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14 Why Not Say It Directly? Neural Basis of Indirect Speech Comprehension

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1. Introduction

Indirect speech is an utterance in which a speaker says something they do not mean literally. In most cases of indirect speech, speakers veil their requests and opinions, masking their real feelings.
Consider the following exchange:
Mary has been on a diet for a long time, and asks Peter "Did I lose weight?" Peter responds "You are still fat." Such a negative answer to Mary's question would be likely to cause Mary disappointment, and create an awkward situation. On the other hand, if Peter responded "It's difficult to lose weight", this indirect reply would convey an expression of sympathy for Mary, and would not be likely to cause a socially uncomfortable situation. Utterances can induce various feelings in others, and the use of indirect speech often improves cooperative relationships in daily communication.

Pinker, Nowak, and Lee (2008) recently proposed a three-part theory of indirect speech using game theory, social psychology, and evolutionary psychology. Based on the cooperative principle of conversation (Grice, 1975), and the politeness theory of Brown and Levinson (1987), Pinker and colleagues proposed that indirect speech allows for plausible deniability, which can permit a cooperative listener to accept a request, while recognizing that an uncooperative listener is less likely to react negatively to an ambiguous, indirect suggestion. In cases of plausible deniability, a negative message can thus be conveyed without losing face, making indirect speech an important face-saving device in everyday communication.

We recently conducted a study to compare the neural activity induced by indirect speech and literal sentence using functional magnetic resonance imaging (fMRI; Shibata et al. *in press*). The results revealed that that indirect speech comprehension increased activation in the medial prefrontal cortex (MPFC), which is associated with mentalizing processes, and the bilateral inferior frontal gyri (IFG), which are associated with the detection of non-literal or indirect meaning compared to literal sentence comprehension. These findings indicated that the cognitive processes underlying indirect speech comprehension are more complex processes in our communication than those involved in literal sentence comprehension. Although we have been reported the cognitive processes underlying indirect speech comprehension, the mechanism how the emotional state induced by these utterances affects these comprehension process is unknown. To address this question, we examined the neural substrates involved in evaluating the emotional effects of indirect speech utterances and literal sentences using functional MRI.

2. Methods

2.1. Participants

Fourteen graduate and undergraduate students (11 females and three males; mean age = 23.5 years; range: 21–32) participated in this experiment. None of the participants had a history of mental disorders, and all were right-handed native Japanese speakers. The experiment was approved by the Ethics Committee of Keio University. All participants gave written informed consent prior to participation.

2.2. Design and materials

Two factors were manipulated in this experimental design: Sentence Type (Indirect speech vs. Literal Sentence) and Emotion Type (negative vs. positive) in a 2×2 within-subjects design (see Table 1). Each scenario consisted of three sentences. The first sentence explained the situation of the protago-

Table 1. Example senario

	Indirect speech	Literal sentence
Negative	You got a job in first-rate company, but have become depressed by the overtime involved. You ask your friend, "Should I quit and change jobs?"	You began searching for a job, but couldn't decide what type of job to apply for. You asked your elders for advice, "Should I take the civil service exam?"
	Target sentence: "There is a job shortage due to the recession."	**Target sentence:** "That's impossible for you at the moment."
Positive	You got a job after a long time trying, but became depressed because of the monotonous tasks involved. You ask your friend "Should I quit and change jobs?"	You were seeking a job, but failed an employment exam. You asked your elders for advice, "Should I take a certification exam?"
	Target sentence: "It's possible that the economy will improve."	**Target sentence:** "That's a good idea!"

nists. In the second sentence, one protagonist asked a question of the other protagonist, who replied in the third sentence (the target sentence). Participants were instructed to place themselves into the role of the first protagonist. The third sentence had either an indirect (positive/negative) or literal (positive/negative) meaning (see Table 1). In the indirect speech scenarios, the reply violated Grice's (1975) relevance maxim (*e.g. "Did I lose weight?"-"It's difficult to lose weight"*). In the literal scenarios, the context of the scenario supported a literal reading of the reply (*e.g. "Did I lose weight?"-"You are still fat."*).

2.3. Procedures

The MRI scanning phase consisted of two sessions (288 functional image volumes per session). The trials were ordered pseudo-randomly. Participants were instructed to place themselves into the role of a protagonist asking another protagonist a question. They were instructed to think about the emotional valence associated with the other protagonist's response, and to rate their resulting subjective feelings in terms of emotional valence with a button press, ("How unpleasant/pleasant does this utterance make you feel?": 1-highly pleasant, 2-more pleasant, 3-neutral, 4-more unpleasant, 5-highly unpleasant; VALENCE task). Each stimulus was displayed at the center of a rear-projection screen. Participants viewed the screen through a mirror system mounted on the head coil. Each participant was tested individually, and reaction times and judgments were recorded. The first two sentences were presented for 8 s, and were immediately followed by the presentation of a fixation cross for 2 s. The final sentence was presented for 6 s and was immediately followed by the presentation of a fixation cross for 6 s. The presentation of the stimuli and recording of participants' responses were controlled with E-prime (Psychology Software Tools, Inc.).

2.4. fMRI data acquisition and analysis

A Siemens Trio on 3-T scanner was used to acquire high-resolution T1-weighted anatomical images and gradient-echo EPIs with blood oxygenation level-dependent (BOLD) contrast of 44 axial slices. The parameters of the sequence were as follows: repetition time (TR) = 2.35 s, echo time (TE) = 30 ms, flip angle = 90°, slice thickness = 2 mm, and slice gap = 1 mm. A total of 576 scans were acquired per participant (288 volumes × 2 sessions). The data were analyzed with SPM8 (http://www.fil.ion.ucl.ac.uk/spm).

3. Results

3.1. Behavioral results

Table 2 shows the mean reaction time and mean rating score in each condition. A one-way analysis of variance (ANOVA) revealed a significant main effect of reaction time ($F(3, 59) = 33.34$, $p < .0001$), and Tukey-Kramer *post hoc* tests revealed significant differences in reaction time among the four types of sentences ($HSD(3) = 2.65$, $p < .05$). The mean reaction time for the indirect speech condition was significantly longer than that in the literal sentence condition (Table 2).

Table 2. Behavioral Data

	Indirect speech		Literal sentence	
	Negative	Positive	Negative	Positive
Rating				
Mean	0.97	1.05	1.32	1.36
SD	0.65	0.76	0.59	0.56
Reaction times (msec)				
Mean	3385.4	3072.1	2968.0	2525.6
SD	1054.6	1181.2	1023.4	836.5

3.2. Imaging results

We conducted an ANOVA to test the main effects of the two factors and any interaction effects. The analysis revealed a significant main effect of Sentence Type in the bilateral IFG (BA 45/47), superior frontal gyrus (SFG: BA 8/9), middle temporal gyrus (MTG: BA 21), right MPFC (BA 10), the thalamus, and the supramarginal gyrus (Table 3 and Figure 1). In addition, we

Table 3. Brain regions showing significant BOLD signal increases during each factors.

Region of activation	Left/Right	Brodmann area	Cluster size	*F* value	MNI cordinates		
					X	Y	Z
Indirect speech vs. Literal sentences							
Inferior Frontal	L	47	27	14.37	-48	30	-10
Inferior Frontal	R	47	12	15.10	48	36	-12
Medial Frontal	R	10	20	15.17	4	70	14
Superior Frontal	R	9	17	14.06	26	34	34
Middle Temporal	L	21	83	23.14	-50	4	-26
Middle Temporal	R	21	26	17.57	54	0	-18
Supramarginal	L	40		16.97	-60	-54	24
Thalamus	R			14.74	6	-28	-6
Negative utterance vs. Positive utterance							
Precentral	L	4	2299	169.02	-38	-26	58
Precentral	R	4	2344	145.08	36	-22	58
Medial Frontal	L	6	176	22.60	-10	-22	56
Medial Frontal	R	6	72	20.42	12	-16	54
Inferior Occipital	L	18	129	17.37	-28	-92	-10
Inferior Occipital	R	18	160	19.48	30	-86	-14
Lingual	L	18	1775	72.82	-12	-78	4
Postcentral	L	3	53	17.34	-50	-20	20
Putamen	L		334	56.62	-32	-12	0
Putamen	R		16	13.43	32	-10	-2
Insula	L	13	181	30.42	54	24	0
Insula	R	13	25	19.42	-40	0	18
Thalamus	L		219	26.52	16	-18	0
Anterior Cingulate	R	32	22	18.26	10	48	-8

This table presents the results of the 2nd level random effects group analysis. The Voxel F-values represent thevalue for local maxima at p < .001 (uncorrected). The cluster size refers to the total number of voxels includedin the cluster (minimum of 10 voxels).

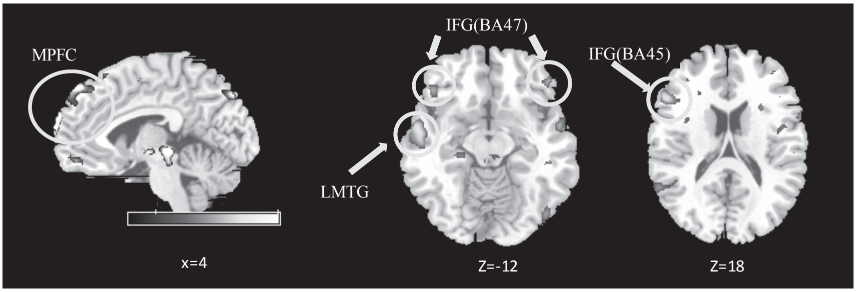

Figure 1. fMRI results for the main effect of Sentence Type. A random-effects analysis was performed (p < .001,uncorrected).

found a significant main effect of Emotion Type in the bilateral precentral, MPFC, the inferior occipital gyri (IOG: BA 18), the putamen, the insula, left lingual gyrus (BA 18), postcentral gyrus, the thalamus and right anterior cingulate cortex (ACC: BA32) ($p < .001$, uncorrected, Table 3).

3.3. Parametric modulation analysis

A parametric modulation analysis was performed to investigate the correlation between rating value and the amplitude of cortical activation. The results of the parametric modulation analysis revealed a significant positive correlation between rating value and the amplitude of the cortical responses in the indirect speech (positive utterance) and literal sentence (negative utterance) conditions. Specifically, in the literal sentence (negative utterance) condition, a significant correlation ($p < .005$, uncorrected) was observed with activity in the bilateral IFG (BA 45), middle frontal gyrus (MFG: BA 6/9, 46), IOG (BA 18/19), putamen, the left STG (BA 39), lingual gyrus (BA 17), precuneus, insula, amygdala, right thalamus and ACC (Table 4).

Table 4. Brain regions showing significant BOLD signal increases relating to rating of emotional valence.

Region of activation	Left/Right	Brodmann area	Cluster size	T value	MNI cordinates		
					X	Y	Z
Indirect speech (Positive utterance)							
Anterior Cingulate	L	32	449	3.60	-2	44	-6
Anterior Cingulate	R	32	25	3.04	10	24	-6
Literal sentence (Negative utterance)							
Inferior Frontal	L	45	197	3.59	-42	18	16
Inferior Frontal	R	45	18	3.11	60	22	20
Middle Frontal	L	6/9	164	3.73	-34	22	30
Middle Frontal	R	46	20	3.07	38	28	20
Superior Temporal	L	22	18	3.24	-66	-22	2
Inferior Occipital	L	18	112	3.20	-34	-88	-16
Inferior Occipital	R	19	133	3.27	26	-90	4
Lingual	L	17	49	3.15	-18	-88	0
Precuneus	L		82	3.36	-12	-56	36
Putamen	L		88	4.01	-16	4	-8
Putamen	R		34	3.07	26	10	-4
Insula	L	13	278	3.49	-38	-8	26
Amygdala	L		12	3.04	-30	0	-28
Thalamus	R		78	3.23	12	-22	4
Anterior Cingulate	R	24	19	3.21	2	32	8

The T values in the parametoric analyses with rating of emotional valence are shown (p < .005, uncorrected).The cluster size refers to the total number of voxels included in the cluster (minimum of 10 voxels).

4. Discussion

The current results revealed significantly greater activation for indirect speech comprehension than literal sentence comprehension in bilateral IFG (BA 45/47), SFG (BA 8/9), MTG (BA 21), right MPFC (BA 10), thalamus, and supramarginal gyrus. These findings are similar to the results of our previous study (Shibata et al. *in press*), lending further support to the notion that the right and left fronto-temporal networks play a crucial role in detecting contextual violations, whereas the MPFC is important for generating inferences to make sense of remarks within a context.

In the main effect of Emotional Type (negative vs. positive) the activation we observed in motor areas is likely to be associated with pressing the button. On the other hand, the activation associated with emotional processing areas appeared to have been induced by negative utterances. In addition, we investigated the modulation of neural activity by rating value using a correlation analysis ($p < .005$, uncorrected, $k > 10$) examining subjective ratings of emotional feelings from individual subjects as regressors. Significant positive correlations between BOLD activation and rating values in the negative literal sentence condition were observed in the bilateral IFG (BA 45), MFG (BA 6/9, 46), IOG (BA 18/19), putamen, left STG (BA 39), lingual gyrus (BA 17), precuneus, insula, amygdala, right thalamus and ACC (BA24). These findings indicate that direct negative utterances strongly induce negative emotion in the hearer, and activate these brain regions involved in emotional processing.

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