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# Psychopathy and Physiological Response to Emotionally Evocative Sounds

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Despite considerable evidence that psychopathic criminals are deviant in their emotional reactions, few studies have examined responses to both pleasurable and aversive stimuli or assessed the role of different facets of psychopathy in affective deviations. This study investigated physiological reactions to emotional sounds in prisoners selected according to scores on the 2 factors of Hare's Psychopathy Checklist—Revised (PCL–R; R. D. Hare, 1991). Offenders high on the PCL-R emotional–interpersonal factor, regardless of scores on the social deviance factor, showed diminished skin conductance responses to both pleasant and unpleasant sounds, suggesting a deficit in the action mobilization component of emotional response. Offenders who scored high only on the social deviance factor showed a delay in heart rate differentiation between affective and neutral sounds. These findings indicate abnormal reactivity to both positive and negative emotional stimuli in psychopathic individuals, and suggest differing roles for the 2 facets of psychopathy in affective processing deviations.

Cleckley (1976) characterized psychopathy as a "mask of sanity" in which overtly normal intelligence and verbal presentation disguise a severe underlying pathology. Cleckley theorized that the disjunction between the psychopath's surface demeanor and his or her self-defeating actions and disturbed interpersonal relations reflected a fundamental disconnection between cognition and affect. Research to date has provided considerable support for this conceptualization, including findings of reduced electrodermal reactivity to cues signaling noxious stimulation (cf. Arnett, 1997; Hare, 1978; Siddle & Trasler, 1981), reduced electrocortical discrimination between affective and neutral words (e.g., Kiehl, Hare, McDonald, & Brink, 1999; Williamson, Harpur, & Hare, 1991), and diminished potentiation of the defensive startle reflex during exposure to aversive emotional pictures or warning cues (Levenston, Patrick, Bradley, & Lang, 2000; Patrick, 1994; Patrick, Bradley, & Lang, 1993).

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A limitation of this existing literature is that most published studies have assessed reactivity to unpleasant emotional cues only, typically in the context of conditioning or quasi-conditioning (stressor anticipation) paradigms. Only a few studies have examined responses to appetitive as well as aversive stimuli, and all of these have used visual affective stimuli. The current study extended the existing literature by investigating physiological reactions to both pleasurable and aversive acoustic stimuli in psychopathic individuals.

## Emotion and Psychopathy

Emotion involves readiness for adaptive action—at a basic level, readiness to approach stimuli that are life sustaining and to avoid stimuli that are aversive or life threatening (Izard, 1993; Lang, 1995). The body's visceral and somatic responses can be viewed as direct efferent sequelae of emotional action states (Lang, 1979). Electrodermal activity indexes sympathetic arousal associated with action mobilization, whether appetitive or defensive (Greenwald, Cook, & Lang, 1989). Cardiac change reflects the metabolic demands of stimulus processing and orienting (Lacey, 1967) and can be acceleratory or deceleratory depending on the context of emotional processing (e.g., imaginal vs. perceptual; Lang, Bradley, & Cuthbert, 1990). Affective modulation of the protective startle reflex indexes the valence (appetitive or defensive nature) of emotional activation; this response is inhibited during processing of pleasurable stimuli and augmented during processing of aversive stimuli (Lang et al., 1990). Facial muscle response is an overt, visible facet of emotional expression that serves a basic communicative function and is sensitive to social context (Fridlund, Ekman, & Oster, 1986).

Cleckley's (1976) concept of a "mask of sanity" implies that certain aspects of emotional response should be deviant in psychopathy, and others comparatively intact. This is the pattern of results that has emerged from empirical studies examining deficits in emotional reactivity associated with psychopathy. These studies have consistently shown that psychopathic subjects exhibit reduced skin conductance response (SCR) to conditioned aversive stimuli or visual cues signaling an upcoming shock or loud noise (e.g., Hare, 1965, 1970; Hare, Frazelle, & Cox, 1978; Lippert & Senter, 1966; Lykken, 1957). Studies assessing heart rate (HR) reactivity in anticipation of aversive stimuli have produced less consistent group effects (for reviews, see Arnett, 1997; Hare, 1978). A limitation of these past studies is that they have not specifically assessed autonomic reactivity to pleasurable–appetitive stimuli.

Some more recent studies have examined positive as well as negative emotion using pictures drawn from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1999). The basis for psychopathy group assignments in this more recent work has been Hare's (1991) Psychopathy Checklist—Revised (PCL–R), which has emerged as the diagnostic standard in this area of research. In one study, Patrick et al. (1993) reported a deviant quadratic startle response pattern in PCL–R-defined psychopathic subjects, with blinks inhibited during both pleasant and unpleasant pictures compared with neutral pictures—implying an absence of normal defensive (fear) reactivity. In a follow-up study, Levenston et al. (2000) replicated this basic finding and further established that divergence in response was greatest for vicarious victim scenes (cf. Blair, Jones, Clark, & Smith, 1997): For scenes of this type, nonpsychopathic subjects evidenced significant startle potentiation, whereas psychopathic subjects showed significant blink inhibition. Psychopathic subjects in this study also failed to show attentional modulation of startle early in the picture-viewing interval, implying a lack of automatic orienting to emotionally relevant material of pleasant and unpleasant content (cf. Lang, Bradley, & Cuthbert, 1997). Later in the viewing interval, psychopathic subjects showed more HR deceleration to pleasant and unpleasant pictures compared with neutral pictures, but less SCR differentiation—indicating that they attended preferentially to affective content during later stages of picture processing, but this enhanced attention was not emotion driven. In contrast, psychopathic subjects in this study (and in Patrick et al., 1993) showed normal facial and self-report responses to emotional pictures.

Studies using brain response measures have also yielded evidence of aberrant reactivity to both pleasant and unpleasant stimuli among psychopathic individuals. Williamson et al. (1991) reported a lack of brain potential differentiation between affective (positive, negative) and neutral words in psychopathic subjects, as well as a lack of reaction time difference, despite equivalent classification accuracy. The interpretation was that these subjects processed the affective words in a superficial, semantic fashion. These electrocortical and behavioral findings have been replicated in subsequent research using similar word-processing tasks (Kiehl et al., 1999; Lorenz & Newman, 2002). The findings of this research, together with those of the aforementioned picture studies, suggest that psychopathic individuals show diminished reactivity to both pleasant and unpleasant stimuli at a basic action–response level (e.g., electrodermal response, startle reflex modulation, electrocortical reactivity), whereas their verbal reports and overt facial expressions appear normal. These findings are consistent with the concept of a dissociation between overt expressive behavior and basic emotional response in psychopathy (Cleckley, 1976).

A further point that emerges from this recent work is that emotional reactivity differences may be associated with specific diagnostic aspects of psychopathy. A notable feature of Hare's PCL–R is that it indexes distinct, albeit interrelated, facets of psychopathy. The dominant perspective to date has been that the PCL–R taps two correlated factors (Hare et al., 1990; Harpur, Hare, & Hakstian, 1989): Factor 1 (F1) consists of items reflecting the core affective–interpersonal features emphasized by Cleckley (1976; i.e., charm, egocentricity, shallow affect, absence of remorse or empathy, and blame externalization); Factor 2 (F2) reflects a socially deviant lifestyle (e.g., early behavior problems, delinquency, aggression, impulsiveness, and irresponsibility). The discriminant validity of these factors in terms of personality and behavior has been extensively documented (e.g., Hare, 1991; Harpur et al., 1989; Patrick, 1994; Verona, Patrick, & Joiner, 2001; Woodworth & Porter, 2002).

In a post hoc analysis examining the influence of these two factors, Patrick et al. (1993) reported that inmates high on both F1 and F2 showed a deviant quadratic startle pattern, whereas offenders scoring high only on the antisocial deviance factor (F2) showed a normal linear startle pattern. However, offender groups were not selected a priori in this study, so it was unclear whether diminished physiological reactivity to emotional stimuli was tied to high F1 scores or to the combination of high F1 and high F2 specifically. The only study to date that has examined the emotional reactivity of groups defined a priori on the basis of PCL–R factor scores was one described by Patrick (1994). Individuals high in F1 (regardless of their F2 scores) showed deficient fear-potentiated startle in a pseudoconditioning paradigm in which a warning cue (i.e., asterisk string) signaled an imminent noxious event (i.e., noise blast). High F1 individuals in this study also showed reduced electrodermal responses to the warning cue (cf. Patrick, 1995).

The current study built on this prior work by assessing responses to pleasurable as well as aversive sounds in groups defined a priori on the basis of these two factors of the PCL–R (F1 and F2). In addition, we performed analyses based on an alternative structural model of the PCL–R recently proposed by Cooke and Michie (2001). In this model, F1 is parsed into two separate factors, one encompassing glibness, egocentricity, lying, and manipulativeness ("arrogant and deceitful interpersonal style"; ADI); and the other, deficient remorse and empathy, shallow affect, and blame externalization ("deficient affective experience"; DAE). In addition, Cooke and Michie proposed a third factor, "impulsive and irresponsible behavior" (IIB), to replace PCL–R F2. The IIB factor includes PCL–R items related to stimulation seeking, impulsivity, irresponsibility, and a goal-less existence, and excludes items related specifically to antisocial behavior and conduct problems. As a follow-up to our primary analyses focusing on a priori groups based on the two-factor model, we report on the physiological correlates of these three factors to examine the construct validity of the three-factor conceptualization.

## Sounds as Emotional Stimuli

As discussed above, studies of emotion in psychopathy have focused on visual cues, and recent work of this kind has included more naturalistic representations (i.e., pictures) of both pleasurable and aversive stimuli. However, to gain a complete understanding of affective deviations in psychopathy, it is important to examine responses to emotional stimuli in other sense modalities. The primary auditory centers reside in the temporal lobe of the brain (vs. the occipital lobe for vision) and connect directly to limbic structures and language-processing areas. Audition thus plays a role in the processing of environmental cues with direct survival significance (e.g., growls, shouts, cries) as well as more complex affective information conveyed through language. Auditory paradigms have been used extensively in basic studies of subcortical emotion systems in animals (e.g., amygdala; LeDoux, 1996) and in emotional conditioning studies in humans (e.g., Hamm, Vaitl, & Lang, 1989; Patrick & Berthot, 1995). There is also a growing body of human neuroscience research investigating brain systems involved in basic auditory emotional processing (e.g., Irwin et al., 1996; Morris, Scott, & Dolan, 1999).

Some prior research has compared reactions of psychopathic and nonpsychopathic offenders to auditory stimuli. The findings of this work have been mixed. Psychopathic subjects do not appear to differ in autonomic or direct reactions to presentations of noxious noise stimuli (Hare, 1968), although they do show reduced electrodermal response during anticipation of noise (Hare, 1978). These latter findings suggest that psychopathic individuals show normal phasic responses to acoustic emotional events, but attenuated reactivity to cues that predict such events. However, this work has obvious limitations (i.e., nonnaturalistic stimuli, no inclusion of pleasant sounds). The only study to date that has examined processing of more naturalistic auditory stimuli in psychopathic subjects is one by Blair et al. (2002), which examined identification of vocal intonations conveying different emotions (i.e., happiness, disgust, anger, sadness, fear). Findings indicated impaired recognition of vocal affect in psychopathic versus nonpsychopathic individuals, particularly in recognition of fearful affect. This more recent research suggests that psychopathic individuals are less responsive to acoustic representations of emotion. However, vocal intonation is a subtle affect manipulation compared with picture presentation (e.g., even control subjects in the Blair et al. study misidentified intonations on 24% of trials), and this study did not include direct physiological assessment of affective response.

## Current Study

The current study extended prior research on emotion in psychopathic individuals by examining physiological responses to naturalistic emotional sounds using a procedure directly analogous to that used in recent picture-viewing studies. The sound stimuli were selected from the International Affective Digitized Sounds (IADS) system, an array of 116 naturalistic sounds designed for use in emotion research (Bradley & Lang, 1999). These sounds depict readily recognizable affective and neutral situations and stimuli, and are normed on affective rating dimensions of valence (pleasure), arousal, and dominance, permitting selection of stimulus sets with specifiable affective properties. Bradley & Lang (2000) reported that college students exhibited reliable physiological reactions to IADS sounds, including enhanced SCR and HR deceleration to affective versus neutral sounds, and enhanced zygomatic (smile) and corrugator (frown) facial response to pleasant and unpleasant sounds, respectively.

In the current study, we compared physiological reactions to pleasant, neutral, and unpleasant IADS sounds in male prisoner groups classified according to scores on the affective–interpersonal and social deviance facets of psychopathy (F1 and F2) specified by the traditional two-factor model of the PCL–R. Because data from picture-viewing studies suggest that psychopathic individuals are particularly unresponsive to the emotional reactions of others (Blair et al., 1997; Levenston et al., 2000), vicarious emotional sounds were emphasized. Physiological measures included SCR, HR, and two indices of facial muscle activity: corrugator and zygomatic electromyograph (EMG) measures. Startle reactivity was not assessed because acoustic foreground stimuli (i.e., sounds) call for a different-modality startle stimulus (e.g., visual) to control for attentional effects (Lang et al., 1990), and the necessary apparatus was not available for this study. Evaluative ratings of the sounds were also collected as an index of self-report.

Because this was the first study to use the IADS stimuli in a clinical population, a basic aim was to replicate findings reported for college students (Bradley & Lang, 2000) in the prisoner sample as a whole. Basic replication would help to establish the IADS as a paradigm for studying emotion in this and other psychopathological populations. A second objective was to examine psychopathy-related differences in reactivity to emotional versus neutral sounds. Diagnostic group assignments were made on the basis of scores on the two traditional factors of Hare's (1991) PCL–R in conjunction with overall PCL–R scores, and these factor score groupings were incorporated as between-subjects factors in analyses. In addition, we explored physiological reactivity to emotional sounds within the Cooke and Michie (2001) three-factor model. No prior research has examined the correlates of the three-factor model in this context, thus no specific hypotheses were advanced.

The primary hypothesis was that participants scoring high on F1 (regardless of their status on F2) would show reduced electrodermal reactivity to affective versus neutral sounds in comparison to participants low on Factor 1. Some evidence exists for enhanced cardiac reactivity to affective cues in psychopaths (Hare, 1978; Levenston et al., 2000), but this effect has not been examined in relation to the two PCL–R factors, so no specific hypothesis was advanced for this measure. With regard to facial EMG and affective report, these measures were not expected to differ as a function of psychopathy status.

## Method

### *Participants*

Participants were 68 male inmate residents of the Federal Correctional Institution in Tallahassee, Florida, a large medium-security prison. The participants were selected from a larger cohort of individuals ($N = 180$) who were assessed for psychopathy using the PCL–R (Hare, 1991). Information from a structured interview was used together with prison file data to assign ratings on the PCL–R. Scores on F1 (affective–interpersonal traits) and F2 (antisocial–impulsive behavior) were computed by summing scores for PCL–R items loading on each factor (Hare, 1991; Harpur et al., 1989). Two independent raters, the primary interviewer and a second assessor who viewed a videotape of the interview, completed diagnostic ratings. All raters were advanced graduate or undergraduate students in psychology who had undergone extensive training by the second author (C.J.P.) in the use of the PCL–R. Interrater reliability for the PCL–R was

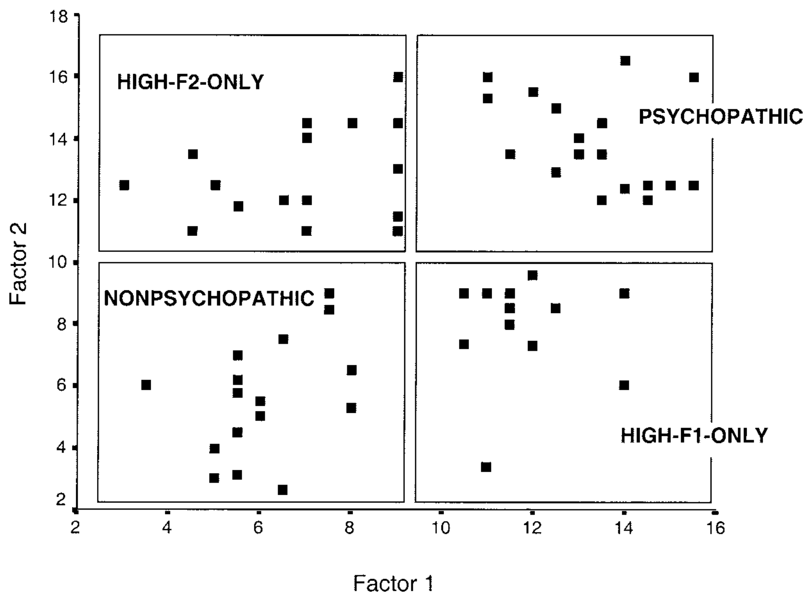


*Figure 1.* Scatterplot of Psychopathy Checklist—Revised (PCL–R; Hare, 1991) Factor 1 and Factor 2 scores for each participant in the study sample ($N = 68$), with PCL–R factor groups indicated. F = factor.

evaluated by intraclass correlation coefficients (Shrout & Fleiss, 1979). Single-rater coefficients for PCL–R F1, F2, and total scores were .85, .90, and .91, respectively; coefficients for the mean of the two raters were .92, .95, and .95, respectively. Diagnostic group assignments were made using the average of the ratings made by the two independent raters. The sample mean and standard deviations for PCL–R total, F1, and F2 scores were as follows: total, $M = 22.44$, $SD = 7.74$; F1, $M = 9.90$, $SD = 4.22$; F2, $M = 9.38$, $SD = 3.51$.

Participants were assigned to four study groups on the basis of their scores on the two PCL–R factors: (a) nonpsychopathic, having low scores on both F1 and F2 and a total PCL–R score of 20 or less ($n = 18$); (b) high-F1-only, having high scores on F1 but low scores on F2 ($n = 15$); (c) high-F2-only, having high scores on F2 but low scores on F1 ($n = 17$); and (d) psychopathic, having high scores on both factors and total PCL–R scores of 30 or more ($n = 18$). These groupings (see Figure 1) were achieved via a two-stage process. We began by assigning participants to groups on the basis of extreme low-high cutoff scores for the two PCL–R factors (i.e., F1: $<8$, $>11$; F2: $<9$, $>12$) along with overall PCL–R score criteria for the nonpsychopathic ($<20$) and psychopathic ($>30$) groups. Once we reached target *n*s of 18 in the psychopathic and nonpsychopathic groups and median F1 and F2 scores for the overall assessment sample were known, we assigned additional participants to the high-F1-only and high-F2-only groups using median values for each factor as the criteria for low-high in order to enhance *n*s in these two groups (F1 median = 9.1; F2 median = 9.5). Individuals from the assessment cohort not represented in the testing sample were excluded either because they did not meet inclusionary criteria for one of the study groups or because they had left the prison before they could be tested.

Ethnic representation across all offender groups was as follows: 34 (50%) African American, 28 (41%) Caucasian, and 6 (9%) Hispanic. The mean age of the sample as a whole was 32.8. A chi-square test for ethnic status and an analysis of variance (ANOVA) test for age revealed no significant differences between diagnostic groups on these demographic variables.

## *Stimulus Materials*

Stimuli consisted of nine sound clips of 6-s duration chosen from the IADS (Bradley & Lang, 1999). Three sounds of each valence were used (pleasant: baby laugh, female erotic moan, and crowd cheer; unpleasant: baby cry, female attack sound, male attack sound; neutral: chicken cluck, toilet flush, toothbrush).[1] These specific sounds were chosen so as to vary thematic content within each valence category (i.e., to enhance generalizability), while ensuring that affective sounds were maximally evocative compared with neutral. Specifically, pleasant and unpleasant sounds were chosen to be extreme in rated arousal and comparably different from neutral in rated valence. Mean IADS normative valence ratings (9-point scale) for pleasant, neutral, and unpleasant sounds were 8.1, 5.6, and 2.3, respectively. Mean normative arousal ratings (9-point scale) were 6.9, 1.5, and 7.2, respectively. Stimuli in the three categories were matched for peak sound intensity (cf. Bradley & Lang, 2000); peak means for pleasant, neutral, and unpleasant sounds were 92.4, 91.2, and 91.3 dB, respectively. The nine sounds were presented three times each, in a blocked sequence (see below), to permit analysis of habituation effects.

## *Physiological Measures*

EMG activity was recorded from the corrugator supercilii muscle and the zygomaticus major muscle using miniature electrodes positioned above the left eyebrow and over the left cheek, respectively (Fridlund & Cacioppo, 1986). Coulbourn (Allentown, PA) bioamplifiers and contour-following integrators were used to process these signals (filter cutoffs = 90 and 1000 Hz; time constant = 500 ms), and these were sampled at 20 Hz. EMG response was defined as the average change in microvolts during the 6 s of sound presentation from the 1-s baseline immediately preceding sound onset.

SCR was recorded from adjacent sites on the palm of the nondominant hand using SensorMedics (Anaheim, CA) 1-cm Ag-AgCl electrodes (Lykken & Venables, 1971). Electrodes were connected to a Coulbourn S71–23 isolated skin conductance coupler. SCR was defined as the largest increase (from the 1-s baseline) observed within the 6 s of sound presen-

[1] IADS sound numbers were: pleasant—201, 220, 353; unpleasant—261, 279, 286; neutral—132, 700, 720.

tation. Raw scores were used in the analyses of SCR.[2] Equipment failure resulted in the loss of SCR data for 1 nonpsychopathic participant.

HR activity was recorded from SensorMedics 1-cm Ag-AgCl electrodes positioned on the right and left inner forearms, and filtering was done with a Coulbourn S75-01 high gain bioamplifier. Interbeat intervals were recorded in milliseconds and were reduced offline to HR in beats per minute for each half second of the pre-sound baseline and sound viewing intervals. HR reactivity was defined as the average change during the 6-s sound presentation period from the 1-s baseline immediately preceding sound onset.

## *Procedure and Study Design*

After electrodes were attached, sound clips were presented binaurally through Telephonics stereo headphones. Each trial included a 1-s baseline, followed by a 6-s sound presentation period. Intertrial intervals (ITIs) ranged from 16 to 24 s ($M = 20$ s). Nine different stimulus orders were used to balance the presentation of sounds across participants within diagnostic group, and each sound was presented once on three consecutive blocks. Across the nine stimulus orders and three presentation blocks, each sound stimulus was represented equally at each serial position. Physiological responses were recorded during the 27 trials of sound presentation.

Afterward, participants listened to the nine sounds again one by one, and this time rated each on affective dimensions of valence (pleasantness), arousal, and dominance using a computerized version of Lang's (1980) Self-Assessment Manikin (SAM). Participants also rated the interest value of each sound (from *not at all interesting* to *very interesting*) on a computerized analog scale.

## *Data Analyses*

All dependent measures (self-report and physiological) were analyzed within a mixed-model ANOVA with F1 (low vs. high) and F2 (low vs. high) as between-subject variables and sound category (pleasant, neutral, unpleasant) as a within-subject variable.[3] Analysis of physiological measures included a second within-subject factor, block (1–3). Planned orthogonal comparisons were used to maximize power to detect effects involving sound category and block (Bradley & Lang, 2000; Levenston et al., 2000; Patrick et al., 1993). Specifically, sound category was decomposed into orthogonal quadratic (pleasant/unpleasant vs. neutral) and linear (pleasant vs. unpleasant) contrasts to examine overall response to affective (vs. neutral) sound stimuli and specific response differences between positive (vs. negative) sounds, respectively. Block was decomposed into orthogonal Blk1v23 (Block 1 vs. Blocks 2 and 3) and Blk2v3 (Block 2 vs. Block 3) contrasts that afforded maximal power to assess reactivity differences for initial, compared with subsequent, presentations of the sound stimuli.

# Results

## *Overall Responses to Sound Categories*

*Self-report ratings.* Across all offender participants, pleasant and unpleasant sounds were rated as more arousing (*M*s = 12.1 and 10.1; *SD*s = 4.5 and 4.8) and more interesting (*M*s = 14.1 and 9.1; *SD*s = 4.1 and 4.7) than neutral sounds (arousal: $M = 5.0$, $SD = 4.0$; interest: $M = 5.8$, $SD = 4.6$), quadratic $F$s(1, 64) = 100.73 and 78.50, respectively, *p*s < .01. The pleasant sounds were also judged to be more arousing and more interesting than the unpleasant sounds, linear $F$s(1, 64) = 12.16 and 51.09, respectively, *p*s < .01. Pleasant sounds were judged to be higher in valence than unpleasant sounds (*M*s = 15.0 and 5.9; *SD*s = 3.0 and 3.4, respectively), linear $F(1, 64) = 160.30$, *p*s < .01. A parallel effect was found for dominance ratings (pleasant, $M = 13.6$, $SD = 4.1$; unpleasant, $M = 8.0$, $SD = 4.6$), linear, $F(1, 64) = 69.28$, $p < .01$.

*Physiological measures.* Participants responded with more zygomatic muscle activity to pleasant sounds than to unpleasant sounds (*M*s = .20 and .06; *SD*s = .34 and .22, respectively), and more corrugator muscle activity to unpleasant sounds than to pleasant sounds (*M*s = .29 and –.11; *SD*s = .68 and .62, respectively), linear $F$s(1, 64) = 14.08 and 14.81, respectively, *p*s < .01. For the autonomic measures, participants in general showed greater SCR and greater HR deceleration to affective sounds (*M*s = .03 and –.25; *SD*s = .06 and 1.25, respectively) compared with neutral sounds (SCR: $M = .01$, $SD = .02$; HR: $M = .54$, $SD = 1.40$), quadratic $F(1, 63) = 10.08$ and $F(1, 64) = 20.17$, respectively, *p*s < .01. For SCR, greater overall reactivity was also observed for pleasant versus unpleasant sounds (*M*s = .03 and .02; *SD*s = .07 and .06, respectively), linear $F(1, 63) = 7.98$, $p < .01$.

A significant Blk1v23 contrast was observed for the SCR and HR measures, with the magnitude of SCR and HR deceleration decreasing from the first (*M*s = .02 and –.77; *SD*s = .09 and 3.32) to the second and third blocks (*M*s = .001 and .42; *SD*s = .04 and 3.58), $F(1, 63) = 13.59$ and $F(1, 64) = 30.36$, respectively, *p*s < .01. The Blk2vs3 contrast was not significant for any of the physiological measures. No interactions between sound category and block were observed.

## *Psychopathy Effects on Emotional Responses to Sounds*

*Self-report ratings.* As expected, few effects of PCL-R F1 or F2 were found on self-report ratings of sounds. A significant main effect of F1 was found for ratings of arousal, $F(1, 65) = 13.71$, $p < .01$, with offenders high in F1 reporting higher arousal across all sound categories than offenders low in F1 (*M*s = 10.43 and 7.77, respectively). No interaction between F1 or F2 and sound category was found for any of the rating variables.

*Physiological measures.* For SCR, a main effect of F1 was observed: Participants high in F1 exhibited lower SCR to all sounds, $F(1, 63) = 7.77$, $p < .01$. A significant F1 × Sound Category (quadratic contrast) interaction was also found, $F(1, 63) = 5.36$, $p < .05$, indicating that participants high in F1 displayed reduced differentiation between affective (pleasant/unpleasant) and neutral sounds compared with offenders low in F1 (see Figure 2). A significant F1 × Sound Category linear contrast (pleasant vs. unpleasant) was also observed for SCR, $F(1, 63) = 8.58$, $p < .05$. Whereas participants low in F1 exhibited enhanced SCR to pleasant as compared with unpleasant sounds, linear $F(1, 63) = 10.14$, $p < .01$, offenders high in F1 did not show this

[2] We also performed analyses using log-transformed (log[SCR + 1]) scores, a common transformation for SCR data. Because results were essentially the same for these analyses, we report results for only the raw, untransformed scores.

[3] Analyses were conducted on dichotomized PCL–R factor scores because participants were assigned a priori to high and low F1 and F2 to allow for counterbalancing of stimuli across groups in a quasi-experimental design, and to facilitate reporting and graphical presentation of complex interactions. However, all significant effects reported in the text from the dichotomous F1 and F2 analyses were replicated within regression analyses utilizing continuous F1 and F2 scores as predictors.

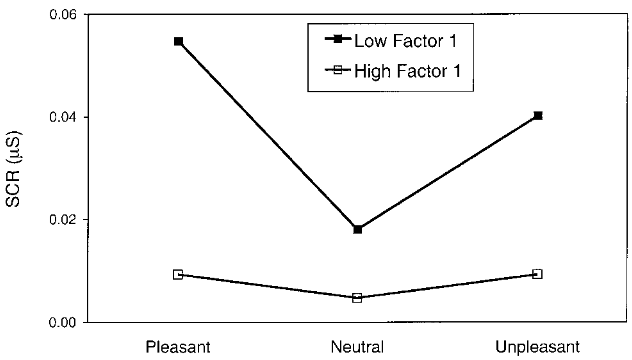


*Figure 2.* Mean skin conductance response (SCR), by sound valence category (pleasant, neutral, unpleasant) and Psychopathy Checklist—Revised Factor 1 group (low vs. high).

difference, $F(1, 63) = .01$, *ns*. No significant F1 or F2 interactions involving block were observed.[4]

For HR, a significant F1 × F2 × Sound Category (*quadratic* contrast) × Block (*Blk1v2/3* contrast) interaction was observed, $F(1, 64) = 5.06$, $p < .05$. To further examine this interaction, a Sound Category × Block analysis was performed separately for each F1 and F2 group (nonpsychopathic, high-F2-only, high-F1-only, psychopathic). HR responses to affective versus neutral sounds differed from Block 1 to Blocks 2 and 3 for the high-F2-only offenders, Sound Category (quadratic contrast) × Blk1v23 $F(1, 16) = 5.16$, $p < .05$. This Sound Category × Block interaction was not significant in the other groups. Follow-up analyses for the high-F2-only group revealed that the quadratic contrast was not significant in Block 1, $F(1, 16) = .11$, $p = .75$; however, during Blocks 2 and 3, this group showed the pattern of greater deceleration for affective versus neutral sounds that was evident in the other groups across all blocks, $F(1, 16) = 6.36$, $p < .05$ (see Figure 3). No significant main effects or interactions involving F1 or F2 were observed for the two EMG measures.

### *Cooke and Michie (2001) Three-Factor Model*

In addition to analyses based on the original two-factor model of the PCL–R (Hare et al., 1990; Harpur et al., 1989), we performed follow-up analyses based on Cooke and Michie's (2001) three-factor conceptualization to supplement our a priori analyses and to explore the construct validity of this newer model. Follow-up analyses examined relations between PCL–R factor scores from the three-factor model (DAE, ADI, and IIB) and physiological response effects observed for the original PCL–R factors (i.e., SCR effects associated with F1, and HR effects associated with F2). To reexamine SCR effects in relation to Cooke and Michie's (2001) model, we computed correlations between their two facets of F1 (i.e., interpersonal [ADI] and affective [ADE] factors) and the magnitude of quadratic and linear SCR effects. ADI and DAE factor scores were both negatively related to the magnitude of the SCR quadratic contrast (i.e., higher factor scores were associated with less affective versus neutral differentiation), *r*s = –.37 and –.10, respectively, although only the former relationship was significant at $p < .05$. In addition, both ADI and DAE scores were significantly and negatively related to the SCR linear contrast, indicating less pleasant versus unpleasant differentiation as a function of higher factor scores, *r*s = –.32 and –.26, *p*s < .05. These negative correlations are consistent with the pattern of results reported above for SCR in high F1 offenders.

As for HR, correlational analyses using Cooke and Michie's (2001) third (IIB) factor, a 5-item subset of the original 9-item F2, yielded results consistent with the above-noted deficit in HR differentiation found for high-F2-only participants. A significant negative correlation was found between scores on the IIB factor and magnitude of the quadratic (affective > neutral) HR deceleration effect among individuals low in F1 (i.e., sum of ADI and DAE) during Trial Block 1, $r = –.37$, $p < .05$, but not during Blocks 2 and 3, $r = .14$. In contrast, among individuals high in F1, IIB scores were unrelated to the magnitude of quadratic HR differentiation in Trial Block 1, $r = .18$, *ns*, or in subsequent blocks, $r = –.04$.

## Discussion

### *Response Patterns in Criminal Offenders Versus College Students*

In general, patterns of self-report and physiological reactivity to IADS sound stimuli in this sample of adult male prisoners closely resembled those reported for younger college students (Bradley & Lang, 2000). Mean ratings of affective valence and dominance were higher for pleasant and lower for unpleasant than for neutral sounds, and sounds in both emotional categories were rated as more arousing and interesting than neutral sounds. Among the physiological measures, larger SCR was observed for affective (pleasant and unpleasant) sounds in comparison to neutral, indicating enhanced sympathetic activation to emotional stimuli. Greater zygomatic (smile) reactivity was observed for pleasant compared with unpleasant sounds, and greater corrugator (frown) response was evoked by unpleasant in comparison to pleasant sounds (Lang, 1995).

For HR, greater deceleration was evident for both pleasant and unpleasant sounds in comparison to neutral. This overall pattern departs from that normally observed with pictures, where cardiac deceleration tends to be greater for unpleasant than pleasant scenes (Greenwald et al., 1989; Lang, 1995). These results highlight the point that emotional processing of auditory versus visual stimuli may involve different brain mechanisms. Understanding in this domain seems likely to progress in light of the growing interest

[4] The presence of a significant main effect of F1 for overall SCR raises the possibility that high F1 participants actually differentiated between affective and neutral pictures to a similar degree within their effective range of responsiveness (cf. Lykken, Rose, Luther, & Maley, 1966). To address this possibility, we repeated the SCR analysis using range-corrected scores (i.e., dividing raw scores by the difference between a participant's minimum and maximum levels during the sound procedure; Lykken et al., 1966). Predictably, the range-correction procedure eliminated the F1 main effect, $F(1, 63) = 1.96$. However, a significant F1 × Sound Category interaction was still obtained using the range-corrected scores, $F(2, 62) = 4.31$, $p < .02$, with both the F1 × Quadratic and the F1 × Linear contrasts reliable, *F*s(1, 63) = 3.79 and 7.20, respectively, *p*s = .056 and .01. These results indicate that high F1 participants showed reduced differentiation between affective (vs. neutral) and pleasant (vs. unpleasant) sounds within their effective range of SCR.

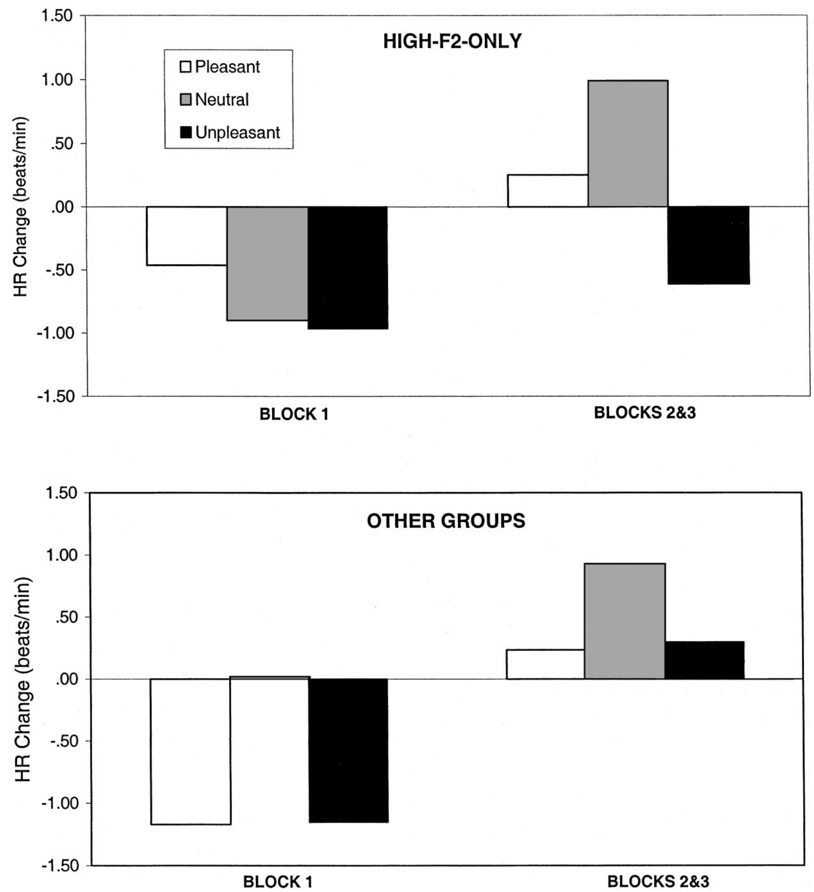


*Figure 3.* Mean heart rate (HR) change from baseline to sound presentation, by sound valence category and stimulus block (1 vs. 2 and 3), for participants in the high-F2-only group (top panel) compared with participants in the other three Psychopathy Checklist—Revised factor groups combined (bottom panel). F = factor.

among human neuroscience researchers in investigating these alternative affect-processing pathways (e.g., Morris et al., 1999).

### *Psychopathy Group Differences in Responses to Affective Sounds*

Offenders scoring high on the core affective–interpersonal factor of the PCL–R exhibited attenuated SCR to both pleasant and unpleasant sounds in comparison to neutral (quadratic sound category effect), and also failed to show SCR differentiation between pleasant and unpleasant sounds (linear effect) that was evidenced by the rest of the study sample. Electrodermal reactivity reflects sympathetic activation mediated, at least in part, by subcortical centers in the brain (e.g., amygdala; Boucsein, 1992; Mangina & Beuzeron-Mangina, 1996), and reduced SCR therefore implies a deficit in the low-level action mobilization normally evoked by emotionally significant stimuli. The current data add to a growing body of evidence indicating that high psychopathy individuals do not discriminate normally between nonemotional and emotional cues, whether pleasurable or aversive, in basic physiological response systems—including brain potential activity (Williamson et al., 1991) and early attentional modulation of the startle reflex (Levenston et al., 2000). In particular, our data suggest that psychopathy is associated not only with deficits in defensive (fear) activation, but also with a lack of responsiveness to pleasant cues, including erotic sounds.

These findings seem at odds with postulations by theorists in the area who have suggested that psychopathic individuals exhibit normal or enhanced appetitive reactivity (e.g., Fowles, 1980; Gorenstein & Newman, 1980). An important basis for the idea that such persons are normal in appetitive reactivity is that they show strong sensation-seeking tendencies (e.g., Lykken, 1995). However, stimulation-seeking behavior does not necessarily reflect enhanced sensitivity to pleasant cues. Indeed, it may be that psychopathic individuals seek out highly stimulating and adventurous contexts in order to compensate for reduced internal stimulation derived from pleasurable cues (cf. Eysenck, 1967; Zuckerman, 1979). Of course, this position is speculative. Nevertheless, our results encourage further research on physiological responses to both pleasurable and aversive emotional stimuli in psychopathy.

Another interesting aspect of the sound stimuli in the current study was that they all involved expressions of emotion by other persons. Blair and colleagues (Blair, 1999; Blair et al., 1997) have proposed that psychopathic individuals are uniquely insensitive to vicarious affective stimuli. The results from the current study extend Blair's work by demonstrating that psychopathic individuals show a general lack of responsiveness (i.e., lack of empathy) to vicarious emotional depictions, including those of a pleasant nature. Further research comparing reactivity to vicarious and self-referential cues is needed to evaluate this hypothesis further.

With regard to the interpersonal (ADI) and affective (DAE) facets of F1 specified by Cooke and Michie (2001), both were associated with diminished SCR differentiation between affective and neutral sounds, although only the correlation for ADI was significant. In addition, both factors significantly predicted aberrant nondifferentiation between pleasant and unpleasant sounds. The stronger relationship for the ADI versus the DAE factor is somewhat unexpected, given that the latter ostensibly reflects aberrant emotional reactivity. However, ours is the first study to report on the physiological correlates of these two facets of PCL–R F1, and therefore our findings require replication. Moreover, given that we selected participants according to their scores on the two original PCL–R factors, the current sample may not be optimal to test hypotheses regarding the three factors of Cooke and Michie (2001). Nonetheless, these initial data suggest that the ADI and DAE facets of the PCL–R are both associated with deviant emotional processing. Future research should strive to establish, in an a priori fashion, the distinct correlates of the three-factor model.

Compared with the robust group effect for SCR in the current study, SCR differences in prior psychopathy studies assessing reactivity to pleasant, neutral, and unpleasant picture stimuli have been equivocal (Levenston et al., 2000; Patrick et al., 1993). This difference may reflect the unique features of emotional sound versus picture processing. Sound processing may activate subcortical emotion systems through less direct neural pathways than pictures (cf. Bradley & Lang, 2000). If so, delineation of the relevant pathways for the two modalities could yield clues as to the nature of emotional processing deficits in psychopathy.

In contrast to the results for SCR, participants high in F1 did not differ in patterns of self-report or facial or cardiac reactivity. The one group difference that emerged from the self-report analyses was that ratings of arousal were higher overall among inmates high in F1. This could mean that these participants were generally less activated during intervals between sound presentations (ITIs averaged 20 s) and thus experienced the sound stimuli as more arousing by comparison (cf. Patrick & Lavoro, 1997). Nevertheless, the contrasting effect for SCR (i.e., reduced reactivity in this group) indicates that arousal reactions to the sound stimuli were smaller in absolute terms.

The finding of normal corrugator and zygomatic EMG reactivity to emotional sounds adds to a growing body of empirical data indicating that psychopathic individuals do not differ in overt facial expressions of emotion. The finding of normal cardiac differentiation but attenuated electrodermal response coincides with dissociations reported in past studies of autonomic reactivity to aversive warning cues (Hare, 1965, 1970; Hare et al., 1978; Lippert & Senter, 1966; Lykken, 1957; Patrick, 1994). SCR and HR both covaried with orienting in the current study, as evidenced by parallel habituation of these responses across presentation blocks. However, SCR reflects sympathetic arousal in support of action mobilization (Greenwald et al., 1989), whereas HR deceleration indexes sensory intake and attentional engagement (Lacey, 1967). The fact that individuals high in the affective–interpersonal component of psychopathy (PCL–R F1) evidenced differential cardiac orienting to pleasurable and aversive sounds without accompanying sympathetic (SCR) activation implies a "cold," ratiocinative assessment of the significance of these affective stimuli (cf. Cleckley, 1976).

In addition to these results for PCL–R F1, some interesting effects were obtained for PCL–R F2. In the analysis of sound valence categories, a unique HR pattern emerged for individuals high on F2 but low on F1. The finding of enhanced HR deceleration for affective sounds relative to neutral, observed across all sound presentation blocks in the other prisoner groups, was evident solely in Blocks 2 and 3 for this high-F2-only group. Within the initial sound block, high-F2-only offenders showed uniform cardiac deceleration for pleasant, neutral, and unpleasant sounds. A similar pattern was found for normal participants under conditions of alcohol intoxication (Stritzke, Patrick, & Lang, 1995); the interpretation was that alcohol impaired cortical associative processing of the picture content. From this perspective, the lack of HR differentiation in Sound Block 1 among these high-F2-only offenders could signify a delay in processing the affective significance of the sounds at a higher cortical level. On the other hand, this group did show enhanced SCR to affective pictures across blocks, indicating differentiation at a more basic sympathetic level.

### *Implications, Future Directions, and Limitations*

Psychopathy has traditionally been viewed as a unitary syndrome in which impulsive acting out behavior arises from a core affective–interpersonal deficit (cf. Cleckley, 1976). Our data add to a growing body of evidence indicating that the different components of psychopathy, although correlated, are dissociable—analogous to anxiety and depressive disorders, which have been conceptualized as correlated but distinct syndromes (Mineka, Watson, & Clark, 1998). Prior work has established that F1 is associated positively with agency/dominance and negatively with trait anxiety (Harpur et al., 1989; Verona et al., 2001) and, behaviorally, with greater use of strategic–instrumental aggression (Patrick, Zempolich, & Levenston, 1997; Woodworth & Porter, 2002). In contrast, F2 shows selective positive relations with trait dimensions of impulsivity/disinhibition and negative emotionality—the latter encompassing traits of aggression, alienation, and anxiety (Harpur et al., 1989; Patrick, 1994; Verona et al., 2001). Behaviorally, F2 is associated positively with child and adult antisocial deviance, abuse of alcohol and drugs, impulsive–reactive aggression, and suicide attempts (Patrick et al., 1997; Smith & Newman, 1990; Verona et al., 2001).

Taken together, findings from existing studies indicate that the emotional–interpersonal factor of the PCL–R (F1)—which is regarded as the core of the syndrome (Cleckley, 1976; Harpur et al., 1989; Lykken, 1995)—reflects a fundamental weakness in affective reactivity. In contrast with the longstanding theory that psychopathy reflects a specific deficit in aversive response (Fowles, 1980; Lykken, 1957), our results point to a broader weakness in emotional reactivity, entailing diminished reactivity to both pleasurable and aversive stimuli. This may be especially the case for vicarious emotional stimuli, which were featured in the current study. It will be important to examine this issue systematically in future research by examining psychopathic individuals' reactivity to positive emotional cues of different kinds within different sensory modalities. In addition, further work on the emotional and physiological correlates of Cooke and Michie's (2001) three-factor model is warranted.

Available data indicate that the social deviance factor of the PCL–R (F2) reflects impairments in the ability to regulate emotion and action. Building on earlier work (Smith & Newman, 1990), recent research (Patrick, Hicks, Krueger, & Lang, 2003) has revealed a close association between this facet of psychopathy and a broad vulnerability factor reflecting the covariance among "externalizing" disorders (i.e., conduct disorder, adult antisocial behavior, alcohol and drug dependence) within the *DSM* (American Psychiatric Association, 1994). Other work has shown that this externalizing factor is highly heritable (Krueger et al., 2002), and there are indications that it may account for findings of reduced brain potential (P300) and executive function deficits in these disorders (e.g., Morgan & Lilienfeld, 2000; Peterson & Pihl, 1990). Based on these lines of evidence, we hypothesize that the social deviance facet of the PCL–R reflects impairments in higher (i.e., frontal) brain systems that are crucial for affect regulation and response inhibition. On the other hand, PCL–R F2 (vs. F1) has also been associated with familial/environmental variables involving childhood adversity, neglect, and abuse (Harpur et al., 1989). It will be important in future work to examine how these environmental factors interact with brain-based vulnerabilities to impact dysregulated affect and behavior in these individuals.

In closing, some limitations should be acknowledged. The current study included only a sample of the diverse sound contents available in the IADS, and this selection should be expanded in follow-up research. It will also be useful to include a broader range of physiological measures, such as the visual startle-probe reflex (Bradley & Lang, 2000) and brain potential response. The current work could also be extended to include both visual and acoustic affective stimuli in order to directly assess whether group differences (e.g., in SCR) are moderated by stimulus modality. Further work would also benefit from larger participant samples in which relations between continuous scores on the PCL–R and its facets can be used to examine relations with affective processing, and potential mediators of such relations, within a dimensional framework. Notwithstanding these limitations, the current study provides valuable new information about basic affective reactivity differences in psychopathic individuals, and adds to a growing body of data indicating that such differences are uniquely tied to the emotional–interpersonal facet of psychopathy.

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