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Faux pas deficits in people with medial frontal lesions as related to impaired understanding of a speaker's mental state

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ABSTRACT

This study examined the nature of deficits in mentalizing, the ability to read the mental state of other people, as measured by a faux pas task in people with medial frontal lesions. A total of 56 Mandarin-speaking Chinese individuals participated (9 participants with medial frontal lesions, 12 participants with lateral frontal lesions, 5 participants with non-frontal lesions, and 30 healthy controls). The faux pas test ascertained the participants' ability to identify and understand a social faux pas, and to understand the mental states of the characters (the speaker and the recipient in a conversation with a social faux pas). Although the participants with medial frontal lesions performed less well than the other clinical participants and the control participants on all aspects of the faux pas test, the most significant deficit was observed in understanding mental states and hence inferring the speaker's intentions. The performance on the various aspects of decoding a social faux pas by people with medial frontal lesions suggests that the cognitive processes, and hence the respective neural correlates subserving these various processes, may be different. Our results add to existing literature and illustrate the very nature of deficits of mentalizing, measured by a faux pas test, experienced by people with medial frontal lesions. The data have also prompted that future behavioral and neuroimaging studies may be applied to further decode both the neural mechanisms and the cognitive variables affecting "mentalizing".

1. Introduction

Humans are social animals that under normal circumstances seek rewarding social interactions for adaptive learning and psychological satisfaction (Amodio & Frith, 2006; Cohen, 2004). To accomplish this important goal, we must be equipped with cognitive processes and the accompanying neural mechanisms that underpin both competent and successful interaction and communication with other people. These processes are classified under the construct termed *social cognition*, which, as defined by Brothers (1990), is the mental operation underlying social interactions, including the human ability to perceive the intentions and dispositions of others.

Among the various social cognitive skills essential to adaptive social learning and interactions, the ability to "mentalize," that is, to read the mental states of other agents (Frith & Frith, 2006), enables the attribution of cognitive and affective states of self and others. It is this awareness that allows one to detect the intentions and inner mental states of the self and others during social interactions (Baron-Cohen, Leslie, & Frith, 1985; David et al., 2008). In other words, mentalizing is the ability to represent another person's psychological perspective so that one may predict the behaviors of others (Amodio & Frith, 2006).

One strategy for assessing the ability to mentalize is the use of faux pas tests (Stone, Baron-Cohen, & Knight, 1998). *Faux pas* is a French term meaning a "false step," in other words, a speaker

Abbreviations: ANOVA, analysis of variance; FC, frontal cortex; FL, frontal lesion group; fMRI, functional magnetic resonance imaging; LFC, lateral frontal cortex; MFC, medial frontal cortex; NFC, non-frontal lesion control; DMFC, dorsomedial medial frontal cortex; VMFC, ventromedial frontal cortex.

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says something he or she should not have said, not knowing or not realizing the words' inappropriateness, which could hurt the recipient's feelings. An example of a social faux pas is as follows:

> "*Jessica was at Maria's apartment. While appreciating a crystal vase that she gave Maria as a birthday gift, she accidentally dropped the vase to the ground, which was then shattered into pieces. Jessica felt really sorry about breaking the vase. Maria said, "Don't worry about it. I never like this vase anyway.*"

When an individual recognizes the occurrence of a faux pas, he or she mentalizes that the speaker who said what was said did not intend to hurt the listener's feelings, and predicts that the individual who heard the words will be upset (Stone et al., 1998). Being able to mentalize another person's inner psychological state allows us to evaluate the intentions behind the behavior of others and hence decide how to react. According to previous research, children aged 9–11 years are able to recognize a faux pas involving the capacity to understand a situation in which one character should have kept information from another but did not (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999).

Applying the principle of faux pas, Stone et al. (1998) developed a faux pas test to assess the ability to mentalize. Ten stories, each containing a faux pas, are presented to participants one at a time. The participants are required to answer the following questions:

1. Detecting a faux pas: did someone say something he (or she) should not have said?
2. Understanding the faux pas: who said something he (or she) should not have said?
3. Understanding the recipient's mental state: why should he (or she) not have said it?
4. Understanding the speaker's mental state: why did he (or she) say it?

The participants are then asked a final control question to tap the important details of the story without inferring another's mental state in order to test their story comprehension.

Impaired faux pas performance has been widely reported in various clinical groups. Children with Asperger syndrome or high-functioning autism were found to perform significantly poorer than a control group in detecting faux pas stories, while performing well on first- and second-order false belief tasks (Baron-Cohen et al., 1999; Stone et al., 1998).

It has been suggested that the ability to mentalize other people's mental states and the capability of processing information about oneself may be subserved by a similar group of neural substrates (Mitchell, Macrae, & Banaji, 2004) in the frontal cortex (FC). The FC is functionally and anatomically heterogeneous (Happaney, Zelazo, & Stuss, 2004) and can be broadly subdivided into the lateral, dorsomedial, and orbital FC. Functionally, the dorsomedial and orbital FCs are often considered together as the medial FC (MFC). As such, the orbital FC, together with the dorsomedial FC, may function collaboratively (Öngür & Price, 2000) in processing inputs from sensory modalities for regulating consummatory behaviors (Kringelbach, 2005).

About possible neural correlates of mentalizing, the MFC, the superior temporal sulcus, the temporal–parietal junction, and the temporal poles (adjacent to the amygdala) are candidates serving social cognitive functions (Amodio & Frith, 2006; Frith & Frith, 2003). Researchers have suggested that the MFC, plays an important role in mentalizing (Mazza et al., 2007; Stuss, Gallup, & Alexander, 2001). Earlier studies have reported impaired performance on a faux pas test in patients with lesions in the orbitofrontal cortex and amygdala (Stone et al., 1998; Stone, Baron-Cohen, Young, Calder, & Green, 1999). Amodio and Frith (2006) proposed that the MFC is important for monitoring action, person perception, inferences about others' thoughts, and outcomes related to punishments and rewards. Krueger, Barbey, and Grafman (2009) proposed the structural and temporal representation binding theory, which delineates the special role of the MFC in mediating social event knowledge via structural and temporal binding processes with that in the posterior cerebral cortex and the limbic structures. Critchley et al. (2003) theorized that the MFC is important for integrating interoceptive, cognitive, and motivational states, thereby representing or producing changes in visceral sensations that are present in affective states.

In contrast to the MFC, the lateral FC (LFC) is responsible for non-emotion-related cognitive processes. The literature suggests that the LFC is a key neural substrate of cognitive control for inhibiting a prepotent behavior (Huettel & McCarthy, 2004), selecting a novel behavior (Ranganath & Rainer, 2003), and selecting a response option when competition exists between more than one (Frith, 2000; Robinson, Blair, & Cipolotti, 1998). In clinical studies, damage to the LFC is associated with impaired selection of plans for behavior. Such patients are unable to choose between possible alternatives, preferring well-practiced behaviors regardless of context (Lhermitte, 1986; Mesulam, 2002).

Shamay-Tsoory, Tibi-Elhanany, and Aharon-Perertz (2006) examined patients with MFC damage and observed impairment in tasks requiring affective mentalizing, particularly in reasoning about affective irony and lie conditions involving more contextually embedded mindreading, but not other cognitive theory-of-mind tasks. Following this line of thinking, people with MFC damage should be more impaired in the affective (i.e. understanding mental states) than the cognitive (i.e. identifying a social faux pas) aspects of a faux pas test. Hence, we employed a lesion study methodology, the essence of which is the establishment of testable relationships between brain regions and behaviors (Damasio & Damasio, 1989), to examine the nature of faux pas deficits experienced by people with frontal lesions. We first classified patients with frontal lesions into two groups: one group with lesions in the LFC and the other group with lesions in the MFC. We hypothesized that people with MFC lesions would perform significantly worse than those with LFC lesions, in accordance with the literature on the neural correlates of performing a faux pas test. We then examined scores on each of the faux pas questions to identify the neural correlates of mentalizing, as well as the nature of the faux pas deficits presented by people in the MFC group. We hypothesized that impaired performance on the faux pas test would be related to the understanding of mental states but not to the identification of a faux pas.

2. Methods

2.1. Participants

The participants included a total of 56 right-handed Chinese individuals from Hefei in the Anhui Province of China. Among them were 26 patients of Anhui Medical University who had acquired localized, well-defined brain lesions caused by surgical removal of brain tumors. Their premorbid general intellectual functioning was within average limits as estimated by their premorbid vocational achievement (all participants were engaging in stable full-time competitive employment). Learning disabilities were screened by a neuropsychologist. Potential participants diagnosed of such disabilities were excluded from participation in this study. Developmental history and premorbid social conduct were normal as reported by their respective caregivers. In addition, they had no premorbid history of medical and/or psychiatric illnesses affecting cognitive functioning. The 30 neurologically healthy controls, who had no history of medical conditions affecting cognitive functioning, were recruited from the Hefei community. We matched the clinical and control groups in terms of years of education, general cognitive functioning as measured by the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), and mood state as measured by the Hamilton Depression Scale (HAMD; Hamilton, 1960). The study was approved by the Research Ethics Committee of Anhui Medical University. All participants gave their informed consent to take part in the study according to the Declaration of Helsinki. In addition, for the patients, consent was also obtained from their caregivers.