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 ScienceDirect

Personality and Individual Differences 42 (2007) 585–595

PERSONALITY AND
INDIVIDUAL DIFFERENCES

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Stroop tasks associated with differential activation of anterior cingulate do not differentiate psychopathic and non-psychopathic offenders

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Received 13 February 2006; received in revised form 11 July 2006; accepted 26 July 2006

Available online 1 November 2006

Abstract

Attentional models of psychopathy hold that psychopathic individuals fail to process information that conflicts with goal-directed behavior. However, they display normal interference on color-word Stroop tasks. To determine whether psychopathic individuals' attention deficits are specific to conditions associated with the anterior cingulate (ACC) conflict monitoring system, we administered a Stroop task with a mostly-congruent condition associated with ACC activation, and a mostly-incongruent condition that is not, to 128 criminal offenders assessed for psychopathy using Hare's (2003) PCL-R. Despite replicating previous condition effects associated with differential ACC activation (Carter et al., 2000), psychopathic offenders and controls performed very similarly in both conditions. Results do not support an association between ACC-related deficits in conflict monitoring and the attention deficits of psychopathic offenders. © 2006 Published by Elsevier Ltd.

Keywords: Psychopathy; Conflict monitoring; Anterior cingulate cortex

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1. Introduction

The antisocial lifestyles of psychopathic individuals reflect a problem forming meaningful relationships with others and learning from previous experience. Consequently, these individuals are prone to chaotic lifestyles filled with destructive interpersonal relationships, severe adjustment problems at work and at home, and chronic maladaptive behavior. Not surprisingly, psychopathic individuals readily engage in illegal activity, commit a disproportionate number of crimes, and are more likely to recidivate than other offenders (Hare, 2003). Thus, characterizing the psychobiological processes that undermine self-regulation and social adjustment in psychopathy is an important and challenging focus of research.

Psychopathy has been linked to a broad range of cognitive, affective, and perceptual deficits that may explain the difficulty psychopaths have maintaining context appropriate behavior (see Kiehl, *in press*; MacCoon, Wallace, & Newman, 2004). In particular, psychopathic individuals display deficits in emotion processing and aversive conditioning (Flor, Birbaumer, Hermann, Ziegler, & Patrick, 2002; Hare, 1986), fail to inhibit pre-potent responses when responding to changing environmental contingencies (Mitchell, Colledge, Leonard, & Blair, 2002; Newman, Patterson, & Kosson, 1987), and are less responsive to secondary cues that conflict with or contraindicate their goal-directed behavior (Hiatt, Schmitt, & Newman, 2004; Lykken, 1957; Newman & Kosson, 1986; Newman, Schmitt, & Voss, 1997). Such findings have led researchers to propose that the deficient self-regulation of individuals with psychopathy may reflect either a specific insensitivity to bottom-up threat cues or a more general deficit in reallocating attention from a pre-potent goal when bottom-up cues signal the need to modify goal-directed behavior (Jutai & Hare, 1983; Kosson, 1996; Patterson & Newman, 1993).

For example, Newman and colleagues (MacCoon *et al.*, 2004; Patterson & Newman, 1993) have proposed that the processing deficits demonstrated by psychopathic individuals result from a problem incorporating secondary or bottom-up information while engaged in goal-directed behavior, a process identified as response modulation (RM). When incoming information via a bottom-up network conflicts with goal-directed behavior, efficient RM re-directs attentional resources to resolve the conflict. This shift in attentional resources, in turn, allows individuals to integrate bottom-up information and regulate their goal-directed behavior. Conversely, in the absence of efficient RM, the reallocation of attention does not occur, preventing individuals from modulating their goal-directed behavior.

From its inception, theorizing about the response modulation deficits of psychopathic individuals has been based on neurological circuitry that includes the septo-hippocampal system and its connections to orbitofrontal cortex (Gorenstein & Newman, 1980). This neural circuitry has also been linked to behavioral inhibition and anxiety by Gray (1982) and to psychopathy by Fowles (1980). However, the potential implications of the septo-hippocampal system for behavioral regulation and response modulation have been relatively ignored by cognitive and affective neuroscientists (*cf.* Gray & McNaughton, 2000; Wall & Messier, 2001). Conversely, the anterior cingulate cortex (ACC) has received a great deal of attention as a potential neurological substrate for the type of conflict monitoring and cognitive control that might underline the response modulation and self-control deficits associated with psychopathy (*e.g.*, Botvinick, Braver, Barch, Carter, & Cohen, 2001; Gruber & Yurgelun-Todd, 2005).

Cognitive control models have generally emphasized the contribution of dorso-lateral prefrontal cortex (DLPFC) to the regulation of cognitive control processes, because of its putative role in maintaining a task appropriate response set in the face of pre-potent, task-irrelevant, distracters (e.g., name the color of a word while inhibiting the pre-potent tendency to read the incongruent color word as in the standard Stroop task; Miller & Cohen, 2001). More recently, however, cognitive control theorists have emphasized the importance of the anterior cingulate cortex (ACC) for bringing DLPFC-mediated resources on line when circumstances require such cognitive control (Botvinick et al., 2001). In support of this contention, Carter et al. (2000) reported that variation in ACC activation during two conditions of a color-word Stroop task depended on the degree of cognitive control evoked by each condition. When incongruent stimuli were frequent throughout a condition, individuals appeared to employ strategic (i.e., top-down) processes to overcome the pre-potent tendency to read the word, which resulted in both minimal response conflict to incongruent stimuli and minimal activation in the ACC. In contrast, when incongruent stimuli were infrequent and strategic processing was less necessary to control the pre-potent response tendency on a trial-by-trial basis, participants responded more rapidly overall, but they also displayed a stronger conflict response to the relatively rare incongruent trials and greater ACC activation. In other words, the ACC appeared to be particularly important for modulating top-down attention when incongruent information and response conflict were relatively unexpected or bottom-up, and less important when top-down resources were already allocated to resolving response conflict.

With regard to psychopathy, the ACC-mediated conflict monitoring system provides a potentially useful framework for clarifying the situation-specific response modulation deficits displayed by psychopaths. Supporting a potential association between psychopathy and ACC functioning, investigators have reported irregularities in ACC functioning in psychopathic individuals during affective tasks. For instance, using fMRI, Kiehl et al. (2001) found abnormal activity in the ACC along with several other paralimbic structures in psychopathic compared to non-psychopathic offenders during affective memory tasks. Furthermore, Birbaumer et al. (2005) demonstrated diminished ACC activity (along with several other affective processing systems) in psychopaths as compared to controls in a classical conditioning paradigm. Thus, there is reason to believe that anomalies in ACC functioning may be associated with the affective and self-regulatory deficits that characterize psychopathic individuals.

The primary purpose of this study was to test the hypothesis that a deficit in conflict monitoring, of the type associated with ACC, may underlie the situation-specific deficits in response modulation demonstrated by psychopathic individuals. More specifically, in light of (1) parallels between response modulation (RM) and conflict monitoring, (2) compelling evidence linking conflict monitoring to the ACC, and (3) evidence of abnormal ACC activity in psychopathic individuals, we attempted to measure the behavioral correlates of ACC functioning in psychopathic individuals using the two versions of the Stroop color-word task employed by Carter et al. (2000).

Although previous research using the Stroop task with psychopathic and non-psychopathic individuals has revealed comparable interference in psychopathic and non-psychopathic participants (e.g., Hiatt et al., 2004; Smith, Arnett, & Newman, 1992), the frequency of incongruent and congruent trials in these studies was roughly equivalent (i.e., 33% congruent, 33% incongruent, and 33% neutral). In contrast, the Carter et al. (2000) task that correlated with ACC activation involved three times as many congruent (75%) as incongruent (25%) trials. Thus, to the extent

that psychopathic participants manifest a specific deficit (i.e., less interference and/or more errors) in the mostly congruent condition, it will support a link between the situation-specific response modulation deficits of psychopathic individuals and the ACC-related conflict monitoring system.

2. Methods

2.1. Participants

Participants consisted of 128 males incarcerated in the Wisconsin State Prison System or the Sand Ridge Secure Treatment Center. We used institutional records and medical notes to ensure that all participants were age 45 or younger, had no history of psychosis or bipolar disorder, and were not receiving psychotropic medication at the time of the study. In addition, all participants earned estimated IQ scores of 70 or greater on the Shipley Institute of Living Scale (Zachary, 1986). Prior to the study, participants received the elements of consent in both verbal and written form and were informed that participation in the study would not affect their status within the prison system or treatment center.

2.2. Psychopathy assessment

Researchers used file information and a 60 min semi-structured interview to diagnose psychopathy using Hare's (2003) Psychopathy Checklist-Revised (PCL-R). The PCL-R contains 20 items that are rated 2, 1 or 0 according to whether the item is significantly (2), moderately (1), or not at all (0) characteristic of the individual. Following the recommendations of Hare (1991), participants were assigned to high and low psychopathy groups based on the standard cutoff scores of 30 and above ($n = 55$) and 20 and below ($n = 42$). Based on previous research supporting the use of the Welsh Anxiety Scale (Welsh, 1956) to distinguish between primary and secondary psychopathy (see Newman, MacCoon, Vaughn, & Sadeh, 2005), a median split on this measure was used to divide participants into high ($n = 50$) and low anxious ($n = 47$) groups. We tested our *a priori* hypotheses using primary psychopathic participants ($n = 26$) and anxiety-matched controls ($n = 21$).

2.3. Procedure

Like Carter et al. (2000), we used a modified version of the color-word Stroop task with 12 blocks of 20 trials. Throughout the 12 blocks, participants responded to four types of experimental blocks: two practice blocks, four mostly congruent blocks, four mostly incongruent blocks, and two neutral word blocks. In the practice blocks (prac), participants read the names of colors typed in white font on a black background. During mostly congruent blocks (con), 80% of the trials were color words typed in congruent colored fonts (con/con) and 20% were color words typed in incongruent colored fonts (con/inc). In addition, the first four trials in these blocks were always congruent and no incongruent trial was ever followed by an incongruent trial. Conversely, in the mostly incongruent blocks (inc), 80% of the trials were color words typed in incongruent colored fonts (inc/inc) and 20% were color words typed in congruent colored fonts (inc/con). Fur-

thermore, the first four trials in these blocks were always incongruent and no congruent trial was ever followed by another congruent trial. Finally, in the neutral¹ blocks, participants read the names of body parts (i.e., arm) that were matched for color word length and presented in colored fonts. Participants completed this task in one of two fixed orders to counterbalance between block presentations: (1) prac, prac, inc, con, con, inc, neutral, con, inc, inc, con, neutral; or (2) prac, prac, con, inc, inc, con, neutral, inc, con, con, inc, neutral.

The color-word Stroop task was administered on a Windows-based computer with a 15-in. monitor. A microphone recorded participants' responses. Each stimulus appeared on the screen for a total 500 ms with an inter-trial interval of 2000 ms. Experimenters, blind to participants' group membership, sat next to the participant and recorded response accuracy.

3. Results

3.1. Preliminary analyses

3.1.1. Effects of accuracy

Before evaluating reaction time data, we conducted a 2 Psychopathy group \times 2 Anxiety group mixed-model, analysis of variance (ANOVA), with Condition (mostly congruent versus mostly incongruent) and Trial type (congruent versus incongruent) as repeated measures to determine whether the groups displayed comparable error rates. The analysis revealed no significant effects involving the grouping variables, although the Anxiety group \times Trial type interaction ($F(1, 93) = 3.48, p = .065, \eta = .036$) and Psychopathy \times Anxiety group interaction ($F(1, 93) = 3.23, p = .076, \eta = .034$) approached statistical significance.

3.2. Primary hypothesis testing

Because a deficiency in monitoring and reacting to conflicts could be expressed as reduced interference and/or less accurate responding on conflict trials, we examined reaction time data for accurate responses only and controlled for group differences in response accuracy when indicated. The reaction time (RT) data were first analyzed using a 2 Psychopathy group \times 2 Anxiety group mixed-model ANOVA, with Condition (mostly congruent versus mostly incongruent) and Trial type (congruent versus incongruent) as repeated measures. This ANOVA revealed a significant main effect for Condition ($F(1, 85) = 6.26, p < .05, \eta = .07$), a significant main effect for Trial type ($F(1, 85) = 327.28, p < .001, \eta = .79$) and a significant Trial type by Condition interaction, $F(1, 85) = 49.05, p < .001, \eta = .37$. As in the Carter et al. (2000) study, participants in the present study responded more quickly in the mostly congruent than in the mostly incongruent condition. They responded more quickly on congruent than on incongruent trials. And, as shown in Fig. 1, they displayed greater interference in the mostly congruent condition than in the mostly

¹ On occasion, psychopathic and non-psychopaths have been found to differ in average response time. Because RT can be related to interference, we included neutral trials so that if we found group differences in RT we could use them to evaluate whether the difference was related to differences in incongruent or congruent trials. However, the absence of general RT effects in the overall analysis obviated the need for neutral trials.

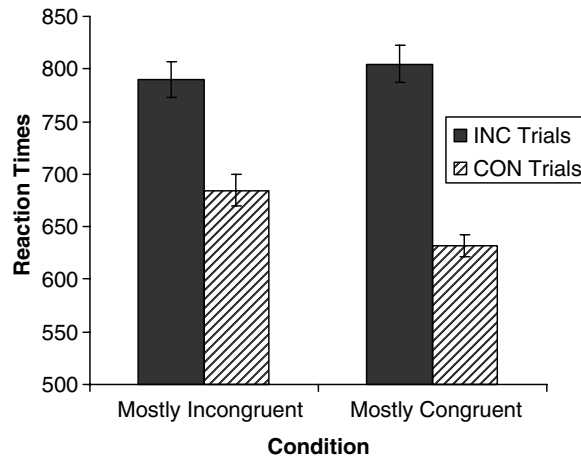


Fig. 1. Mean overall reaction times by trial for the mostly congruent and mostly incongruent conditions.

incongruent condition. In contrast to these task-related effects, the ANOVA yielded no significant main effects or interactions involving Anxiety or Psychopathy.

Given the statistical trends for Anxiety and Psychopathy observed in the preliminary analysis of performance accuracy, the RT analysis was repeated using task accuracy (i.e., mean errors) as a covariate. Again, we observed no significant main effects or interactions involving the group variables.

3.2.1. Planned comparisons

A planned comparison was used to test the hypothesis that psychopathic participants with low-anxiety scores would display less interference than anxiety-matched controls in the mostly congruent condition. Low-anxious non-psychopathic participants responded 167 ms ($SD = 96$) slower on incongruent trials than on congruent trials in the mostly congruent condition. Contrary to hypothesis, low-anxious psychopathic participants displayed non-significantly more interference than controls in this condition, $M = 183$ ms, $SD = 89$ ms, $t(41) < 1.0$. A similar comparison involving data from the mostly incongruent condition revealed that the low-anxious psychopathic group ($M = 88$, $SD = 88$) displayed non-significantly less interference than low-anxious controls ($M = 126$, $SD = 61$), $t(41) = 1.61$, $p > .10$. Table 1 presents group cells sizes, means and standard deviations for reaction time and accuracy on the modified color-word Stroop.

4. Discussion

This study successfully replicated the behavioral findings reported by Carter et al. (2000) using a similar color-word Stroop task. In particular, individuals responded more quickly in the mostly congruent condition than in the mostly incongruent condition, showed significant interference in both conditions, and displayed significantly larger interference when responding to conflict in the mostly congruent condition than in the mostly incongruent condition. These results augment the

Table 1

Means (*M*) and standard deviations (*SD*) for reaction times (*RT*) and accuracy on the modified color-word Stroop by Group

Condition	Trial	Measure	<i>M</i> (<i>SD</i>)			
			Psychopathic individuals		Non-psychopathic individuals	
			Low-anxious (<i>N</i> = 26)	High-anxious (<i>N</i> = 29)	Low-anxious (<i>n</i> = 21)	High-anxious (<i>n</i> = 21)
Mostly congruent	CON	RT	633 (102)	615 (103)	619 (102)	663 (103)
		Errors	1.0 (1.6)	.10 (1.6)	.38 (1.6)	.52 (1.6)
	INC	RT	812 (166)	784 (166)	782 (165)	842 (167)
		Errors	1.8 (1.9)	1.9 (1.9)	1.9 (1.9)	2.7 (1.9)
Mostly incongruent	CON	RT	684 (148)	669 (149)	661 (148)	724 (149)
		Errors	.31 (.62)	.17 (.61)	.14 (.61)	.29 (.61)
	INC	RT	770 (163)	778 (164)	771 (163)	841 (164)
		Errors	3.0 (3.6)	2.9 (3.6)	2.3 (3.6)	4.4 (3.6)

Note: CON = congruent; INC = incongruent.

previous Carter et al. (2000) findings by replicating the effects in a larger sample and generalizing them to a prison population.

The primary purpose of this study was to examine whether psychopathic individuals would display less interference and/or more errors relative to controls under task conditions that have been associated with ACC activation. Given (1) compelling parallels between response modulation and conflict monitoring, (2) evidence linking conflict monitoring to ACC, and (3) evidence of abnormal ACC activity in psychopathic individuals, we reasoned that a deficit in conflict monitoring, of the type associated with ACC, may underlie the situation-specific deficits in response modulation associated with psychopathy. To the extent that psychopathic individuals are insensitive to conflict when a Stroop task instantiates low levels of cognitive control (i.e., mostly congruent condition), yet are normally responsive to conflict when it elicits more strategic processing (i.e., mostly incongruent condition), such results would support theorizing that a deficiency in ACC-related conflict monitoring undermines the automatic integration of bottom-up information in psychopathic individuals.

Although deficits in this conflict monitoring system could account for the difficulties psychopaths have generating contextually appropriate behavior, the results of this study do not support this conclusion. Contrary to prediction, psychopathic individuals did not have difficulty modulating their behavior in the presence of infrequent conflict. Indeed, psychopathic individuals demonstrated non-significantly greater interference than non-psychopathic individuals in the mostly congruent conditions. Such findings provide little support for proposals that ACC dysfunction underlies psychopathic deficits in behavioral regulation.

Though our use of a modified color-word Stroop that has been linked to ACC activation failed to differentiate the performance of psychopathic and non-psychopathic offenders, we must be cautious in drawing inferences regarding potential group differences in ACC functioning for two reasons: Firstly, despite fMRI research indicating that the ACC is differentially activated when individuals respond to conflict in the mostly congruent as opposed to the mostly incongruent

conditions (Carter et al., 2000), the modified Stroop task used in this study is not a direct measure of ACC functioning. As a result, the comparable performance of psychopathic individuals and controls may simply highlight the specificity of the probable ACC deficits in psychopathy. Anatomical tracing studies have uncovered cognitive and affective subdivisions within the ACC based on distinct efferent and afferent projection systems (Vogt, Finch, & Olson, 1992). Moreover, research has indicated that these subdivisions are differentially activated depending upon the type of conflict induced. For example, Bush et al. (1998) demonstrated that the counting Stroop activated more dorsal regions of the ACC, while Whalen et al. (1998), demonstrated fMRI blood oxygenation level-dependent (BOLD) signal increases in a rostral portion of ACC, when using an affective variant of the counting Stroop. Thus, our finding of comparable performance, coupled with the previous abnormal ACC related effects in psychopathic individuals, may indicate that abnormal ACC activity in psychopathy is affect specific. Secondly, it should be noted that neurophysiological differences between psychopaths and controls have been found in the absence of clear behavioral differences. For example, Kiehl et al. (2001) demonstrated abnormalities in the ACC and other temporal-limbic structures of psychopathic individuals in comparison to controls, but failed to show behavioral differences between the two groups. In light of such findings, Kiehl et al. (2001) have proposed that psychopathic individuals may not display performance deficits despite hypo-activation in brain regions generally associated with such performance because they compensate using alternative brain regions (see also Gruber & Yurgelun-Todd, 2005; Hare, Williamson, & Harpur, 1988).

If the behavioral performance of psychopathic individuals is a reflection of their ability to effectively compensate for ACC dysfunction, there is now considerable evidence that they are able to compensate for these deficits consistently. On the standard color-word Stroop, psychopathic individuals have repeatedly displayed normal Stroop interference in comparison to non-psychopaths (Brinkley, Schmitt, & Newman, 2005; Hiatt et al., 2004; Smith et al., 1992). In light of the fact that psychopathic individuals do not display a response modulation deficit on the standard Stroop task, it may seem unusual to examine the potential importance of ACC-related conflict monitoring for response modulation using such a task. However, to the extent that the ACC-related conflict monitoring system plays an important role in response modulation and is differentially involved under mostly congruent Stroop task conditions, the predicted results would have provided strong evidence for a link between ACC functioning and response modulation. Thus, it was important to test the hypothesis that manipulating the frequency of incongruent stimuli would reveal subtle, ACC-related processing deficits in the Stroop performance of psychopathic individuals. However, this was not the case.

In contrast to research using traditional color-word Stroop tasks, psychopathic individuals do show significantly less interference than controls when Stroop stimuli are presented in a spatially separated format. For example, using one standard and two spatially-separated Stroop tasks, Hiatt et al. (2004) found psychopathic individuals exhibited normal interference on the standard format and less interference on the spatially separated format. According to Hiatt et al., these findings suggest that the spatial separation allows psychopathic individuals to allocate their top-down focus of attention to aspects of the display critical for responding while, simultaneously, screening-out irrelevant aspects of the display. The fact that psychopathic offenders differ from controls in spatially separated Stroop tasks but display similar performance in spatially integrated Stroop tasks – even under mostly congruent conditions – may indicate that a psychobiological

mechanism other than the ACC-related conflict monitoring system is responsible for their difficulty re-directing top-down attention and integrating bottom-up information while engaged in goal-directed behavior.

In this regard, Gray (1982) has outlined a hypothetical behavioral inhibition system (BIS) that, like the conflict monitoring system described by cognitive control theorists, functions to redirect attention and facilitate top-down processing in response to the bottom-up detection of “mismatches”. Gray’s BIS differs from the ACC-related conflict monitoring system with regard to underlying neural substrate (i.e., the septo-hippocampal system (SHS) as opposed to the ACC) and, related to its different neural substrate, has been associated with a different type of conflict processing (see Gray & McNaughton, 2000, for details). In addition to its historical link with response modulation (see Gorenstein & Newman, 1980; McCleary, 1966), the SHS has also been related to the threat processing, passive avoidance, and other inhibitory deficits associated with psychopathy (i.e., Fowles, 1980; Newman, MacCoon, Hiatt, Bertsch, & Buckholtz, *in press*; Patterson & Newman, 1993). In light of these connections, investigators interested in using progress in neuroscience to advance understanding of the disinhibitory psychopathology associated with psychopathy may find research on the SHS to be fertile ground.

As already noted, a limitation of the current study is the lack of physiological and neurological measures to supplement our behavioral index of ACC processing in psychopathic individuals. Additional research with variations of the Stroop task that combine behavioral and neuroimaging data is needed. Such research could help to determine whether the apparently normal performance of psychopaths is associated with differential ACC activation or whether abnormal ACC activation previously demonstrated in psychopathic offenders is affect specific. In addition, this research strategy could be used to clarify the neurological correlates of the reduced Stroop interference displayed by psychopathic individuals on spatially separated versions of the Stroop task.

Despite its limitations, this investigation into the conflict monitoring capabilities of psychopathic individuals has important implications for understanding the attentional processing deficits attributed to psychopathy and for identifying the neural substrates that may underlie these deficits in behavior regulation. In particular, the ability of psychopathic individuals to successfully adapt their behavior in response to infrequent conflict in the modified color-word Stroop does not support the presence of a cognitively-based ACC deficit in psychopathy. Indeed, the results of this study suggest a mechanism other than the ACC is responsible for the situation-specific response modulation deficits demonstrated by psychopathic offenders.

Acknowledgements

This research was supported by a grant from the National Institute of Mental Health (MH53041). We gratefully acknowledge the assistance of the staff at the Oshkosh Correctional Institution and the Sand Ridge Secure Treatment Center, as well as the cooperation of the Wisconsin Department of Corrections. We especially thank Warden Judy Smith, Dr. Alexander Stolarski, and Sandy Henrickson of the Oshkosh Correctional Institution for their assistance. We also thank Joshua Zeier, Joshua Buckholtz, and Donal MacCoon for interviewing and diagnosing participants.

References

- Birbaumer, N., Veit, R., Lotze, M., Erb, M., Hermann, C., Grodd, W., et al. (2005). Deficient fear conditioning in psychopathy: A functional magnetic resonance imaging study. *Archives of General Psychiatry*, *62*, 799–805.
- Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*(3), 524–652.
- Brinkley, C. A., Schmitt, W. A., & Newman, J. P. (2005). Semantic processing in psychopathic offenders. *Personality and Individual Differences*, *38*, 1047–1056.
- Bush, G., Whalen, P. J., Rosen, B. R., Jenike, M. A., McInerney, S. C., & Rauch, S. L. (1998). The counting Stroop: An interference task specialized for functional neuroimaging – validation study with functional MRI. *Human Brain Mapping*, *6*(4), 270–282.
- Carter, C. S., MacDonald, A. M., Botvinick, M., Ross, L. L., Stenger, A., Noll, D., et al. (2000). Parsing executive processes: Strategic versus evaluative functions of the anterior cingulate cortex. *Proceedings of the National Academy of Sciences*, *97*, 1944–1948.
- Flor, H., Birbaumer, N., Hermann, C., Ziegler, S., & Patrick, C. J. (2002). Aversive Pavlovian conditioning in psychopaths: Peripheral and central correlates. *Psychophysiology*, *39*, 505–518.
- Fowles, D. C. (1980). The three arousal model: Implications for Gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. *Psychophysiology*, *17*, 87–104.
- Gorenstein, E. E., & Newman, J. P. (1980). Disinhibitory psychopathology: A new perspective and a model for research. *Psychological Review*, *87*(3), 301–315.
- Gray, J. A. (1982). *The neuropsychology of anxiety: An enquiry into the functions of the septohippocampal system*. New York: Clarendon Press/Oxford University Press.
- Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety: An enquiry into the function of the septohippocampal system*. Oxford: Oxford University Press.
- Gruber, S. A., & Yurgelun-Todd, D. A. (2005). Neuroimaging of marijuana smokers during inhibitory processing: a pilot investigation. *Cognitive Brain Research*, *23*, 107–118.
- Hare, R. D. (1986). Twenty years of experience with the Cleckley psychopath. In W. H. Reid, D. Dorr, J. I. Walker, & J. W. Bonner, III (Eds.), *Unmasking the psychopath: Antisocial personality and related syndromes*. New York: W.W. Norton & Company.
- Hare, R. D. (1991). *The Hare psychopathy checklist – Revised*. Toronto, ON: Multi-Health Systems.
- Hare, R. D. (2003). *Manual for the Hare psychopathy checklist – Revised* (2nd ed.). Toronto, ON: Multi-Health Systems.
- Hare, R. D., Williamson, S. E., & Harpur, T. J. (1988). Psychopathy and language. In T. E. Moffitt & S. A. Mednick (Eds.), *Biological contributions to crime causation*. Dordrecht, Netherlands: Nijhoff Martinus.
- Hiatt, K. D., Schmitt, W. A., & Newman, J. P. (2004). Stroop tasks reveal abnormal selective attention in psychopathic offenders. *Neuropsychology*, *18*(1), 50–59.
- Jutai, J. W., & Hare, R. D. (1983). Psychopathy and selective attention during performance of a complex perceptual-motor task. *Psychophysiology*, *20*(2), 146–151.
- Kiehl, K. A. (in press). A paralimbic dysfunction hypothesis of psychopathy: A cognitive neuroscience perspective. In D. Barch (Ed.), *Cognitive and affective neuroscience of psychopathology*. Oxford: Oxford University Press.
- Kiehl, K. A., Smith, A. M., Hare, R. D., Mendrek, A., Forster, B. B., Brink, J., et al. (2001). Limbic abnormalities in affective processing by criminal psychopaths as revealed by functional magnetic resonance imaging. *Biological Psychiatry*, *50*(9), 677–684.
- Kosson, D. S. (1996). Psychopathy and dual-task performance under focusing conditions. *Journal of Abnormal Psychology*, *105*, 391–400.
- Lykken, D. T. (1957). A study of anxiety in the sociopathic personality. *Journal of Abnormal and Social Psychology*, *55*, 6–10.
- MacCoon, D. G., Wallace, J. F., & Newman, J. P. (2004). Self-regulation: the context-appropriate allocation of attentional capacity to dominant and non-dominant cues. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 422–446). New York: Guilford.

- McCleary, R. A. (1966). Response-modulating function of the limbic system: Initiation and suppression. In E. Stellar & J. M. Sprague (Eds.), *Progress in physiological psychology* (Vol. 1, pp. 209–271). New York: Plenum.
- Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, 24, 167–202.
- Mitchell, D. G. V., Colledge, E., Leonard, A., & Blair, R. J. R. (2002). Risky decisions and response reversal: Is there evidence of orbito-frontal cortex dysfunction in psychopaths? *Neuropsychologia*, 40, 2013–2022.
- Newman, J. P., & Kosson, D. S. (1986). Passive avoidance learning in psychopathic and nonpsychopathic offenders. *Journal of Abnormal Psychology*, 95, 252–256.
- Newman, J. P., MacCoon, D. G., Hiatt, K. D., Bertsch, J., & Buckholtz, J. (in press). Deficient integration of top-down and bottom-up influences on attention in psychopaths: Potential contribution of the septal-hippocampal system. In D. Barch (Ed.), *Cognitive and affective neuroscience of psychopathology*. Oxford: Oxford University Press.
- Newman, J. P., MacCoon, D. G., Vaughn, L. J., & Sadeh, N. (2005). Validating a distinction between primary and secondary psychopathy with measures of Gray's (1987) BIS and BAS constructs. *Journal of Abnormal Psychology*, 114, 319–323.
- Newman, J. P., Patterson, C. M., & Kosson, D. S. (1987). Response perseveration in psychopaths. *Journal of Abnormal Psychology*, 96, 145–148.
- Newman, J. P., Schmitt, W. A., & Voss, W. (1997). The impact of motivationally neutral cues on psychopaths: Assessing the generality of the response modulation hypothesis. *Journal of Abnormal Psychology*, 106, 563–575.
- Patterson, C. M., & Newman, J. P. (1993). Reflectivity and learning from aversive events: Toward a psychological mechanism for the syndromes of disinhibition. *Psychological Review*, 100, 716–736.
- Smith, S. S., Arnett, P. A., & Newman, J. P. (1992). Neuropsychological differentiation of psychopathic and nonpsychopathic criminal offenders. *Personality and Individual Differences*, 13, 1233–1245.
- Vogt, B. A., Finch, D. M., & Olson, C. R. (1992). Functional heterogeneity in cingulate cortex: The anterior executive and posterior evaluative regions. *Cerebral Cortex*, 2, 435–443.
- Wall, P. M., & Messier, C. (2001). The hippocampal formation – Orbitomedial prefrontal cortex circuit in the attentional control of active memory. *Behavioural Brain Research*, 127(1–2), 99–117.
- Welsh, G. (1956). Factor dimensions A and R. In G. S. Welsh & W. G. Dahlstrom (Eds.), *Basic readings on the MMPI in psychology and medicine* (pp. 264–281). Minneapolis: University of Minnesota Press.
- Whalen, P. J., Bush, G., McNally, R. J., Wilhelm, S., McInerney, S. C., Jenike, M. A., et al. (1998). The emotional counting Stroop paradigm: A functional magnetic resonance imaging probe of the anterior cingulate affective division. *Biological Psychiatry*, 44, 1219–1228.
- Zachary, R. A. (1986). *Shipley institute of living scale: Revised manual*. Los Angeles: Western Psychological Services.