

# ASYMMETRIC FUNCTIONAL ROLES OF RIGHT AND LEFT VENTROMEDIAL PREFRONTAL CORTICES IN SOCIAL CONDUCT, DECISION-MAKING, AND EMOTIONAL PROCESSING

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## ABSTRACT

The aim of this study was to begin to parse the relative contributions of the right and left ventromedial prefrontal cortices (VMPC) in regard to social conduct, decision-making, and emotional processing. We hypothesized that the right VMPC is a critical component of the neural systems that subserve such functions, whereas the left VMPC is not. Seven participants with focal, stable unilateral lesions to the right ( $n = 4$ ) or left ( $n = 3$ ) VMPC were studied with procedures designed to measure social conduct, decision-making, and emotional processing and personality. The right-sided participants had profound disturbances of social and interpersonal behavior and of the ability to maintain gainful employment; they had defective performance and impaired anticipatory skin conductance responses during the Gambling Task; most had profound abnormalities of emotional processing and personality, and met criteria for “acquired sociopathy.” By contrast, the left-sided participants had normal social and interpersonal behavior; they had stable employment; they performed normally and had normal skin conductance responses on the Gambling Task; they had normal emotional processing; and their personalities were unchanged from premorbid status. The marked deficits in social conduct, decision-making, and emotional processing in participants with unilateral right VMPC lesions are reminiscent in kind of those that have been reported in connection with bilateral VMPC lesions, albeit perhaps of lesser severity. The findings provide preliminary evidence that insofar as social, decision-making, and emotional functions are concerned, the right-sided component of the VMPC system may be critical, whereas the left-sided component may be less important.

Key words: prefrontal cortex, psychopathy, emotion, brain damage, gambling

## INTRODUCTION

Building on a long history of notable case studies (for reviews, see Damasio and Anderson, in press; Stuss and Benson, 1986), we have shown that bilateral damage to the ventromedial prefrontal region produces grave impairments of social conduct, decision-making, and emotional processing (Barrash et al., 2000; Bechara et al., 1994, 1996, 1997, 2000a, 2000b; Damasio et al., 1990, 1991; Eslinger and Damasio, 1985; Tranel, 1994; Tranel et al., 2000). Patients with such lesions display poor judgment regarding their personal and occupational affairs, they make bad decisions both in real-life and in laboratory tasks designed to measure complex decision-making, and they have impaired feelings and emotions. Our studies, however, along with much of the work in this area from other laboratories (e.g., Blair and Cipolotti, 2000; Blumer and Benson,

1975; Goel et al., 1997; Grafman et al., 1993; Levin et al., 1991; Manes et al., 2002; Mavaddat et al., 2000; Rahman et al., 2001; Rolls, 2000; Shallice and Burgess, 1991; Sirigu et al., 1996; Stuss and Benson, 1986; Zalla et al., 2001), have focused primarily on patients with bilateral ventromedial prefrontal lesions. There are several reasons for this, perhaps the most influential having to do with the nature of lesion etiology. Lesions to the ventromedial prefrontal region are commonly caused by rupture of aneurysms located in the anterior cerebral or anterior communicating arteries; in most instances, this pathology is likely to inflict a bilateral lesion. Lesions produced by surgical treatment of tumors in this region (e.g., resection of orbitofrontal meningiomas), and by head injury, also have a proclivity to cause bilateral damage.

Against this background, it remains an open question as to whether the right and left ventromedial prefrontal regions make asymmetric contributions to social conduct, decision-making, and emotional processing. Extrapolating from what is known about right hemisphere processing in general, however, there are some hints of asymmetric roles. For example, there is considerable evidence supporting a predominant role for right hemisphere structures in emotional processing, and in related functions such as the mapping of body states and the comprehension of somatic information at a neurocognitive level (Damasio, 1994, 1999). Lesions to various sectors of the right hemisphere have been shown to impair processing of emotional faces or scenes (Adolphs et al., 1996, 2000, in press; DeKosky et al., 1980), to impair emotional experience and arousal (Heller, 1993), and to impair imagery for emotion (Blonder et al., 1991; Bowers et al., 1991). Right hemisphere lesions also have a more dramatic effect on autonomic responses, compared to left hemisphere lesions, causing a profound attenuation or even abolition of responses such as skin conductance (Angrilli et al., 1999; Heilman et al., 1978; Morrow et al., 1981; Tranel, 2002a; Tranel and Damasio, 1994; Zahn et al., 1999; Zoccolotti et al., 1982; see Critchley et al., 2000, for consistent evidence in a functional imaging paradigm). The phenomena of anosognosia and anosodiaphoria, and related body schema disturbances, are also strongly linked to right hemisphere damage (Denburg and Tranel, in press). Hemispatial neglect is strongly associated with right hemisphere lesions (Heilman et al., in press). Right hemisphere damage can produce decision-making impairments (Bechara et al., 1999). And there is evidence that the right ventral prefrontal region plays an important role in reversal and extinction learning (Rolls et al., 1994). This and related evidence are reviewed in more detail in the Discussion section of the current paper, in the context of situating findings from the current study in the perspective of the available literature.

Here, we report a preliminary study in which we began to address the question of whether there may be functional asymmetries in the right and left ventromedial prefrontal sectors. On the basis of the available literature, we hypothesized that the right-sided sector of the ventromedial prefrontal cortex (VMPC) is crucial for social conduct, decision-making, and emotional processing, whereas the left-sided sector is not. Accordingly, we predicted that unilateral damage to the right VMPC would produce impairments in social conduct, decision-making, and emotional processing; by contrast, we predicted that unilateral damage to the left VMPC would not produce such impairments.

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