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# Interpretation of mentalistic actions and sarcastic remarks: Effects of frontal and posterior lesions on mentalising

Shelley Channon [a,*], Andrea Rule [a], David Maudgil [b], Marina Martinos [a], Asa Pellijeff [a], Jessica Frankl [a], Helena Drury [a], Colin Shieff [c]

[a] *Department of Psychology, University College London, Gower Street, London WC1E 6BT, UK*
[b] *Department of Radiology, Heatherwood and Wexham Park Hospitals NHS Trust, UK*
[c] *Department of Neurosurgery, Royal Free Hospital, UK*

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**Abstract**

Recent work has linked mentalising ability to ventromedial frontal brain regions, the temporal poles and the temporo-parietal junction. The present study set out to examine the performance of participants with focal frontal and posterior lesions and a matched healthy control group on mentalising tasks with different types of pragmatic materials. Four types of materials were used: control physical events, human actions, and direct and indirect sarcastic remarks. Ability to interpret these was tested by asking participants both to explain the events, actions or remarks, and then to choose the best solution from four alternatives presented. Those with frontal lesions were impaired in comprehension of each of the sets of mentalistic materials, but were intact in comprehension of the control non-mentalistic items. There was some evidence linking the generation of free responses for the mentalistic materials to lateral frontal regions; this may be mediated by executive skills. There was also evidence linking selection amongst alternative solutions to right frontal regions, particularly ventromedial areas. There was little evidence that posterior regions played any significant part, at least for the present mentalistic materials. Errors in sarcasm comprehension made by participants with frontal lesions revealed that these were not always literal in nature, suggesting two separable components in comprehension: appreciating that a meaning is not intended literally, and understanding the specific meaning in the social context.


*Keywords:* Social cognition; Theory of mind; Mentalising; Sarcasm; Frontal lobes

## 1. Introduction

Making correct mentalistic inferences about people's beliefs and intentions from their words and actions in everyday settings depends upon the social context. Contextual cues convey information about the relevant pragmatic meaning of people's words and actions. Pragmatic communication typically involves non-literal meanings such as indirect requests, humour, deception and sarcasm. Ability to interpret human actions and pragmatic language appropriately is fundamental to successful functioning in many aspects of everyday life, and is often disrupted after brain injury despite intact ability to process syntactic and semantic aspects of language.

Impaired processing of the pragmatic meaning of words and actions has been reported in a range of clinical populations. These include studies of those with right hemisphere lesions (e.g. Brownell, Simpson, Bihrle, Potter, & Gardner, 1990; Winner, Brownell, Happé, Blum, & Pincus, 1998), and more recently those with frontal lobe lesions and with traumatic brain injury (e.g. Channon & Crawford, 2000; Channon, Pellijeff, & Rule, 2005; Gregory et al., 2002; McDonald & Pearce, 1996; Pearce, McDonald, & Coltheart, 1998; Rowe, Bullock, Polkey, & Morris, 2001; Shamay, Tomer, & Aharon-Peretz, 2002; Shamay-Tsoory, Tomer, Berger, & Aharon-Peretz, 2003; Stuss, Gallup, & Alexander, 2001). Neurodevelopmental disorders, especially schizophrenia (e.g. Corcoran, Mercer, & Frith, 1995; Mitchley, Barber, Gray, Brooks, & Livingston, 1998) and autism (e.g. Dennis, Lazenby, & Lockyer, 2001; Ozonoff & Miller, 1996), have been associated with impaired processing of pragmatic materials. Impairments have also been

* Corresponding author. Tel.: +44 20 7679 1099; fax: +44 20 7679 1099.
*E-mail address:* S.Channon@ucl.ac.uk (S. Channon).

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described in fronto-temporal dementia (e.g. Lough, Gregory, & Hodges, 2001; Snowden et al., 2003).

The present study focuses in particular on the comprehension of sarcasm, a common and relatively complex form of pragmatic communication. The simplest type consists of what will be referred to here as 'direct sarcasm', involving reversal of the direct meaning. An example is given by Shamay-Tsoory, Tomer, and Aharon-Peretz (2005): 'Joe came to work, and instead of beginning to work, he sat down to rest. His boss noticed his behaviour and said "Joe, don't work too hard!"' *Questions*: 'Did Joe work hard?' 'Did the manager believe Joe was working hard?'. In real life usage, sarcastic remarks do not always have a direct, opposite meaning, but may have indirect meanings (i.e. different from, but not directly opposite to, the literal meaning), referred to here as "indirect sarcasm". It has been argued that comprehension of indirect sarcasm involves greater cognitive demands than direct sarcasm (Bosco et al., 2004), and there is some evidence that ability to process indirect sarcasm may develop later than ability to process direct sarcasm (e.g. Bosco & Bucciarelli, reported in Bosco et al., 2004). However, it is not clear whether the distinction between direct and indirect sarcasm affects processing in adults with focal brain damage after normal development, since previous studies have usually assessed only direct sarcasm. Channon et al. (2005) compared direct and indirect sarcasm, and found that the interpretation of both forms was impaired after traumatic brain injury in adults. This may reflect the diffuse effects of traumatic brain injury. The present study therefore investigated the comprehension of both direct and indirect sarcasm in adults with focal lesions.

Sarcasm comprehension has typically been assessed using yes/no questions or forced-choice responses (e.g. McDonald, Flanagan, Rollins, & Kinch, 2003; McDonald & Pearce, 1996; Shamay-Tsoory et al., 2005), providing a clear indication of whether sarcastic remarks are understood correctly, but casting no light on the nature of any errors. Early models of pragmatic language comprehension supposed that literal meanings were automatically processed, and that non-literal meanings could only then be accessed by detecting contradiction between the social context and the literal meaning of the remark (e.g. Grice, 1975). Later models have posited that literal meanings are not necessarily processed first, and that non-literal meanings may be accessed directly, depending upon the salience (e.g. Giora, 1999) and the richness of the social context (e.g. Gibbs, 2002). However, these models do not predict incorrect non-literal errors in processing sarcasm. Channon et al. (2005) showed that asking participants to generate explanations for sarcastic remarks revealed both literal and non-literal processing errors after traumatic brain injury. The present study also asked participants to explain the sarcastic remarks, in addition to selecting amongst alternatives. This permits differentiation between errors arising from failures to recognise non-literal meanings versus those arising from recognition of a non-literal meaning, but incorrect interpretation of the particular meaning. Selecting amongst alternatives permits the examination of ability to comprehend the materials without the executive demands of generating a response.

The type of contextual cues available may also influence processing, since some developmental evidence suggests that facial and bodily gestures may facilitate sarcasm comprehension more than verbal cues in younger children (Bosco et al., 2004). This may also influence processing in adults with acquired brain damage. For instance, Shamay-Tsoory et al.'s (2005) sarcasm task consisted of aurally-presented stories that were either neutral and spoken with neutral intonation, or sarcastic and spoken with sarcastic intonation. Aural presentation of the sarcastic materials thus provided two possible routes for interpretation: affective cues from voice intonation, and cognitive cues from the mismatch between the literal meaning of the remark and the story context. Reliance on nonverbal cues was avoided in the present study by presenting the materials in written form, so that the pragmatic meaning could only be derived from the story context.

Recent lesion studies of pragmatic materials, including sarcasm, have primarily implicated the frontal lobes as playing a key role in mentalising (e.g. Channon & Crawford, 2000; Gregory et al., 2002; McDonald & Pearce, 1996; Rowe et al., 2001; Shamay et al., 2002; Shamay-Tsoory et al., 2003; Stuss et al., 2001). Studies focusing on hemispheric differences rather than on anterior–posterior differences have emphasised the role played by the right hemisphere, although this may be linked predominantly to right frontal regions (see, e.g. McDonald, 1993, for a discussion). There is relatively little lesion evidence clarifying the role of different regions within the frontal lobes. Rowe et al. (2001) examined comprehension of lengthy mentalistic stories, and did not find a clear relationship with the side, site or size of participants' frontal lobe lesions. Stuss et al. (2001) found no relationship between lesion location and performance for a visual mentalising task, but did find greater impairment on a deception task in those with bilateral frontal lesions; correlational analysis suggested right ventromedial regions to be important. Shamay-Tsoory et al. (2003) reported that those with ventromedial but not dorsolateral frontal lesions were impaired in detecting faux pas, and a recent study of sarcasm comprehension implicated the right ventromedial region (Shamay-Tsoory et al., 2005). Bird, Castelli, Malik, Frith, and Hussain (2004) failed to find support for the role of medial frontal regions in a woman with extensive damage to bilateral medial frontal regions, with some sparing of lateral medial regions. Despite executive dysfunction she performed normally on a range of mentalising tasks, except that she showed mild difficulties in judging socially embarrassing situations and faux pas, suggesting possible disruption of affective processing. The postulated key role of ventromedial frontal regions in mentalising thus needs further evaluation.

In addition to the body of work implicating the frontal lobes in mentalising, several recent studies have ascribed a role in mentalising to the temporoparietal junction (TPJ) (see, e.g. Abu-Akel, 2003; Saxe & Kanwisher, 2003). Samson, Apperly, Chiavarino, and Humphreys (2004) described impairment in three cases with lesions involving the TPJ on a simple nonverbal false belief task, although the impairment tended to be mild. Apperly, Samson, Chiavarino, and Humphreys (2004) studied a larger mixed series, and reported that only the three cases with both left superior STS and angular gyrus (AG) involvement