they were: (a) above age 40 or below age 18; (b) assessed at or below the fourth grade level in reading; or (c) taking psychotropic medication or identified as actively psychotic. Approximately 10% of the inmates contacted for the interview and 5% of the inmates called back for the experiment refused to participate. Six *S*s (3 psychopaths and 3 controls) were excluded from the analyses because of unusable EKG and pulse data. In addition, one low-anxious control who had only one usable trial of HR data following punishment was excluded from all but one of the analyses (see below).

Measures

Psychopathy was assessed using the Revised Psychopathy Checklist (PCL-R; Hare, 1985b). The PCL-R is based primarily on Cleckley's (1976) conception of psychopathy and was developed for use with male criminal offenders. Detailed reliability and validity information on the PCL-R is reported in Hare, Harpur, Hakistian, Forth, Hart and Newman (1990).

Thirty-one psychopaths and 32 controls were identified based on their scores on the PCL-R. *S*s scoring 30 and above were designated psychopaths and *S*s scoring 22 and below were designated controls. In addition, *S*s were divided into subgroups using a median split on the Welsh Anxiety Scale (Welsh, 1956). This scale is generally thought to measure anxiety and maladjustment and taps into five major content areas: (1) problems in thinking and thought processes; (2) negative emotional tone; (3) pessimism and lack of energy; (4) personal sensitivity; and (5) deviant thought processes (Greene, 1980).

*S*s also completed the Shipley Institute of Living Scale (Zachary, 1986). This measure provides an estimate of WAIS-R Full Scale IQ.

Task and apparatus

The task was a successive go/no go discrimination with four reward stimuli (S+'s) and four punishment stimuli (S−'s) controlled by an Apple II Plus computer and presented on an Apple

Monitor (Model A2M 2010). *S*s were required to learn by trial-and-error to press a button to the S+'s and withhold responding to the S−'s. The response apparatus was a rectangular, black plastic box (12.5 × 9 × 9.5 cm) containing one push button located on the top surface of the box. Following correct responses *S*s received positive feedback consisting of a high tone (0.25 sec at 665 Hz), the word "CORRECT!" presented on the screen just below the stimulus, and the experimenter adding a white poker chip worth 10 cents to the *S*'s pile of chips. Following incorrect responses *S*s received negative feedback consisting of a low tone (0.25 sec at 94 Hz), the word "WRONG!" presented below the stimulus, and the experimenter removing a chip worth 10 cents. *S*s began the task with $1.00.

All stimuli were three-digit numbers chosen so that no characteristic of a number was differentially associated with either S−'s or S+'s. Numbers were presented as green color on a dark background. The size of each digit was 5.1 × 2.5 cm. Stimuli were presented for 3 sec and *S*s were informed that they must respond within this time period or their response to the stimulus would not count. The visual portion of the feedback remained on the screen for a random interval of 8 to 14 sec. If the *S* did not press the button, the screen remained black for a similar random interval. The long interval was used to allow for psychophysiological recording. A variable interval was used so that anticipatory responses to successive stimuli would be less likely to occur. Four combinations of stimuli were used resulting from a 2 × 2 matrix involving two sets of numbers and, within each set, two categorizations of stimuli as S+'s and S−'s. *S*s were randomly assigned to one of the four combinations of the matrix in a successive fashion.

Each *S* received 6 demonstration trials consisting of numbers not used during the task, followed by 72 task trials. The first 8 task trials served as practice and consisted of the presentation of 2 S+'s and 2 S−'s two times each. Stimuli used during practice trials were not presented again during the rest of the task. The next 64 trials consisted of 8 blocks of trials during which each S+ and S− was presented once per block. Order of stimulus presentation within each block was determined using modified randomization procedures that precluded the occurrence of more than three consecutive S+ or S− stimuli.

Psychophysiological recording

EKG. EKG was recorded by attaching an electrode to the *S*'s chest on the right and left side of the torso using adhesive collars and Beckman Standard 1 cm^2 Ag–AgCl electrodes with Spectra 360 electrode gel as the conducting medium. Prior to electrode placement, the *S*'s skin was abraded using gauze moistened with isopropyl alcohol. Output from the electrodes was fed into a Coulbourn S75-01 hi gain bioamplifier/coupler. The signal was then routed to a Coulbourn S21-06 bipolar comparator. This device signaled the occurrence of each EKG R-wave spike when the R-wave exceeded a threshold value. The experimenter adjusted this threshold for each *S* after inspecting the EKG wave on an oscilloscope. The computer then recorded the time of each R-wave onset signal for future analysis.

Pulse. Pulse was measured using a photo-plethysmograph, the output of which was fed into a Coulbourn S71-40 pulse monitor optical densitometer. The photo-plethysmograph measured peripheral blood pulses and the pulse monitor signaled pulse onset. The experimenter adjusted the onset threshold for each *S* after inspecting the pulse wave on an oscilloscope. The computer recorded the time of each pulse onset signal for later analysis.

Skin conductance (SC). SC was recorded from the two middle fingers of the nondominant hand using Beckman Standard 1 cm^2 Ag–AgCl electrodes. A Unibase and saline mixture was used as the conducting medium (see Fowles, Christie, Edelberg, Grings, Lykken & Venables, 1981, p. 235 for formula). SC signals were amplified by a Coulbourn S71-22 SC module set for DC recording with an AC excitation current. The output was directly digitized and recorded by the computer at a rate of 20 Hz.

Procedure

All *S*s meeting the selection criteria were contacted about participating in a study involving an initial semi-structured interview and several follow-up problem solving tasks providing the opportunity to earn money. *S*s were paid $3.00 for the interview and recontacted within 2 to 4 weeks for the experiment described here.

The interview covered a variety of topics including family background, school and work history, friendships and sexual relationships, criminal history, drug and alcohol use, and medical history (see Smith & Newman, 1990, for more details on the interview and psychopathy assessment).

Prior to the experiment, all *S*s were naive to the experimental situation and no *S* participated in any experiment before the current one. *S*s were run individually on the task by one of two male experimenters blind to *S*'s psychopathy and anxiety status. After obtaining consent for participation in the current study, the *S* was first asked to wash his hands. Then the SC electrodes were attached to the *S*'s nondominant hand and he completed a battery of questionnaires (including the Welsh Anxiety Scale). After a minimum of 20 min and a maximum of 30 min, the *S* returned to the experimental room, the EKG electrodes were attached, and the photo-plethysmograph was attached to the *S*'s left ear. After making the necessary adjustments on the psychophysiological recording equipment, the *S* was asked to sit quietly while a 2-min baseline of his physiology was recorded.

Following the baseline, the experimenter began reading the instructions for the task. As part of these instructions, the experimenter demonstrated the task to the *S* using one S+ and one S− for 6 trials during which the experimenter pressed the response button. Following the demonstration trials, the *S* was given a chance to practice before playing the task for money. Chips were given and taken away during these practice trials, but the experimenter "reset" the *S*'s pile of chips to 10 (equal to $1.00) prior to the beginning of the task. After the practice trials the *S* was reminded to try to win as much money as possible and asked if he had any questions prior to starting the task.

At the end of the task, total winnings were presented on the screen and the *S* was debriefed. The Shipley Scale was given on a subsequent testing day following the administration of a neuropsychological assessment battery (see Smith *et al.*, 1992).

Data reduction

HR. The off-line R-wave onset times from the EKG were edited with a computer program designed to identify invalid heart periods. When EKG R-wave offset times were invalid, an estimate was obtained using the offset of the pulse wave plus median pulse transit time from the prior 10 heart beats. For 72% of the *S*s, EKG was the primary source of determining heart periods. Of these 72%, 51% were psychopaths. For the remaining 28% of *S*s (50% psychopaths), heart periods were determined using a combination of the EKG and pulse. The resulting EKG R-waves and R-wave estimates were then converted to second-by-second HR (Graham, 1978) for the 2-min baseline, the pre-stimulus second, the stimulus presentation second(s) and the 8 sec following the onset of feedback. Eight seconds following feedback were used because a minimum of 8 sec was available on every trial.

SC. SC responses were identified from the digitized data by a Pascal implementation of the WAVE SC scoring program developed by Strayer and Macias (1982). Responses greater than or equal to 0.05 μS were identified. Two measures of reactivity to each type of feedback were used. The first, SC amplitude, consisted of the average amplitude of the largest SC response (SCR) on each trial (including those of amplitude 0) beginning between 1 and 3.0 sec following presentation of the feedback. The second SC measure, number of SCRs, consisted of the average number of SCRs per trial (including trials with no measurable SCRs) occurring between 1 and 8 sec following feedback.

RESULTS

Subject characteristics

Table 1 lists group means and standard deviations (SDs) for age, PCL-R scores, WAIS-R IQ estimates, and Welsh Anxiety Scale scores. The median Welsh Anxiety Scale score for the sample was 9.5; this value was used to divide *S*s into high- and low-anxious subgroups. A Psychopathy × Anxiety analysis of variance (ANOVA) was used to test for group differences in age and intelligence. No significant main effects or interactions were found.

Table 1. Means and standard deviations for S characteristics as a function of group

	Psychopaths		Controls	
Variable	Low-anxious[a] Mean (SD)	High-anxious[b] Mean (SD)	Low-anxious[c] Mean (SD)	High-anxious[d] Mean (SD)
Age	25.3 (3.9)	24.8 (4.2)	26.9 (4.9)	25.3 (5.9)
PCL-R	32.5 (2.4)	33.3 (1.9)	13.7 (5.0)	18.6 (3.4)
IQ	99.6 (8.8)	95.6 (13.2)	93.7 (15.1)	98.9 (11.1)
WAS	3.6 (2.4)	16.7 (6.1)	3.8 (2.9)	20.9 (7.5)

PCL-R = Revised Psychopathy Checklist scores; IQ = Shipley Institute of Living Scale WAIS-R IQ estimate; WAS = Welsh Anxiety Scale.
[a]$n = 13$; [b]$n = 18$ except for IQ ($n = 16$); [c]$n = 18$ except for IQ ($n = 16$); and [d]$n = 14$ except for IQ ($n = 12$).

HR analyses

Computation of HR. Because we were interested in HR change following feedback, we computed change scores by subtracting the HR of the pre-stimulus second from the HR of each second following feedback. Although other HR reference values could have been employed (such as median baseline HR), we chose the pre-stimulus second due to its closer proximity to the response to feedback. Nonetheless, so that we could be confident that any effects found were in response to reward and punishment feedback and not a result of pre-existing differences in HR, we assessed whether the groups differed in median HR at the pre-stimulus second. Moreover, we analyzed median baseline HR (median of the 120 1-sec HR data points collected during the pre-task 2-min baseline) to assess possible pre-task differences in HR. The Psychopathy × Anxiety ANOVAs revealed no significant main effects or interactions involving psychopathy in either analysis.

Although there was no *a priori* reason that any of the groups' HR would differ at the pre-stimulus second prior to a rewarded or punished trial, a Psychopathy × Anxiety × Pre-Feedback Second mixed model ANOVA with pre-feedback second as the repeated measure was computed to insure that collapsing across the pre-stimulus second prior to reward and punishment did not mask pre-existing group differences. To maintain consistency with the rest of the data analyses, only pre-feedback seconds preceding actual responses were used in the analysis. Neither the Psychopathy × Anxiety × Pre-Feedback Second nor the Psychopathy × Pre-Feedback Second interactions were statistically significant, demonstrating that the groups did not differ as a function of the upcoming feedback in the pre-stimulus interval.

Similarly, although we did not expect psychopaths and controls to change differentially in their pre-stimulus HR level over the course of the task, a Psychopathy × Anxiety × Trials mixed model ANOVA with trials as the repeated measure was conducted to insure that collapsing across the pre-stimulus second prior to reward and punishment did not mask differential group changes in pre-stimulus HR level over the course of the task. In this analysis, the levels of the trials factor consisted of the median pre-stimulus second HR value for every two 8-trial blocks (the task consisted of 64 trials, so 4 median HR values were computed per S). Again, median calculations for each block were restricted to pre-stimulus seconds preceding actual responses. Neither the Psychopathy × Anxiety × Trials nor the Psychopathy × Trials interactions were statistically significant, demonstrating that the groups displayed comparable changes in pre-stimulus HR level over the course of the task. Therefore, to enhance the reliability of the pre-stimulus HR value used, the pre-stimulus HR values prior to reward and punishment were combined and a median pre-stimulus HR value was calculated and used as the reference point for computing change scores during the stimulus presentation and following feedback.

Finally, to ensure that any differences found for feedback were in response to feedback as opposed to pre-existing differences during the presentation of S+ or S− stimuli that preceded feedback, an additional Psychopathy × Anxiety × Stimulus Type mixed model ANOVA was conducted to determine if the groups displayed different HR levels during the stimulus presentation

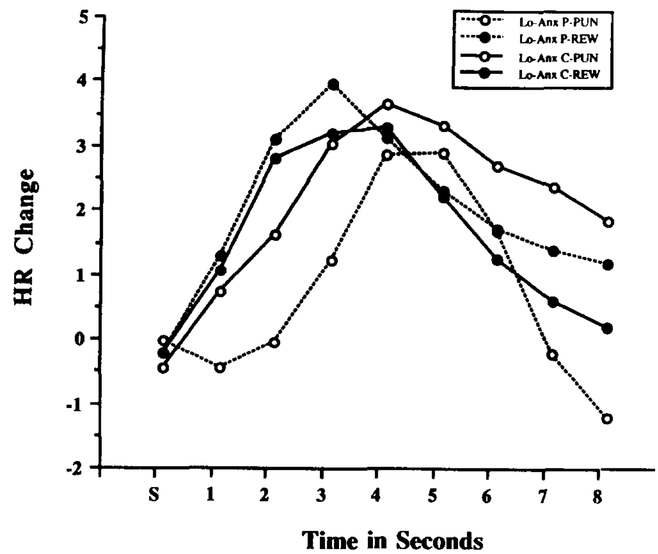

Fig. 1. HR change from pre-stimulus level to stimulus presentation second and seconds following punishment and reward trials for low-anxious psychopaths and controls. S = Stimulus presentation second; Lo-Anx P-PUN = Low-anxious psychopaths—punishment; Lo-Anx P-REW = Low-anxious psychopaths—reward; Lo-Anx C-PUN = Low-anxious controls—punishment; and Lo-Anx C-REW = Low-anxious controls—reward.

period prior to the feedback interval*. In order to parallel the following analyses of HR during the feedback interval, this analysis included only those trials on which *S*s responded (i.e. those followed by feedback), and difference scores (i.e. from pre-stimulus second) were employed. No significant main effects or interactions involving psychopathy were found, demonstrating that the groups did not differ in HR during the stimulus presentation.

HR response to reward and punishment feedback. HR values were difference scores obtained by subtracting *S*s' median HR for the pre-stimulus second from: (a) HR during the stimulus presentation; and (b) median HR during each of the 8 sec following feedback. These values were used as repeated measures in the statistical analysis†. The data were analyzed using a $2 \times 2 \times 2 \times 9$ (Psychopathy × Anxiety × Feedback × Seconds) mixed model ANOVA with feedback and seconds as repeated measures. The Psychopathy × Feedback interaction was statistically significant, $F(1,59) = 4.62$, $P < 0.05$, however, planned comparisons indicated that the pattern of results was contrary to prediction. HR following punishment tended to be *greater* for controls than for psychopaths, $F(1,59) = 3.17$, $P < 0.10$. The groups did not differ in their HR following reward, $F(1,59) < 1.0$.

Although none of the three-way interactions were statistically significant, the Psychopathy × Feedback interaction was qualified by a significant four-way Psychopathy × Anxiety × Feedback × Seconds interaction, $F(8,472) = 2.15$, $P < 0.05$ ($P = 0.06$ using the Huynh-Feldt correction). To unpack this four-way interaction, we first examined the three-way Psychopathy × Feedback × Seconds interaction separately within the high- and low-anxious groups. Figure 1 shows cardiac response curves consisting of HR during stimulus presentation and following reward and punishment trials for low-anxious psychopaths and controls. Figure 2 displays the same HR curves for the high-anxious groups. The three-way interaction was not statistically significant in

*Mean HR for the first 2 sec of stimulus presentation was used because all *S*s had data points for these seconds. Many *S*s had no data points for the third second of stimulus presentation because they responded to the stimulus prior to this, which in turn initiated the onset of the feedback interval.

†Although the Psychopathy × Feedback interaction addressed our hypothesis that psychopaths would show greater HR following punishment than controls relative to HR following reward, we included all 8 sec of HR following feedback in the analysis for two reasons. First, the 8 sec were viewed as encompassing the phasic (albeit long phasic) response to feedback. Because there were no group differences prior to the presentation of feedback, we reasoned that any group differences in HR that emerged during the feedback interval were due to differential (i.e. phasic) responses to the feedback. Second, we wanted to be able to explore (*post-hoc*) any effects involving seconds that might be obscured by restricting our analysis to the two-way interaction.

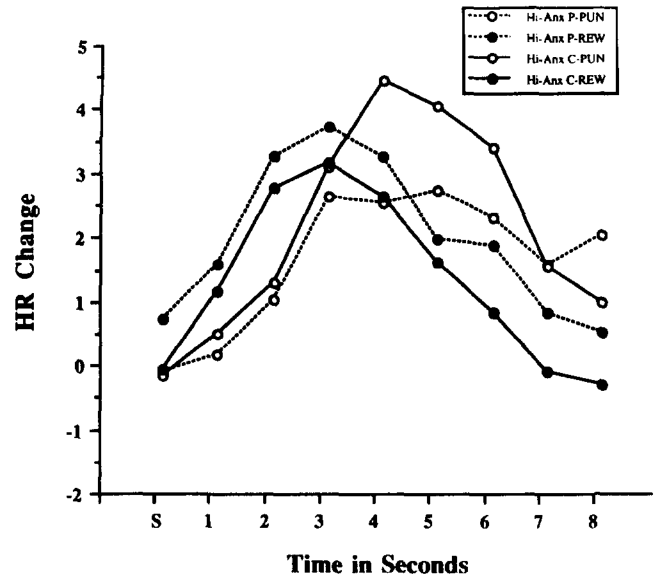

Fig. 2. HR change from pre-stimulus level to stimulus presentation second and seconds following punishment and reward trials for low-anxious psychopaths and controls. S = Stimulus presentation second; Hi-Anx P-PUN = High-anxious psychopaths—punishment; Hi-Anx P-REW = High-anxious psychopaths—reward; Hi-Anx C-PUN = High-anxious controls—punishment; and Hi-Anx C-REW = High-anxious controls—reward.

the high-anxious groups, $F(8,240) < 1.0$, (see Fig. 2). However, a significant effect was found in the low-anxious groups, $F(8,232) = 2.27$, $P < 0.05$ ($P = 0.054$ using the Huynh-Feldt correction) indicating that reaction to rewards and punishments in low-anxious psychopaths and controls varied as a function of feedback second (see Fig. 1). Thus, we examined the Psychopathy × Feedback interactions at each of the 9 sec. Significant Psychopathy × Feedback interactions were found at post-feedback seconds 2 [$F(1,29) = 4.30$, $P < 0.05$], 3 [$F(1,29) = 7.57$, $P < 0.01$], 7 [$F(1,29) = 12.53$, $P < 0.01$], and 8 [$F(1,29) = 18.22$, $P < 0.001$] (see Fig. 1).

The Newman–Keuls' Multiple-Range Test was used to unpack the Psychopathy × Feedback interactions at each second. The criterion for statistical significance for this and subsequent comparisons using the Newman–Keuls' Multiple Range Test was set at 0.05. The within-group comparisons demonstrated that at seconds 2, 3, and 8, low-anxious psychopaths displayed significantly greater HR following *reward* than following punishment. As shown in Fig. 1, the effects at seconds 2 and 3 appear to reflect a combination of low-anxious psychopaths' slow-to-develop reaction to punishment immediately following feedback in contrast to their rapid and immediate HR reactivity following the reward feedback. The effect at second 8 appears to be due to a combination of the relatively rapid recovery of low-anxious psychopaths' HR following punishment and their more gradual recovery following reward. At seconds 7 and 8, low-anxious controls displayed significantly greater HR following *punishment* than following reward.

Table 2. Means and standard deviations for SC variables as a function of group

	Psychopaths		Controls	
Variable	Low-anxious[a] Mean (SD)	High-anxious[b] Mean (SD)	Low-anxious[c] Mean (SD)	High-anxious[d] Mean (SD)
NSRs	0.518 (0.231)	0.356 (0.207)	0.444 (0.304)	0.567 (0.212)
SC Amp PUN	0.056 (0.077)	0.175 (0.172)	0.081 (0.082)	0.187 (0.155)
SC Amp REW	0.132 (0.115)	0.188 (0.237)	0.109 (0.084)	0.183 (0.133)
SCR Num PUN	0.357 (0.265)	0.521 (0.270)	0.421 (0.287)	0.729 (0.445)
SCR Num REW	0.480 (0.243)	0.504 (0.239)	0.449 (0.225)	0.501 (0.203)

NRSs = Nonspecific SC responses per 8 sec during baseline; SC Amp PUN = SC amplitude following punishment; SC Amp REW = SC amplitude following reward; SCR Num PUN = SCR number per trial following punishment; SCR Num REW = SCR number per trial following reward. [a]$n = 13$; [b]$n = 18$; [c]$n = 18$; and [d]$n = 14$.

Table 3. Means and standard deviations for behavioral variables as a function of group

	Psychopaths		Controls	
Variable	Low-anxious[a] Mean (SD)	High-anxious[b] Mean (SD)	Low-anxious[c] Mean (SD)	High-anxious[d] Mean (SD)
PAEs	8.0 (3.42)	9.28 (4.28)	10.55 (4.18)	10.77 (5.48)
OEs	4.77 (3.49)	8.22 (5.67)	4.44 (3.01)	6.57 (5.59)

PAE's = passive avoidance errors; OE's = omission errors.
[a]$n = 13$; [b]$n = 18$; [c]$n = 18$; and [d]$n = 14$.

The only significant between-group effects occurred at seconds 7 and 8 and indicated that low-anxious controls showed higher HR following punishment than low-anxious psychopaths. As shown in Fig. 1, this effect appears to be due to the gradual recovery of low-anxious controls' HR following punishment in contrast to the relatively rapid recovery displayed by low-anxious psychopaths.

SC analyses

Table 2 lists the means and SD's for the SC variables by group. The data for SC amplitude were analyzed using a Psychopathy × Anxiety × Feedback mixed model ANOVA with feedback as the repeated measure. The analysis revealed a significant main effect for anxiety, $F(1,59) = 7.07$, $P = 0.01$, indicating greater amplitude SCRs in high-anxious than in low-anxious *S*s following both reward and punishment. The Psychopathy × Feedback interaction did not approach statistical significance, $F(1,59) = 1.13$.

Number of SCRs per trial in the 8 sec post-feedback interval was analyzed using a Psychopathy × Anxiety × Feedback mixed model ANOVA with feedback as the repeated measure. This analysis revealed a significant main effect for Anxiety, $F(1,59) = 5.51$, $P < 0.05$, and a significant Anxiety × Feedback interaction, $F(1,59) = 6.14$, $P < 0.05$, with high-anxious *S*s showing more SCRs per trial, especially following punishment. The Psychopathy × Feedback interaction approached statistical significance, $F(1,59) = 3.68$, $P = 0.06$, due primarily to a statistical trend for psychopaths to show fewer SCRs per trial following punishment than controls, $F(1,59) = 3.41$, $P < 0.10$. The difference between groups following reward did not approach significance, $F(1,59) < 1.0$.

Behavioral analyses

Table 3 lists means and SD's for the behavioral data. Although, as indicated in Table 3, psychopaths made slightly fewer passive avoidance errors than controls, the Psychopathy × Anxiety ANOVA revealed no significant effects. The *S* (low-anxious control) who was not included in the psychophysiological analyses due to having only one useable trial of HR data was included in this analysis.

A Psychopathy × Anxiety ANOVA with omission errors as the dependent variable revealed a main effect for anxiety, $F(1,59) = 5.65$, $P < 0.05$, with high-anxious *S*s making more errors than low-anxious *S*s.

DISCUSSION

The purpose of this study was to assess psychopaths' autonomic response to reward and punishment in the context of a passive avoidance task. Based on behavioral evidence that low-anxious psychopaths are less likely than low-anxious nonpsychopaths to suspend approach responding following punishment, and that failure to pause following punishment is associated with poorer passive avoidance learning (Newman *et al.*, 1990), we hypothesized that, in comparison to HR following reward, psychopaths would display greater HR following punishment than nonpsychopaths. Contrary to prediction, *controls* tended to display higher HR following punishment than psychopaths.

Post-hoc analyses indicated that low-anxious psychopaths exhibited greater HR following *reward* than following punishment. As indicated in Fig. 1, the HR response of low-anxious psychopaths was slow to develop following punishment feedback whereas their reaction to reward was rapid and immediate. Low-anxious controls' response to reward and punishment was not clearly differentiated during the initial seconds of the feedback interval. However, *later* in the feedback interval low-anxious controls displayed greater HR following *punishment* than following reward, and also displayed higher HR following punishment than low-anxious psychopaths.

*S*s' EDA to reward and punishment feedback was assessed to evaluate potential group differences in sensitivity to punishment feedback that might indicate weak BIS functioning in psychopaths. The results were mixed. Although there were no statistically significant main effects or interactions involving psychopathy for SC amplitude, analyses of SCR *number* revealed a marginally significant Psychopathy × Feedback interaction, with psychopaths displaying a tendency toward fewer SCRs than controls following punishment.

That psychopaths tended to show lower HR and fewer SCRs following punishment relative to controls suggests that they were less reactive to punishment in this task. Such an interpretation is incompatible with our initial hypotheses. Although the marginally significant Psychopathy × Feedback interaction for SCRs provides some support for the weak BIS hypothesis, the group differences in HR following punishment appear to fit less well. Because the BIS acts to suppress activity of the BAS, the weak BIS hypothesis would appear to predict *greater* rather than *lower* HR following punishment among psychopathic offenders. However, proponents of this hypothesis could counter that the inhibitory influence of the BIS on BAS activity will be more apparent during reward feedback, when the BAS is activated, than during punishment feedback when the prospects for reward are reduced. Although this possibility is more consistent with the data, it does not explain psychopaths' lower HR following punishment.

One possibility that is consistent with psychopaths' weaker HR *and* SC responding following punishment is that low-anxious psychopaths engaged in less cognitive processing of the punishment feedback. In fact, Hare (1978) has proposed that psychopaths may "gate out" aversive stimuli and thus experience difficulty learning from punishment. According to Hare (1978), however, this gating out is preceded by HR *acceleration*, but punishment feedback in this study engendered greater HR acceleration in *controls* than psychopaths.

A final interpretation concerns the design of our passive avoidance task. Because every stimulus is either an S+ or an S−, it is possible to perform the discrimination task by focusing on *either* reward or punishment cues alone. *S*s could have mastered the discrimination by learning to recognize the reward stimuli and withhold responses on all other trials, or they could have adopted a strategy of responding on every trial unless they recognized a punishment stimulus. Although the latter strategy may enable better performance on the standard version of this task involving a shorter intertrial interval, both strategies may have been equally effective in the task used in the current study because it involved a longer intertrial interval of between 8 and 14 sec.

In light of the fact that low-anxious psychopaths were more reactive to reward feedback than to punishment feedback whereas low-anxious controls were more reactive to punishment than reward, the most plausible explanation of our data may be that low-anxious psychopaths relied upon reward feedback to master the task whereas low-anxious controls relied upon punishment. Although the group differences were not entirely symmetrical, the larger group differences following punishment versus reward may well reflect the fact that negative feedback requires more cognitive processing than positive feedback because negative feedback involves revising an expectation whereas positive feedback simply confirms an hypothesis (See Patterson *et al.*, 1987, for further discussion of this issue). However, without a direct measure of cognitive processing, our proposal that differences in HR following feedback reflect differences in cognitive processing is speculative and in need of further study.

A final comment concerns the observed main effects for anxiety. In comparison to low-anxious *S*s, high-anxious *S*s displayed significantly more omission errors. They also exhibited larger and more frequent SCRs to feedback, especially following punishment. This pattern of greater behavioral inhibition and greater EDA in high-anxious *S*s is consistent with theories linking anxiety with greater BIS activity (e.g. Fowles, 1980; Gray, 1982). The current investigation demonstrates that this relation appears to hold for incarcerated as well as for nonincarcerated *S*s.

Although the results of our study are informative, the psychophysiological findings should be interpreted with caution given the absence of significant group differences in passive avoidance learning. Psychopaths' physiological response to rewards and punishments may be somewhat different on tasks revealing poor passive avoidance learning in psychopaths. In addition, while the *pattern* of results across measures was consistent and interpretable, several of the effects found were at the level of statistical trends. Finally, it should be noted that positive and negative feedback in our task involved *actual* punishment (i.e. removal of chips) as well as a *cue* for punishment (i.e. the word "wrong"). A purer assessment of *S*s' physiological response to reward and punishment *cues* in a passive avoidance context may have yielded different results.

Despite its shortcomings, this study is noteworthy for at least four reasons. First, it represents the first attempt to assess psychopaths' HR and SC responding to reward and punishment within the context of a passive avoidance task. Second, it is the first report of significant effects for psychopaths' HR *reactivity* to punishment and reward. Differences found in prior research examining psychopaths' HR response to punishment have been in psychopaths' *anticipation* of punishment. Third, the fact that some of the differences found were specific to low-anxious groups is consistent with earlier findings (e.g. Newman *et al.*, 1990, in press; Smith *et al.*, 1992), and reaffirms the importance of exploring psychopathy as a function of anxiety level. Finally, given that the differences found varied as a function of feedback, our study demonstrates that differences in physiological patterning between psychopaths and controls do not necessarily generalize across situations but may differ depending upon the incentive context (i.e. reward/punishment). Additional research is needed to clarify the situations in which psychopaths show weak autonomic *reactivity* to punishment, and the extent to which, if any, weak reactivity to punishment is specific to situations involving monetary rewards as well as punishments (see Newman *et al.*, 1990, in press).

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