

Cognitive empathy modulates the processing of pragmatic constraints during sentence comprehension

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Previous studies have shown that brain regions for mentalizing, including temporoparietal junction (TPJ) and medial prefrontal cortex (mPFC), are activated in understanding the nonliteral meaning of sentences. A different set of brain regions, including left inferior frontal gyrus (IFG), is activated for dealing with pragmatic incongruence. Here we demonstrate that individuals' cognitive empathic ability modulates the brain activity underlying the processing of pragmatic constraints during sentence comprehension. The *lian...dou...* construction in Chinese (similar to English *even*) normally describes an event of low expectedness; it also introduces a pragmatic scale against which the likelihood of an underspecified event can be inferred. By embedding neutral or highly likely events in the construction, we created underspecified and incongruent sentences and compared both with control sentences in which events of low expectedness were described. Imaging results showed that (i) left TPJ was activated for the underspecified sentences, and the activity in mPFC correlated with individuals' fantasizing ability and (ii) anterior cingulate cortex (ACC) was activated for the incongruent sentences, and the activity in bilateral IFG correlated with individuals' perspective taking ability. These findings suggest that brain activations in making pragmatic inference and in dealing with pragmatic failure are modulated by different components of cognitive empathy.

Keywords: cognitive empathy; pragmatic inference; sentence comprehension; fMRI; TPJ; ACC

INTRODUCTION

Pragmatic inference is a complex process that involves understanding the speaker's intended meaning beyond the literal words of a sentence. This process is heavily influenced by contextual information and the listener's cognitive and social abilities. One key aspect of pragmatic inference is the ability to understand nonliteral meanings, such as metaphors, idioms, and implicatures. This ability is often referred to as mentalizing or theory of mind. Previous research has shown that mentalizing is associated with specific brain regions, including the temporoparietal junction (TPJ) and the medial prefrontal cortex (mPFC). The TPJ is involved in understanding the mental states of others, while the mPFC is involved in understanding the speaker's intentions and emotions. In addition to mentalizing, pragmatic inference also involves dealing with pragmatic incongruence. Pragmatic incongruence occurs when the literal meaning of a sentence is inconsistent with the context or the speaker's intended meaning. This type of incongruence is often resolved through pragmatic inference. Research has shown that dealing with pragmatic incongruence is associated with a different set of brain regions, including the left inferior frontal gyrus (IFG) and the anterior cingulate cortex (ACC). The IFG is involved in language processing and the resolution of semantic anomalies, while the ACC is involved in monitoring for conflicts and errors. In this study, we investigate how cognitive empathy modulates the processing of pragmatic constraints during sentence comprehension. Cognitive empathy is the ability to understand and share the feelings of others. It is a complex skill that involves both cognitive and emotional components. We hypothesized that individuals with higher cognitive empathy would show different brain activation patterns when processing pragmatic constraints. Specifically, we expected that higher cognitive empathy would be associated with increased activation in the TPJ and mPFC when processing underspecified sentences, and increased activation in the ACC and bilateral IFG when processing incongruent sentences. To test these hypotheses, we created a series of sentences that were either underspecified or incongruent. Underspecified sentences used the *lian...dou...* construction in Chinese, which is similar to the English *even* construction. Incongruent sentences used the *lian...dou...* construction to describe events that were highly likely or neutral. We used functional magnetic resonance imaging (fMRI) to measure brain activity during sentence comprehension. The results showed that the left TPJ was activated for underspecified sentences, and the activity in the mPFC correlated with individuals' fantasizing ability. The ACC was activated for incongruent sentences, and the activity in the bilateral IFG correlated with individuals' perspective taking ability. These findings suggest that brain activations in making pragmatic inference and in dealing with pragmatic failure are modulated by different components of cognitive empathy.

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$f P < 0.001$ - $f > 100$

Regions of interest analysis

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Table 2

	Region	Cluster size (voxels)	Peak T value	Coordinates (mm)		
				X	Y	Z
Condition 1	BA32	10	5.2	-48	-12	38
	BA22	15	4.8	-45	-15	35
Condition 2	BA32	12	5.5	-50	-10	40
	BA22	18	5.1	-47	-13	37
Condition 3	BA32	14	5.3	-49	-11	39
	BA22	16	4.9	-46	-14	36

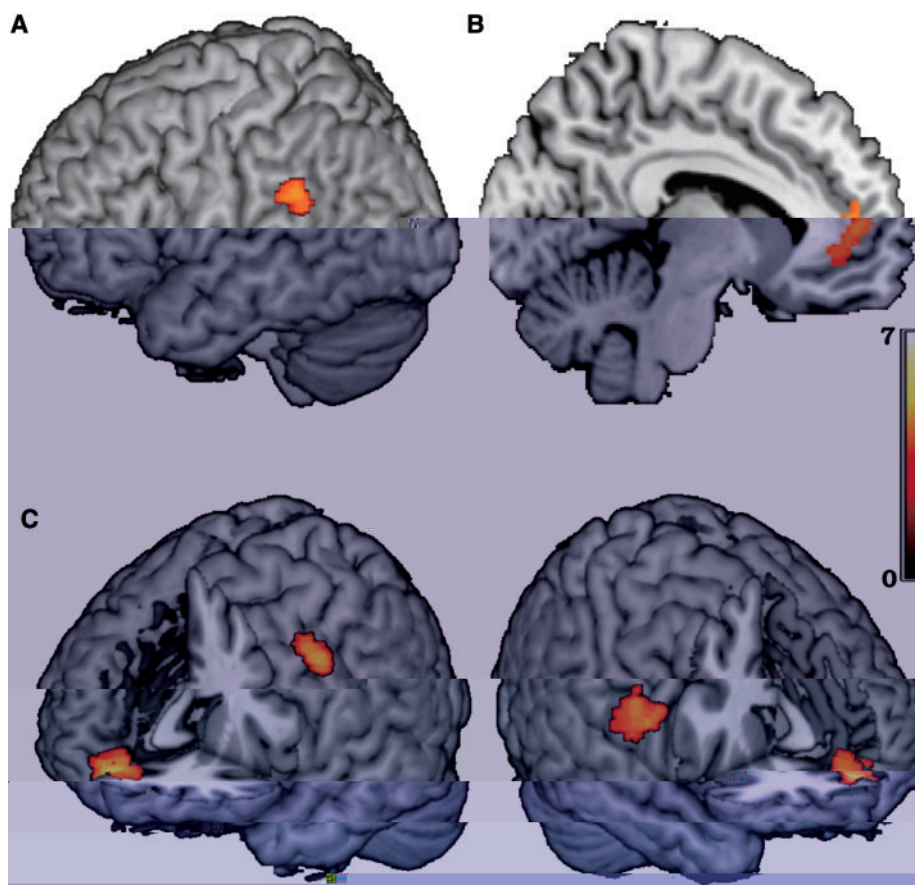


Fig. 1. Brain surface maps showing activation clusters in four views: (A) lateral left, (B) medial left, (C) lateral right, and (D) medial right. The color scale on the right indicates T-values from 0 to 7.

ROI analysis

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