Available online at www.sciencedirect.com
SCIENCE DIRECT®
BIOLOGICAL PSYCHOLOGY
Biological Psychology 73 (2006) 114–123
www.elsevier.com/locate/biopsycho

They know the words, but not the music: Affective and semantic priming in individuals with psychopathy

K.S. Blair [a], R.A. Richell [a], D.G.V. Mitchell [a], A. Leonard [c], J. Morton [b], R.J.R. Blair [a,*]

[a] Mood and Anxiety Disorders Program, National Institute of Mental Health, National Institutes of Health, Department of Health and Human Services, Bethesda, MD, United States
[b] Institute of Cognitive Neuroscience, University College London, London, United Kingdom
[c] Department of Psychology, HM Prison Wormwood Scrubs, London, United Kingdom

Received 20 September 2004; accepted 24 December 2005
Available online 29 March 2006

Abstract

Previous work has indicated dysfunctional affect-language interactions in individuals with psychopathy through use of the lexical decision task. However, it has been uncertain as to whether these deficits actually reflect impaired affect-language interactions or a more fundamental deficit in general semantic processing. In this study, we examined affective priming and semantic priming (dependent measures were reaction times and error rates) in individuals with psychopathy and comparison individuals, classified according to the psychopathy checklist revised (PCL-R) [Hare, R.D., 1991. The Hare Psychopathy Checklist-Revised. Multi-Health Systems, Toronto, Ont.]. Individuals with psychopathy showed significantly less affective priming relative to comparison individuals. In contrast, the two groups showed comparable levels of semantic priming. The results are discussed with reference to current models of psychopathy.
Published by Elsevier B.V.

Keywords: Psychopathy; Affective priming; Semantic priming

1. Introduction

Psychopathy is characterized by a callous, shallow and manipulative affective-interpersonal style combined with antisocial and reckless behavior (Hare, 1991). In his book 'The mask of sanity' Cleckley (1976) observed that there is a discordance between the expressed and experienced values of emotions in individuals with psychopathy and used the term 'semantic dementia' to describe this observation. According to this term, individuals with psychopathy do represent the lexical meaning of emotions, but they do not experience their affective value; they ''know the words but not the music'' (Johns and Quay, 1962).

In line with this clinical description, research on the psycholinguistic processes of individuals with psychopathy has indicated that whereas they understand and apply the lexical meaning of emotional words, they do not experience the affective value attached to them. A clear demonstration of this dichotomy comes from a study by Hare et al. (1988) examining the use of affect-relevant semantic or non-affect-relevant information in the matching of words. In this study, participants were presented with word triads (e.g., ''warm, loving, wise'' and ''foolish, shallow, deep'') and instructed to select the two words that were closer together in meaning. Whereas the comparison individuals grouped words primarily according to their emotional information (e.g., polarity–foolish-shallow—both have a negative connotation), individuals with psychopathy grouped words primarily according to their non-emotional characteristics (e.g., antonym–deep-shallow). From this result Hare concluded that individuals with psychopathy ''appeared to base their judgments more on learned associations between the words than on their emotional significance''.

A more direct demonstration of the intact lexical representation, but reduced impact, of emotional words in individuals with psychopathy comes from studies using the lexical decision task. In lexical decisions (reporting whether or not a letter-string is a word), healthy individuals are faster (Strauss, 1983) at responding to emotional words relative to neutral words. However, individuals with psychopathy often do not show this speed advantage for emotional words (Lorenz and Newman,

* Corresponding author at: Unit on Affective Cognitive Neuroscience, Mood and Anxiety Disorders Program, National Institute of Mental Health, 15K North Drive, Room 206, MSC 2670, Bethesda, MD, United States.
Tel.: +1 301 496 5198; fax: +1 301 594 9959.
E-mail address: blairj@intra.nimh.nih.gov (R.J.R. Blair).

0301-0511/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.biopsycho.2005.12.006

2002; Williamson et al., 1991). In addition, individuals with psychopathy show significantly less difference in event-related potential (ERP) between emotional and neutral words relative to comparison individuals (Williamson et al., 1991). That is, individuals with psychopathy show reduced affect-driven facilitation and physiological response for emotional words.

It is possible that the affective linguistic processing impairments do not reflect impairments in affect but rather a more generalized impairment in linguistic/semantic processing. Lorenz and Newman (2002) examined the influence of word frequency on lexical decision. They found that comparison individuals, relative to individuals with psychopathy, showed a significantly greater reaction time (RT) advantage for high-frequency relative to low-frequency words. However, it should be noted that this was driven by the comparison individuals' slow responses for low frequency items rather than by fast responses for high frequency items. Kiehl et al. (1999) examined the influence of word concreteness on lexical decision and found that individuals with psychopathy committed significantly more errors than comparison individuals identifying abstract words as words, although the two groups committed a comparable number of errors identifying concrete words as words. Moreover, in the same study Kiehl found that while the comparison individuals showed ERP differentiation between concrete and abstract words, the individuals with psychopathy did not (Kiehl et al., 1999). In a subsequent fMRI study, Kiehl et al. (2004) found that individuals with psychopathy showed a reduced neural response in right anterior superior temporal gyrus to abstract words (their response to these words was not significantly greater than baseline in this area) (Kiehl et al., 2004). In addition, Hare and Jutai (1988) found that individuals with psychopathy were less able to recognize a word as belonging to the abstract semantic category of "living thing" (though only if the word was presented in the right, not in the left, visual field) than comparison individuals (Hare and Jutai, 1988). In short, while there are indications of a psycholinguistic impairment in individuals with psychopathy beyond the influence of affect, the nature of this impairment is currently difficult to discern.

In affective/semantic priming tasks the degree to which the target word is related to the prime word determines the degree to which the RT response to the target word is facilitated or inhibited. These priming effects are robust and are found whether the prime and target words are associatively or categorically related to each other (Becker, 1980; Hutchison, 2003; Neely, 1991). Models of semantic memory can be divided into two broad frameworks (Hutchison, 2003): Holistic models (e.g., Anderson, 1983; Collins and Loftus, 1975) and the more recent distributed/connectionist models (e.g., McClelland and Rumelhart, 1985; Plaut and Booth, 2000; Rogers et al., 2004). Holistic models of semantic memory suggest that "holistic representations (i.e., nodes) of concepts reside in a semantic network." These "nodes share connections with other nodes of similar meaning." In contrast, within distributed models of semantic memory, "the units of a network are not whole words but simple, highly interconnected features" (Hutchison, 2003, p. 785). Distinguishing between these frameworks has proven to be difficult empirically (Hutchison, 2003) and will not be attempted here. However, we will ground our study within the Rogers et al. (2004) computational model because the mathematics of such computational models allow the possibility of greater predictive precision.

Within distributed models of semantic memory such as that of Rogers et al. (2004), semantic priming of the concept CAT by the concept DOG can occur because there is an overlap between the units (neurons) coding the features that make up the two concepts (e.g., fur, claws). This means that there is partial activation of the units that make up the semantic representation of CAT by the word DOG. Emotional words can be considered conditioned stimuli; through learning they have acquired affective and motivational significance. Conditioned stimuli generally elicit amygdala activation (e.g., Buchel et al., 1998; Critchley et al., 2002) as do emotional words (Hamann and Mao, 2002; Nakic et al., 2006). The suggestion is that the representation of the word, including its semantic representation, is associated with the activation of affect representations (neurons within the amygdala that respond to reinforcement) such that the representation of the word can come to activate these affect representations. Under this suggestion, affect representations are an additional set of input features that can feed into the semantic layer (cf. Rogers et al., 2004). Within the semantic layer, concepts of emotional words will share features that code the concept's valence. Affective priming of the concept SNAKE by the concept GUN can occur within this account therefore because there is an overlap between the units (neurons) coding the affective features that make up the two concepts (e.g., negative affect).

Interestingly, current models of psychopathy might predict that individuals with psychopathy will only present with reduced priming for certain word group relations. Thus, in accounts emphasizing the reduced ability of individuals with psychopathy to process punishing cues due to reduced anxiety or fear (Fowles, 1980, 1988; Lykken, 1957; Patrick, 1994) this reduced ability results in the weakened representation of aversive conditioned stimuli (CS). In other words, the connections between a negative word representation (e.g., MURDER) and semantic feature units coding negative affect should be weaker relative than in healthy individuals. However, the connections between a positive word representation (e.g., LOVE) and semantic feature units coding positive should be similar in strength to, or stronger than, those of healthy individuals. Fowles (1988, p. 377) has suggested that individuals with psychopathy 'show no deficit in reward learning' while Patrick and colleagues concluded from their work with the augmentation of the startle reflex that 'psychopathy involves (a) normal or perhaps enhanced appetitive reactivity, and (b), defensive reactivity that is weak but not wholly absent' (Levenston et al., 1996). These accounts then would predict that individuals with psychopathy should show reduced affective priming for negative target words, but normal or increased, affective priming for positive target words.

The integrated emotion system (IES) model (see, for full details of this model, Blair, 2004) might be considered an extension of these accounts. The IES model consists of a series of ‘modular’ systems that operate in specific integrated ways in order to perform specific tasks. With respect to psychopathy, the main claim of the IES model is that individuals with psychopathy present with reduced activation of the affect representations implemented by the amygdala (i.e., neurons that activate to reinforcement information). Similar to the fear dysfunction models, this model also suggests that the connections between a negative word representation (e.g., MURDER) and semantic feature units coding negative affect should be weaker relative than in healthy individuals (i.e., there should be reduced affective priming for negative target words). However, in contrast to the fear models but because of its grounding in affective neuroscience and the specific claim of amygdala dysfunction, this model also suggests that the connections between a positive word representation (e.g., LOVE) and semantic feature units coding positive affect should be weaker relative than in healthy individuals. This is because the amygdala responds to appetitive as well as aversive reinforcement (Cardinal and Everitt, 2004; Everitt et al., 2003) and, indeed, positive as well as negative words. The IES model would therefore predict that individuals with psychopathy would show reduced negative and positive affective priming.

Our goal therefore in this study was to examine affective priming in individuals with psychopathy. However, to be sure that any general impairment in affective priming was not due to general difficulties with semantic priming, which some of the psycholinguistic data with individuals with psychopathy might suggest, we also included a semantic priming task. Specifically, we used a categorical relations based priming paradigm because this was the most similar in structure to the categorical distinction on which the affective priming is based.

Three contrasting predictions were tested: (1) individuals with psychopathy will only show weakened affective priming for negative words (fear dysfunction hypothesis); (2) individuals with psychopathy will only show weakened affective priming for negative and positive words (IES hypothesis); (3) individuals will show weakened affective and semantic priming (if semantic memory is generally disrupted).

2. Methods

2.1. Participants

Participants were 52 adult males selected from a pool of 250 individuals residing in Category B (second highest security level) institutions in England. In accordance with the established criteria of the literature and the established guidelines of the PCL-R (e.g., Hare, 1991), individuals with a PCL-R score of 30 or above were included in the psychopathic group, while individuals with a PCL-R score of 20 or less were included in the comparison group. Individuals with a PCL-R score between 20 and 30 were excluded from the study. Although a total of 52 inmates participated in the study, inmate transfers prevented some individuals from participating in both testing sessions. Thirty individuals participated in both studies (15 individuals with psychopathy and 15 comparison individuals). Fourteen individuals participated in the Affective Priming Task only (9 individuals with psychopathy and 5 comparison individuals). Eight individuals participated in the Semantic Priming Task only (4 individuals with psychopathy and 4 comparison individuals).

The Raven’s Advanced Matrix-Set I (Raven, 1965) was used as an estimate of general intelligence and the National Adult Reading Test (NART) was used as an estimate of verbal intelligence. There were no significant group difference in either age, Raven’s scores, or NART scores for either task; see Table 1 for full participant details. The psychopathic group consisted of 22 Caucasian and 6 Afro-Caribbean participants. The comparison group consisted of 20 Caucasian, 2 Afro-Caribbean, and 2 Asian participants. In addition to satisfying PCL-R criteria for high and low levels of psychopathy, psychiatric files were screened for evidence of psychosis or neurological disorder, and individuals who had received diagnoses for psychosis or organic brain damage were excluded from testing.

2.2. Measures

2.2.1. The psychopathy checklist revised (PCL-R) (Hare, 1991)

The PCL-R consists of 20 behavioral items and individuals can score between 0 and 2 on each item. PCL-R scores are most often obtained on the basis of a file review and a semi-structured interview but can also be reliably obtained from file notes alone (Hare, 1991; Wong, 1988). In this study, six participants (four psychopathic and two comparison) inmates were unavailable for interview and so were scored on the basis of file notes only. Two raters scored the participants. Inter-rater reliability was established by means of a Spearman rank correlation. The correlation, $r_{\text{ranks}} = 0.88$ ($p < 0.001$), is similar to that reported in the literature (e.g., Hare, 1991).

2.2.2. The affective priming task

Stimuli consisted of 6 positive, 6 neutral, and 6 negative prime words (e.g., song, chair, bomb), and 24 positive, and 24 negative target words (for word selection details, see below). During the task, stimuli appeared in white against a black background, and were presented in the center of the screen using the Macintosh system font Times (type size = 36 points); see Fig. 1. Stimuli were developed and controlled by the software SuperLab Pro and presented on a Mac PowerBook G4.

The affective priming task had a practice and test phase. The practice phase was designed to familiarize the participants with the response keys. In the practice phase, each trial began with a fixation point (+) presented for 300 ms in the middle of the screen. This was followed immediately by the target word for that trial. The target word was exposed until a response from the participant was registered, at which point the fixation for the subsequent trial appeared on the screen. The target words used in the practice phase were ‘filth’ or ‘money’ (these were not used in the test phase). Both words were presented 40 times, making a total of 80 trials. The response keys used were ‘n’ and ‘c’ with the labels ‘positive’ and ‘negative’

Table 1
Participant characteristics, S.D., and ranges in parentheses

Group	PCL-R	Age	Raven	NART
The affective priming task				
Psychopathic group ($n = 24$)	32.93 (2.30; 30–36)	35.24 (9.78; 20–54)	8.03 (1.99; 3–11)	21.14 (9.06; 9–45)
Comparison group ($n = 20$)	8.56 (1.95; 1.5–16)	32.35 (9.21; 21–50)	8.05 (2.44; 4–12)	23.65 (8.24; 13–39)
The semantic priming task				
Psychopathic group ($n = 18$)	34.10 (2.46; 30–37)	37.22 (8.01; 23–54)	8.06 (1.48; 6–10)	21.28 (9.09; 9–45)
Comparison group ($n = 18$)	9.04 (2.12; 1.5–14)	32.00 (9.16; 21–50)	8.39 (2.20; 5.12)	24.67 (7.88; 14–36)

For all characteristics other than PCL-R score, there were no significant group differences. Affective priming: age, raven, NART $F(1, 43) < 1$ in all cases; n.s. Semantic priming: age, raven, NART $F(1, 35) = 3.32$; $p < 1$; 1.43 respectively; n.s.

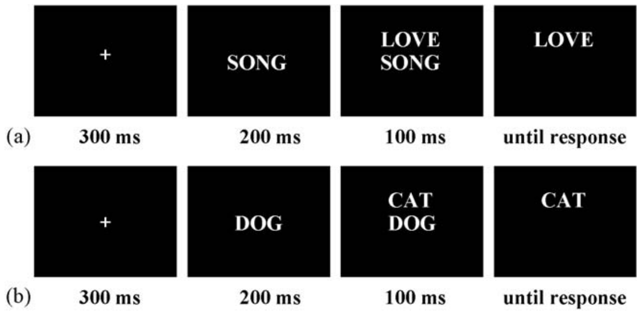

Fig. 1. Example trial sequences: (a) affective priming trial involving a congruent positive trial; (b) semantic priming trial involving a congruent animal trial.

counterbalanced across participants. The participant was instructed to classify the presented word as either positive or negative.

In the testing phase, each trial began with a fixation point (+) presented for 300 ms in the middle of the screen. This was followed immediately by the prime word for that trial. After 200 ms, the target word for that trial would appear either above or below the prime word (counterbalanced across trials). The two words then remained together on the screen for 100 ms, at which point the prime word extinguished. The target word was exposed until a response from the participant was registered, at which point the fixation for the subsequent trial appeared on the screen (see Fig. 1 for example trial). The instructions to the participants read: ''In this task, you will see one word very briefly on the screen, which is then replaced by a second word. The second word stays on the screen until you make a response. When you see the second word I want you to classify the word according to whether you think it is positive or negative. If you feel the word it is positive, press 'positive' and if you feel the word is negative, press 'negative'. Try to do this as quickly as possible and with as few errors as possible. Any questions?''

The response keys used were 'n' and 'c' with the labels 'positive' and 'negative' counterbalanced across participants. Each of the 6 positive and 6 negative prime words was paired with 8 positive and 8 negative target words, resulting in 48 congruent (positive → positive), and 48 incongruent (negative → positive) trials for positive word targets, as well as 48 congruent (negative → negative), and 48 incongruent (positive → negative) trials for negative word targets. Each neutral prime was paired with four positive and negative target words, resulting in 24 neutral (neutral → negative) trials for positive word targets as well as 24 neutral (neutral → negative) trials for negative word targets.

Following the affective priming task, the words used in the paradigm were read out aloud and the participants were asked to provide a pleasantness rating for each word according to a seven-point pleasantness Likert scale. The endpoint valences for the scale were counterbalanced across participants so that one would mean extremely unpleasant and seven extremely pleasant for half the participants, and one extremely pleasant and seven extremely unpleasant for the other half of the participants.

2.2.3. The semantic priming task

This task was developed to provide a measure of semantic priming using a task similar in demands to the affective priming task. The word categories of 'fruit' and 'animal' are typically used in studies examining semantic facilitation effects (White, 1995; Schwartz et al., 2003). Thus, those word categories were employed in the current paradigm. Because of a lack of a sufficient number of high familiarity and low word length fruit words, vegetables were included in the fruit category to give rise to a fruit/vegetable category (for simplicity referred to as the fruit category).

Stimuli consisted of 6 animal and 6 fruit prime words (e.g., horse, apple) and 24 animal, and 24 fruit target words (for word selection details, see below). Stimulus presentation details were identical to those used in the affective priming task; see Fig. 1.

There were slight differences in procedure between the semantic and affective priming tasks. Our pilot work with healthy individuals outside of the forensic institution revealed that a direct copy of the affective priming methodology did not elicit reliable *semantic* priming. Specifically, to elicit reliable semantic priming, it was necessary to rephrase the instructions such that participants now were required to indicate *whether* a target word belonged to a specified target word category (see below for full instructions), rather than indicating *what category* a target word belonged to. Because of this task modification, the semantic priming task involved two practice phases and two testing phases. Each of the two practice phases preceded their respective test phases.

Each semantic priming practice phase trial was identical to that of the affective priming practice phase trials, except for a change in target words and instructions. The target words used in each practice phase were 'elephant' or 'pineapple' (these were not used in the test phase). Both words were presented 40 times, making a total of 80 trials. The response keys used were 'n' and 'c' with the labels 'yes' and 'no' counterbalanced across participants. For the animal semantic priming practice trials, the participant was instructed to respond 'yes' if the stimulus was an animal and 'no' if it was not. For the fruit/vegetable semantic priming practice trials, the participant was instructed to respond 'yes' if the stimulus was a fruit/vegetable and 'no' if it was not.

Each testing phase was identical to affective priming testing phase in terms of presentation timing (see Fig. 1 for example trial).

For the animal semantic priming task, the instructions to the participants read: ''In this task, you will see one word very briefly on the screen, which is then replaced by a second word. The second word stays on the screen until you make a response. When you see the second word, consider the question: 'Is this an animal?'' You can answer yes or no to that question. So if you think the second word is an animal, press yes. If you do not think the second word is an animal, press no. Try to do this as quickly as you can with as few errors as possible. Remember the question you have to consider is: ''Is this an animal?'' and your task is to answer yes or no. Any questions?'' Instructions were identical for fruit/vegetable semantic priming task except that participants were now asked to consider the question: ''Is this a fruit/vegetable?'' The response keys were 'n' and 'c' with the labels 'yes' and 'no' counterbalanced across participants. The two runs were also counterbalanced across participants.

Each of the 6 animal and 6 fruit prime word was paired with 8 animal and 8 fruit target words, resulting in 48 congruent (animal → animal), and 48 incongruent (fruit → animal) trials for animal word targets, as well as 48 congruent (fruit → fruit), and 48 incongruent (animal → fruit) trials for fruit word targets. The trials were separated out in the two experimental runs, such that each run consisted of 24 congruent (animal → animal), and 24 incongruent (fruit → animal) trials for animal word targets, as well as 24 congruent (fruit → fruit), and 24 incongruent (animal → fruit) trials for fruit word targets.

Following the presentation of the semantic priming task, the names of 22 animals were read aloud and the participants were asked to provide a size rating for each animal word according to a seven-point Likert scale. The endpoint valences for the scale were counterbalanced across participants so that one would mean extremely large and seven extremely small for half the participants, and one would mean extremely small and seven extremely large for the other half of the participants. The goal of this task was to ensure that the individuals with psychopathy were capable of making appropriate ratings using a seven-point Likert scale.

2.2.4. Word selection

Emotional words were selected from the Affective Norms for English Words (ANEW) database (Bradley and Lang, 1999). The ANEW indicates the valence of emotional words according to a nine-point valence scale where a score of one indicates an extremely unpleasant words, and nine indicates an extremely pleasant word. Thus, it was possible to match our positive and negative words on relative valence to ensure a comparable emotional impact of the two word groups (the mean of our negative words was 1.57 points from the most extreme negative score of 1, and the mean of our positive words was 1.56 was points from the most extreme positive score of 9; see Table 2). Animal and fruit words were selected from the MRC psycholinguistic database (Coltheart, 1981). Emotional and animal/fruit words were matched on word length, imageability, familiarity, and frequency using the MRC psycholinguistic database as well as strength of association between prime and target words using the University of South Florida Free Association Norms Database (Nelson et al., 1998) and polysemy count using Wordnet (Fellbaum, 1998). A series of ANOVAs confirmed that there was no significant difference for any of these descriptors across word sub-categories (ANOVA; four word sub-categories: positive, negative, animal, fruit), between word categories (ANOVA; two word

Table 2
Mean ratings and S.D. in parentheses for the word categories and sub-categories

Word group	Length	Imageability	Familiarity	Frequency	Strength of association	Polysemy count	Valence
Emotional combined	5.67 (1.56)	596.52 (26.98)	514.57 (64.85)	180.77 (190.92)	0.0053 (0.01)	3.63 (2.14)	–
Positive	5.77 (1.50)	590.93 (25.07)	498.67 (64.24)	165.27 (243.24)	0.0013 (0.01)	3.23 (2.18)	7.43 (0.70)
Negative	5.57 (1.63)	602.10 (28.08)	530.47 (62.51)	196.27 (120.39)	0.0082 (0.03)	4.03 (2.10)	2.57 (0.70)
Fruit/animal combined	5.63 (1.84)	598.32 (35.07)	513.65 (54.28)	145.28 (145.28)	0.0431 (0.13)	4.07 (2.88)	–
Animal	5.30 (1.88)	602.67 (26.46)	505.43 (53.18)	145.83 (224.74)	0.5190 (0.16)	4.37 (3.59)	–
Fruit	5.97 (1.77)	593.97 (41.98)	521.87 (55.01)	144.73 (101.68)	0.0328 (0.06)	3.77 (1.94)	–

For all characteristics other than valence, there was no significant difference in category or sub-category difference. Imageability range 129–667; familiarity range 43–657; frequency range 1–236 472; valence range 1–9.

categories [positive/negative], [animal/fruit]), or between within-category sub-categories (ANOVA; two word sub-categories: positive, negative) and (ANOVA; two word sub-categories: animal, fruit); see Table 2.

2.2.5. Procedure

Each participant was tested individually in a quiet interview room on the wing. Following written consent, each participant was presented with the two paradigms as part of a larger neuropsychological test battery. Participants were always presented with the word rating tasks following the presentation of their respective paradigm. For the participants who took part in both paradigms, the order of tasks were counterbalanced so that half the participants took part in the Affective Priming Task first, and the other half of the participants took part in the Semantic Priming Task first. The duration of the two tasks (including ratings) was approximately 45 min for each participant.

Trials where the RT exceeded 1500 ms or was below 250 ms were excluded from further analysis. RTs and error rates were then entered into ANOVAs to examine the effect of group on congruence and error rates. RTs were only entered into the analyses if they were for correct responses. Mauchly's test of sphericity was not significant for any of analyses. Thus, no correction to degrees of freedom was applied to the data.

3. Results

3.1. The affective priming task

First, the effect of congruence on group RTs was examined. A mixed ANOVA with group (psychopathic, comparison) as between-subjects variable and prime (positive, neutral, negative) and target (positive, negative) as within-subjects variables was conducted on the RT data. The analysis revealed first that there was a significant main effect of prime ($F(2, 84) = 4.00$, $p < 0.05$; $\eta_p^2 = 0.09$); RTs to positive prime words were faster than RTs to either neutral or negative prime words (*M*[positive prime words] = 731.31; S.E. = 18.78, *M*[neutral prime words] = 745.43; S.E. = 20.77, *M*[negative prime words] = 751.92; S.E. = 18.78). There was also a significant main effect of target ($F(1, 42) = 5.25$, $p < 0.05$; $\eta_p^2 = 0.11$); RTs to positive target words were faster than RTs to negative target words (*M*[positive target words] = 735.41; S.E. = 20.04, *M*[negative target words] = 750.37; S.E. = 19.67). The prime × target interaction was highly significant ($F(2, 84) = 18.02$, $p < 0.001$; $\eta_p^2 = 0.30$). Planned comparisons confirmed that RTs to target words following a congruent prime word were significantly faster than target words following an incongruent prime word. This was true for both positive and negative target words. Finally, and crucially, there was a significant prime × target × group interaction ($F(2, 84) = 4.53$, $p < 0.05$; $\eta_p^2 = 0.10$); see Table 3.

In order to further explore the nature of these interactions, separate within groups repeated measures ANOVAs were conducted. For the comparison group, there were no significant main effects but there was a highly significant prime × target interaction ($F(2, 38) = 25.16$; $p = 0.001$; $\eta_p^2 = 0.57$). The comparison individuals showed significant facilitation by positive primes relative to neutral primes for positive targets ($F(1, 19) = 10.15$, $p < 0.005$; $\eta_p^2 = 0.35$) and facilitation by negative primes relative to neutral primes for negative targets ($F(1, 19) = 4.39$, $p < 0.05$; $\eta_p^2 = 0.19$). The comparison individuals showed significant interference by negative primes relative to neutral primes for positive targets ($F(1, 19) = 7.95$, $p < 0.05$; $\eta_p^2 = 0.30$) but did not show significant interference by positive primes relative to neutral primes for negative targets ($F(1, 19) < 1$, n.s.). For the individuals with psychopathy, there were also no significant main effects and the prime × target interaction was only a trend ($F(2, 46) = 2.75$; $p = 0.05$, one-tailed; $\eta_p^2 = 0.11$). The individuals with psychopathy showed no significant facilitation or interference for either positive or negative targets.

Next, the effect of group on congruence on group error rates was examined. A mixed ANOVA with group (psychopathic, comparison) as between-subjects variable and prime (positive, neutral, negative) and target (positive, negative) as within-subjects variables was conducted on the error data. The analysis revealed first that there was a significant main effect of prime ($F(2, 84) = 3.28$; $p < 0.05$; $\eta_p^2 = 0.07$). Planned comparisons showed that the error rate for neutral prime words was

Table 3
Participant RTs and error rates on the affective priming task

Group	Prime	Target	RTs	Error rate
Psychopathic group (*n* = 24)	Positive	Positive	747.50 (29.84)	4.08 (1.13)
	Neutral	Positive	761.50 (26.93)	5.21 (1.55)
	Negative	Positive	786.08 (31.57)	5.21 (1.21)
Comparison group (*n* = 20)	Positive	Positive	669.40 (24.77)	3.59 (0.74)
	Neutral	Positive	705.80 (30.00)	3.33 (0.83)
	Negative	Positive	742.15 (28.83)	5.21 (1.41)
Psychopathic group (*n* = 24)	Negative	Negative	777.75 (29.14)	5.56 (0.99)
	Neutral	Negative	789.63 (32.69)	3.82 (1.20)
	Positive	Negative	774.04 (28.60)	8.51 (2.09)
Comparison group (*n* = 20)	Negative	Negative	701.70 (27.31)	4.53 (1.12)
	Neutral	Negative	724.80 (30.97)	4.17 (1.32)
	Positive	Negative	734.30 (21.54)	6.25 (1.33)

S.E. in parentheses.

significantly lower than the error rate for both positive (F(1, 43) = 5.87; $p < 0.025$; $\eta_p^2 = 0.12$) and negative prime words (F(1,43) = 4.09; $p < 0.05$; $\eta_p^2 = 0.09$); (M[positive prime words] = 5.67; S.E. = 0.83, M[neutral prime words] = 4.17; S.E. = 0.68, M[negative prime words] = 5.15; S.E. = 0.63). There was also a significant prime × target interaction (F(2, 84) = 8.09, $p < 0.01$; $\eta_p^2 = 0.16$); see Table 3. Planned comparisons confirmed that error rates to target words following a congruent prime word were significantly lower than target words following an incongruent prime word. This was true for positive target words (F(1, 43) = 2.95; $p < 0.05$ one-tailed; $\eta_p^2 = 0.64$); M[positive prime – positive target] = 3.86; S.E. = 0.70, M[negative prime – positive target] = 5.21; S.E. = 0.91 and it was true for negative target words (F(1, 43) = 7.44; $p < 0.01$; $\eta_p^2 = 0.15$); M[negative prime – negative target] = 5.09; S.E. = 0.74, M[positive prime – negative target] = 7.49; S.E. = 1.29. There was no prime × group, target × group, or prime × target × group interaction; individuals with psychopathy and comparison individuals demonstrated a similar error pattern on the affective priming task.

3.2. The semantic priming task

First, the effect of congruence on group RTs was examined. A mixed ANOVA with group (psychopathic, comparison) as between-subjects variable and prime (animal, fruit) and target (animal, fruit) as within-subjects variables was conducted on the RT data. The analysis revealed that there was a significant main effect of target (F(1, 34) = 14.85, $p < 0.001$; $\eta_p^2 = 0.30$). A planned comparison confirmed that RTs to animal target words were faster than RTs to fruit target words (F(1, 35) = 15.29, $p < 0.001$; $\eta_p^2 = 0.30$) (M[animal target words] = 631.90; S.E. = 16.14, M[fruit target words] = 653.56; S.E. = 17.12). In addition, there was a significant prime × target interaction (F(1, 34) = 13.70, $p = 0.001$, $\eta_p^2 = 0.29$). As can be seen in Table 4, both the comparison individuals (F(1, 17) = 13.74, $p < 0.01$; $\eta_p^2 = 0.35$) and the individuals with psychopathy (F(1, 17) = 10.03, $p < 0.01$; $\eta_p^2 = 0.37$) showed significant semantic priming for animal targets. However, neither group showed significant semantic priming for fruit targets (F(1, 17) < 1, n.s., in both cases). Crucially, there was no main effect of group or significant interactions with group (main effect of group: F(1, 34) = 1.29, n.s.; all interactions with group: F(1, 34 < 1; n.s.). That is, the psychopathic and the comparison group showed a similar pattern of semantic priming.

Table 4
Participant RTs and error rates on the semantic priming task

Group	Prime	Target	RTs	Error rate
Psychopathic group (n = 18)	Animal	Animal	639.44 (24.40)	4.67 (0.91)
	Fruit	Animal	663.89 (21.86)	5.00 (0.95)
Comparison group (n = 18)	Animal	Animal	599.33 (23.05)	4.11 (1.09)
	Fruit	Animal	624.94 (22.39)	2.56 (0.69)
Psychopathic group (n = 18)	Fruit	Fruit	669.17 (26.39)	10.28 (1.98)
	Animal	Fruit	676.44 (24.41)	11.56 (1.59)
Comparison group (n = 18)	Fruit	Fruit	629.89 (27.87)	8.83 (0.54)
	Animal	Fruit	638.72 (30.97)	11.39 (2.12)

S.E. in parentheses.

Second, the effect of congruence on group error rates was examined. A mixed ANOVA with group (psychopathic, comparison) as between-subjects variable and prime (animal, fruit) and target (animal, fruit) as within-subjects variables was conducted on the error data. The analysis revealed that there was a significant main effect of target (F(1, 34) = 54.35, $p < 0.001$; $\eta_p^2 = 0.62$). Planned comparison confirmed that the number of errors to animal target words were lower than the number of errors to fruit target words (F(1, 35) = 55.69, $p < 0.001$; $\eta_p^2 = 0.61$) (M[animal target words] = 4.08; S.E. = 0.08, M[fruit target words] = 10.51; S.E. = 0.98); see Table 4.

3.3. Word rating

In order to test for group differences in verbal word ratings we first applied a mixed ANOVA with group (psychopathic, comparison) as between-subjects variable and valence (positive, neutral, negative) as within-subjects variable on the word ratings involving emotional words. There was a significant main effect of valence (F(2, 78) = 367.22; $p < 0.001$; $\eta_p^2 = 0.90$); as can be seen in Table 5 participants rated the positive words as more pleasant than the neutral words and the neutral words as more pleasant than the negative words (M[positive words] = 5.81; S.E. = 0.09, M[neutral words] = 4.04; S.E. = 0.18, M[negative words] = 1.47; S.E. = 0.05). Follow-up contrasts showed that this higher rating for positive relative to neutral, and neutral relative to negative words was significant for the two groups individually ($p < 0.001$ for all). In addition, there was a main effect of group (F(1, 39) = 7.74, $p < 0.01$; $\eta_p^2 = 0.17$); individuals with psychopathy rated the words as more pleasant than the comparison individuals (M[psychopathic group] = 3.98; S.E. 0.10, M[comparison group] = 3.57; S.E. = 0.11). Interestingly, the group × valence was significant (F(2, 78) = 6.33, $p < 0.001$; $\eta_p^2 = 0.14$); see Table 5. Planned comparisons confirmed that whereas individuals with psychopathy rated neutral words as more pleasant than comparison individuals (F(1, 39) = 8.95, $p < 0.005$; $\eta_p^2 = 0.32$); (M[psychopathic group] = 4.56; S.E. 0.24, M[comparison group] = 3.51; S.E. = 0.24) they did not rate negative or positive words as

Table 5
Participant ratings and S.D. in parentheses for affective and animal words

Word rating category	Psychopathic group	Comparison group
Valence (negative)	1.45 (0.07)	1.50 (0.08)
Valence (neutral)	4.56 (0.24)	3.51 (0.26)
Valence (positive)	5.92 (0.24)	5.70 (0.14)
Size (small)	1.88 (0.09)	1.75 (0.09)
Size (medium)	3.63 (0.16)	3.60 (0.16)
Size (large)	5.52 (0.11)	5.50 (0.11)

Table 6
Correlations between the performance on the affective and semantic priming tasks and the PCL-R and its constituent parts

Task	PCL-R Factor 1 score	PCL-R Factor 2 score	Total PCL-R score
Affective priming	−0.459*	−0.484*	−0.479*
Semantic priming	0.001	−0.118	−0.066

* $p < 0.005$.

more emotive than comparison individuals ($F = 1.45$ and $p < 1$, respectively).

We next applied a mixed ANOVA with group (psychopathic, comparison) as between-subjects variable and size (small, medium, large) as within-subjects variable to the word ratings involving animal size. There was a significant main effect for size ($F(2, 68) = 1596.50$, $p < 0.001$; $\eta_p^2 = 0.98$); participants rated the large animals as large than the mid-sized animals and the mid-sized animals larger than the small animals (M[large animals] = 5.51; S.E. = 0.08, M[medium animals] = 3.61; S.E. = 0.08, M[small] = 1.82; S.E. = 0.07). There was no significant main effect of group and there was no significant group × size interaction ($n < 1$ for both); the psychopathic group and the comparison group demonstrated a similar rating pattern on the rating of animal words (see Table 5).

3.4. Correlational analyses with PCL-R Factor 1, PCL-R Factor 2, and total PCL-R score

Next, correlational analyses examined the interrelationships between performance on respectively the affective priming and semantic priming tasks and score on the PCL-R and its constituent factors; see Table 6.

The correlational analysis for the affective priming task showed that performance (RT difference between incongruent and congruent trials ([incongruent positive] + [incongruent negative]) − ([congruent positive] + [congruent negative])) was significantly related with PCL-R Factor 1 ($r = -0.459$; $p < 0.005$), PCL-R Factor 2 ($r = -0.484$; $p < 0.005$), and with total PCL-R score ($r = -0.479$; $p = 0.005$). In contrast, the correlational analysis for the semantic priming task showed that performance (RT difference between incongruent and congruent trials ([incongruent animal] + [incongruent fruit]) − [congruent animal] + [congruent fruit])) was not significant related with the PCL-R or any of its constituent factors; see Table 6.

4. Discussion

To our knowledge, this is the first study to investigate affective and semantic priming in individuals with psychopathy and comparison individuals. The results revealed that individuals with psychopathy showed reduced affective priming relative to comparison individuals. In addition, their word ratings were anomalous; they rated the words more positively than the comparison individuals, particularly the neutral words. However, individuals with psychopathy showed comparable semantic priming relative to comparison individuals. Moreover, they showed no difficulty with their size ratings of the items from the semantic priming task.

The comparison individuals in the present study showed, as our pilot non-forensic populations had done originally, significant levels of both affective and semantic priming. The individuals with psychopathy showed significant semantic priming but very little indications of affective priming. As noted in the introduction, within distributed models of semantic memory such as that of Rogers et al. (2004), semantic priming occurs because there is an overlap between the units (neurons) coding the features that make up the two concepts. We argued an analogous account for affective priming; some of the features that make up the semantic representation of emotional words are affect based. The difference between affective and semantic priming is that affective priming is based on valence specific affect based feature units while semantic priming is based on object based feature units. We have suggested elsewhere that the principle impairment in psychopathy involves reduced activation of the affect representations by reinforcement information (Blair, 2001, 2004). This would mean that during learning, individuals with psychopathy would form weaker connections between the affect representations (neurons within the amygdala activated by reinforcement information) and affect based feature units. These reduced connections would mean weaker affective priming. However, this would not influence semantic priming. As can be seen in our data, semantic priming appears intact in individuals with psychopathy.

One caveat might be raised with regards to the semantic priming. While we observed semantic priming for animal targets, we did not for fruit/vegetable targets (perhaps due to increased decision complexity due to the category containing two types of items). It could be suggested that we did not observe a between group difference in basic semantic processes because our manipulation was not effective in the comparison participants. However, it is important to note that semantic priming was seen for animal targets in both groups and it was seen with very comparable power. Moreover, a second group has also observed semantic priming in individuals with psychopathy (Brinkley et al., 2005). In short, it does appear that semantic priming, but not affective priming, is intact in individuals with psychopathy.

Individuals with psychopathy are not devoid of knowledge regarding affect. They could classify the words as either positive or negative. However, it is not clear that you need emotional responses to make this basic classification. Moreover, individuals with psychopathy are not devoid of emotional responses, it is just that their emotional responses are reduced, for specific stimulus categories, relative to comparison individuals (Blair et al., 1997; Levenston et al., 2000). The prediction is that the more a task is reliant on the activation of affect representations/affect-based feature representations, the more impairment will be seen in individuals with psychopathy. While we would not suspect the basic valence based categorical judgments (positive/negative, good/bad) would reveal group differences, these did emerge in the context of an affective priming task. The word rating task was very easy—our emotional stimuli were all either highly negative or highly positive. But even here the individuals with psychopathy showed impairment. We are currently examining performance on a task where the participant has to judge which of two words is either more positive or larger (i.e., two discrimination paradigms based on our word rating task). We predict no impairment in the individuals with psychopathy for size based discriminations but significant impairment for valence based discriminations.

Because the individuals with psychopathy were rating the neutral items more positively than the comparison individuals, it could be suggested that the individuals with psychopathy did not show facilitation for positive targets because the neutral primes acted as positive primes. However, this would lead to the prediction that the individuals with psychopathy should have shown heightened facilitation for negative targets (because the neutral primes would have acted more similarly to interfering positive primes). However, the individuals with psychopathy showed no significant facilitation or interference for positive or negative targets.

Previous work with individuals with psychopathy has indicated difficulties in processing the affective value attached to words. Hare et al. (1988) reported that individuals with psychopathy did not tend to group words by their emotional characteristics, unlike comparison individuals, but instead by their non-emotional characteristics. In lexical decision tasks, individuals with psychopathy do not show the RT advantage for emotional words over neutral words that is shown by healthy individuals (Lorenz and Newman, 2002; Williamson et al., 1991). The current study extends these data by showing that individuals with psychopathy are also impaired in affective priming but not in semantic priming.

The fact that while our comparison individuals showed significant facilitation by positive primes for positive targets and by negative primes for negative targets (RTs were significantly faster in these two conditions relative to the neutral prime equivalents) but that individuals with psychopathy showed no significant facilitation in either case is of interest. According to the low fear or anxiety accounts (Fowles, 1980, 1988; Lykken, 1957; Patrick, 1994), individuals with psychopathy have reduced ability to process punishing cues. In contrast, according to these accounts, individuals with psychopathy have normal, or even superior, ability to processing rewarding cues (Fowles, 1980; Levenston et al., 1996). Such accounts should predict that individuals with psychopathy will show reduced facilitation by negative primes for negative targets but either appropriate, or even augmented facilitation by positive primes for positive word targets. In the present study, individuals with psychopathy showed reduced facilitation for both negative and positive primes. These results are thus not consistent with respect to the fear dysfunction accounts as they were originally expressed.

As stated above, we consider the integrated emotion system (IES) model (see, for details of this model, Blair, 2004) to be an extension of the fear dysfunction accounts. Within this model, at the anatomical level, both positive and negative affect representations are thought to be implemented by the amygdala. There is considerable data that the amygdala is implicated in processing both positive and negative stimuli (Baxter and Murray, 2002; Garavan et al., 2001; Liberzon et al., 2003; Siebert et al., 2003). The current data, with individuals with psychopathy showing reduced facilitation by both negative and positive primes, suggest that both positive and negative affect representations (i.e., the units that respond to both reward and punishment) are dysfunctional in individuals with psychopathy (specifically, they activate to a lesser extent than in healthy individuals to a comparable reward/punishment intensity; Blair, 2001, 2004). This issue is not yet resolved however.

Individuals with psychopathy show appropriate suppression of the startle reflex following the presentation of positive visual primes but reduced augmentation of the startle reflex following the presentation of negative visual primes (Levenston et al., 2000; Patrick et al., 1993). This suggests intact responding of positive affect representations in individuals with psychopathy. However, in the lexical decision task literature, comparison individuals are faster to identify both positive and negative emotional words than neutral ones, while individuals with psychopathy show significantly less of an emotional advantage for both (Lorenz and Newman, 2002; Williamson et al., 1991). In addition, Verona et al. (2004) reported reduced skin conductance responses to both positive and negative auditory stimuli in individuals with psychopathy. Finally, in recent work within our own group, using decision-making paradigms (Blair et al., 2006), passive avoidance tasks (Blair et al., 2004) and examining the impact of emotional material on on-going operant responding (Mitchell et al., in press), we have found impaired processing of both positive and negative material but that this impairment is particularly severe for negative material.

In short, it is currently unclear what parameters determine the degree to which the processing of positive emotional material is impaired in individuals with psychopathy. Certain consistencies are emerging, however. In tasks that, according to the IES model, involve the interaction of affect representations (the amygdala) and the basic threat circuitry (hypothalamus and periaqueductal gray), such as those involving the startle reflex paradigm, individuals with psychopathy show intact responsiveness to reward information (Levenston et al., 2000; Patrick et al., 1993); though the results of Verona et al. (2004) are not apparently consistent with this. In tasks that, according to the IES model, involve the interaction of affect representations and sensory/semantic representations (regions of temporal cortex) such as the current one but also lexical decision (Lorenz and Newman, 2002; Williamson et al., 1991) and the emotional interrupt (Mitchell et al., in press) roughly equivalent impairment in the processing of positive and negative material has been reported. In tasks that, according to the IES model, involve the interaction of affect representations and stimulus selection units (medial orbital frontal cortex), impairment in the processing of positive and negative material can be seen but the impairments is markedly more severe for the processing of punishment information (Blair et al., 2006). These results indicate a degree of dissociation in the affect representations and a degree of differential impairment in these dissociable affect representations that is a function of the systems to which these affect representations interact. This issue is a major focus of our current research program. We have recently completed an fMRI examination of affective priming in healthy adults using an adapted version of the current paradigm (Blair et al., in preparation). This paradigm will be taken to individuals with psychopathy and comparison individuals in the near future.

Even though the current data, and those of Brinkley et al. (2005), do not indicate impairment in semantic priming it is possible that other aspects of semantic processing are impaired in individuals with psychopathy. Lorenz and Newman (2002) did find reduced influence of word frequency on lexical decision in individuals with psychopathy. However, this was because comparison individuals were slower for low relative to high frequency words. The individuals with psychopathy, in contrast, were as fast for low and high frequency words as comparison individuals were for high frequency words. In other words, these data do not indicate *impairment* in individuals with psychopathy as such as their performance was, if anything, superior to the comparison individuals. Hare and Jutai's (1988) data revealed that individuals with psychopathy were less able to recognize a word as belonging to the abstract semantic category of ''living thing'' but only if the word was presented in the right, not in the left, visual field. This does not suggest impairment in semantic processing but rather a difficulty in accessing the semantic system when stimuli are presented to the right visual field. Kiehl et al. (1999) found that individuals with psychopathy committed significantly more errors than comparison individuals identifying abstract words as words. This might indicate semantic impairment but it might also indicate that the individuals with psychopathy did not know the words (although his subsequent fMRI work does indicate some impairment with abstract words; Kiehl et al., 2004). In short, if there is impairment in semantic processing it is likely to reflect difficulties with abstract words. One interesting extension of the current work would be to examine semantic priming for abstract as opposed to concrete words in individuals with psychopathy. It is possible that semantic priming is only intact for the more concrete abstract words used in the current study.

In conclusion, affective and semantic priming were examined in individuals with psychopathy. Our data suggest that individuals with psychopathy present with reduced affective priming. In addition, our data suggest that the semantic/linguistic impairments in individuals with psychopathy do not extend to semantic priming. Cleckley (1976) suggested that there is a discordance between the expressed and experienced values of emotions in individuals with psychopathy. We have reinterpreted this suggestion within the distributed models of semantic memory (e.g., Rogers et al., 2004) as the claim that the affect based feature units that make up the semantic representation of emotional words in healthy individuals are dysfunctional in individuals with psychopathy.

Acknowledgements

The authors would like to thank the Psychology Department and Staff at HMP Wormwood Scrubs. This research was supported by the Intramural Research Program of the National Institutes of Health: National Institute of Mental Health.

References

Anderson, J.R., 1983. Spreading activation theory of memory. Journal of Verbal Learning and Verbal Behavior 22, 261–295.

Baxter, M.G., Murray, E.A., 2002. The amygdala and reward. Nature Reviews Neuroscience 3, 563–573.

Becker, C.A., 1980. Semantic context effects in visual word recognition: an analysis of semantic strategies. Memory and Cognition 8, 493–512.

Blair, R.J., 2004. The roles of orbital frontal cortex in the modulation of antisocial behavior. Brain and Cognition 55, 198–208.

Blair, R.J.R., 2001. Neuro-cognitive models of aggression, the antisocial personality disorders and psychopathy. Journal of Neurology, Neurosurgery and Psychiatry 71, 727–731.

Blair, K.S., Smith, B.W., Morton, J., Zametkin, A., Pessoa, L., Pine, D.S., Blair, R.J.R. Affective priming for positive and negative words: a MRI investigation, in preparation.

Blair, R.J.R., Jones, L., Clark, F., Smith, M., 1997. The psychopathic individual: a lack of responsiveness to distress cues? Psychophysiology 34, 192–198.

Blair, R.J.R., Mitchell, D.G.V., Leonard, A., Budhani, S., Peschardt, K.S., Newman, C., 2004. Passive avoidance learning in psychopathic individuals: modulation by reward but not by punishment. Personality and Individual Differences 37 (6), 1179–1192.

Blair, K.S., Leonard, A., Morton, J., Blair, R.J.R., 2006. Differential stimulus-reward and stimulus-punishment learning in individuals with psychopathy. Personality and Individual Differences, in press.

Bradley, M.M., Lang, P.J., 1999. Affective norms for English words (ANEW): stimuli, instruction manual and affective ratings. Technical Report C-1. The Center for Research in Psychophysiology, University of Florida, Gainesville, FL.

Brinkley, C.A., Schmitt, W.A., Newman, J.P., 2005. Semantic processing in psychopathic offenders. Personality and Individual Differences 38 (5), 1047–1056.

Buchel, C., Morris, J., Dolan, R.J., Friston, K.J., 1998. Brain systems mediating aversive conditioning: an event-related fMRI study. Neuron 20, 947–957.

Cardinal, R.N., Everitt, B.J., 2004. Neural and psychological mechanisms underlying appetitive learning: links to drug addiction. Current Opinion in Neurobiology 14, 156–162.

Cleckley, H.M., 1976. The Mask of Sanity. Mosby, St. Louis, MO.

Collins, A.M., Loftus, E.F., 1975. A spreading activation theory of semantic processing. Psychological Review 82, 407–428.

Coltheart, M., 1981. The MRC psycholinguistic database. The Quarterly Journal of Experimental Psychology 33 (A), 497–505.

Critchley, H.D., Mathias, C.J., Dolan, R.J., 2002. Fear conditioning in humans: the influence of awareness and autonomic arousal on functional neuroanatomy. Neuron 33 (4), 653–663.

Everitt, B.J., Cardinal, R.N., Parkinson, J.A., Robbins, T.W., 2003. Appetitive behavior: impact of amygdala-dependent mechanisms of emotional learning. Annual New York Academy of Sciences 985, 233–250.

Fellbaum, C., 1998. WordNet: An Electronic Lexical Database. MIT Press, http://wordnet.princeton.edu.

Fowles, D.C., 1980. The three arousal model: implications of gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. Psychophysiology 17, 87–104.

Fowles, D.C., 1988. Psychophysiology and psychopathy: a motivational approach. Psychophysiology 25, 373–391.

Garavan, H., Pendergrass, J.C., Ross, T.J., Stein, E.A., Risinger, R.C., 2001. Amygdala response to both positively and negatively valenced stimuli. Neuroreport 12, 2779–2783.

Hamann, S., Mao, H., 2002. Positive and negative emotional verbal stimuli elicit activity in the left amygdala. Neuroreport 13, 15–19.

Hare, R.D., 1991. The Hare Psychopathy Checklist-Revised. Multi-Health Systems, Toronto, Ont..

Hare, R.D., Jutai, J.W., 1988. Psychopathy and cerebral asymmetry in semantic processing. Personality and Individual Differences 9, 329–337.

Hare, R.D., Williamson, S.E., Harpur, T.J., 1988. Psychopathy and language. In: Moffitt, T.E., Sarnoff, A.M. (Eds.), Biological Contributions to Crime Causation. NATO Advanced Science Series D: Behavior and Social Sciences. Martinus Nishoff Publishing, Dordrecht, The Netherlands, pp. 68–92.

Hutchison, K.A., 2003. Is semantic priming due to association strength or feature overlap? A *micro*analytic review. Psychonomic Bulletin and Review 10, 785–813.

Johns, J.H., Quay, H.C., 1962. The effect of social reward on verbal conditioning in psychopathic and neurotic military offenders. Journal of Consulting and Clinical Psychology 26, 217–220.

Kiehl, K.A., Hare, R.D., McDonald, J.J., Brink, J., 1999. Semantic and affective processing in psychopaths: an event-related potential (ERP) study. Psychophysiology 36, 765–774.

Kiehl, K.A., Smith, A.M., Mendrek, A., Forster, B.B., Hare, R.D., Liddle, P.F., 2004. Temporal lobe abnormalities in semantic processing by criminal psychopaths as revealed by functional magnetic resonance imaging. Psychiatry Research 130, 27–42.

Levenston, G.K., Patrick, C.J., Bradley, M.M., Lang, P.J., 1996. Psychopathy and startle modulation during affective picture processing: a replication and extension. In: Annual Meeting of the Society for Psychophysiological Research, Vancouver, Canada.

Levenston, G.K., Patrick, C.J., Bradley, M.M., Lang, P.J., 2000. The psychopath as observer: emotion and attention in picture processing. Journal of Abnormal Psychology 109, 373–386.

Liberzon, I., Phan, K.L., Decker, L.R., Taylor, S.F., 2003. Extended amygdala and emotional salience: a PET activation study of positive and negative affect. Neuropsychopharmacology 28, 726–733.

Lorenz, A.R., Newman, J.P., 2002. Deficient response modulation and emotion processing in low-anxious Caucasian psychopathic offenders: results from a lexical decision task. Emotion 2, 91–104.

Lykken, D.T., 1957. A study of anxiety in the sociopathic personality. Journal of Abnormal and Social Psychology 55, 6–10.

McClelland, J.L., Rumelhart, D.E., 1985. Distributed memory and the representation of general and specific information. Journal of Experimental Psychology: General 114, 159–171.

Mitchell, D.G.V., Richell, R.A., Leonard, A., Blair, R.J.R., in press. Emotion at the expense of cognition: psychopathic individuals outperform controls on an operant response task. Journal of Abnormal Psychology, in press.

Nakic, M., Smith, B., Busis, S., Vythilingham, M., Blair, R.J.R., 2006. The role of the amgydala and inferior frontal cortex in lexical decisions: The impact of affect and frequency. Neuroimage, in press.

Neely, J.H., 1991. Semantic priming effects in visual word recognition: a selective review of current findings and theories. In: Besner, D., Humphreys, G.W. (Eds.), Basic Processes in Reading: Visual Word Recognition. Erlbaum, Hillsdale, NJ.

Nelson, D.L., McEvoy, C.L., Schreiber, T.A., 1998. The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu/FreeAssociation/.

Patrick, C.J., 1994. Emotion and psychopathy: startling new insights. Psychophysiology 31, 319–330.

Patrick, C.J., Bradley, M.M., Lang, P.J., 1993. Emotion in the criminal psychopath: startle reflex modulation. Journal of Abnormal Psychology 102, 82–92.

Plaut, D.C., Booth, J.R., 2000. Individual and developmental differences in semantic priming: empirical and computational support for a single-mechanism account of lexical processing. Psychological Review 107, 786–823.

Raven, J.C., 1965. Advanced Progressive Matrices, Sets I and II. HK Lewis, London.

Rogers, T.T., Lambon, R.M.A., Garrard, P., Bozeat, S., McClelland, J.L., Hodges, J.R., et al., 2004. Structure and deterioration of semantic memory: a neuropsychological and computational investigation. Psychological Review 111, 205–235.

Schwartz, S., Baldo, J., Graves, R., Brugger, P., 2003. Pervasive influence of semantics in letter and category fluency: a multidimensional approach. Brain and language 87, 400–411.

Siebert, M., Markowitsch, H.J., Bartel, P., 2003. Amygdala, affect and cognition: evidence from 10 patients with Urbach-Wiethe disease. Brain 126, 2627–2637.

Strauss, E., 1983. Perception of emotional words. Neuropsychologia 21, 99–103.

Verona, E., Curtin, J.J., Patrick, C.J., Bradley, M.M., Lang, P.J., 2004. Psychopathy and physiological response to emotionally evocative sounds. Journal of Abnormal Psychology 113, 99–108.

White, M., 1995. Unattended words need to be primed to be recognized. Canadian Journal of Experimental Psychology 49, 273–286.

Williamson, S., Harpur, T.J., Hare, R.D., 1991. Abnormal processing of affective words by psychopaths. Psychophysiology 28, 260–273.

Wong, S., 1988. Is Hare's psychopathy checklist reliable without the interview? Psychological Reports 62, 931–934.