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10 What is the Difference between Metaphor and Simile? -fMRI Study-

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I. Introduction

A metaphor is a figurative statement expressed by means of a copula sentence (An X is a Y), whereas a simile is a figurative statement using a hedge word such as "like" or "as" (An X is like a Y). With these explicit remarks, simile is literally true assertion. Though metaphor and simile use different sentence patterns, it has traditionally been considered that they express almost the same figurative meaning and that a metaphor can be paraphrased as a simile. Aristotle stated in Rhetoric, "The Simile is also a metaphor, the difference is but slight". According to his theory, metaphors are abbreviated similes. For example, "My lawyer is a shark" is an abbreviation of "My lawyer is like a shark".

In contrast, recent psycholinguistic models have suggested that metaphors are not abbreviated similes and that human understanding of the two figures of speech may rely on different comprehension processes. The class-inclusion model (Glucksberg & Keysar, 1990; Glucksberg, 2003) argues that simile can be understood as a process of comparison involving explicit remarks, while metaphor can be understood as a categorization process. In the sentence "My lawyer is like a shark", "shark" refers to the marine creature, whereas in the sentence "My lawyer is a shark", "shark" does not refer to the literal creature. In the latter case, the lawyer is categorized as a predator, and the shark is used to represent predators. Thus, the class-inclusion model argues that the comprehension processes used in understanding metaphor and simile differ.

Here, we focus on the sentence patterns of metaphor and simile. Metaphor is expressed by means of a copula sentence, whereas a simile is expressed using a hedge word such as "like" or "as". Usually, a copula sentence expresses a class inclusion relation ("the dog is a mammal") or an attribute relation ("Socrates is wise"). In some instances, we can understand the meaning of a copula sentence, while in other instances we cannot. Even if we can understand the meaning, there are two cases. One is a case that we can understand literally ("the dog is a mammal"); another is the case that we can understand figuratively ("My lawyer is a shark"). The latter case is a metaphor. Thus, a copula sentence is understood as a metaphor only in specific cases. Further, how do copula sentences differ from simile sentences? These two sentences differ in sentence pattern. As with copula sentences, when we are presented with a simile sentence, in some cases we can understand the meaning ("An education is like stairs"), while in other cases we cannot ("Time is like a strawberry"). Considering the relationships between copula sentences, metaphors and similes, we can classify sentence patterns that use these figures of speech into five types (literal sentence, metaphor, simile, anomalous sentence and anomalous simile). In this study, we investigated cortical activation patterns using five types of experimental sentences, and evaluated whether or not differences exist in the comprehension processes used in understanding metaphor and simile.

II. Methods

1. Participants

Twelve healthy graduate and undergraduate students (eight men and four women; mean age 23.8 years, range 21–29 years) participated in this experiment. The participants were all native Japanese speakers. Handedness was assessed by the Edinburgh Handedness Survey (Oldfield, 1971) and all participants were found to be right-handed.

2. Design and materials

The experimental design included five conditions of sentence type (literal, metaphor, simile, anomalous simile, and anomalous sentence). The materials consisted of 20 literal sentences (e.g., “A dolphin is an animal.”), 20 metaphor sentences (e.g., “Memory is a warehouse.”), 20 simile materials (e.g., “An education is like stairs.”), 20 anomalous sentences (e.g., “Scissors are dogs.”) and 20 anomalous simile sentences (e.g., “Time is like a strawberry.”).

3. Procedures

The fMRI scanning phase consisted of two sessions (120 functional image volumes per session with 4 initial volumes to avoid transient non-saturation effects) with 50 sentences (10 literal sentences, 10 metaphor sentences, 10 simile sentences, 10 anomalous sentences and 10 anomalous simile sentences) per session. The trials were pseudo-randomly ordered. Each stimulus sentence was displayed at the center of a rear projection screen for 3 s and was immediately followed by the presentation of a cross-hair that varied between 3 s and 5 s (on average, 4 s). The participants were asked to read each sentence carefully in order to understand the content of the sentences and to press one of two buttons with their left index finger if they understood the meaning of the sentence and with their middle finger if they did not, regardless of whether the meaning was literal or metaphorical. The participants literally determined the meaning of the literal sentence and metaphorically determined the meaning of the metaphor and simile sentences.

4. fMRI data acquisition and analysis

A whole-body 1.5 T Signa Echo-Speed scanner (General Electric, Inc.) was used to acquire high-resolution T1-weighted anatomical images and gradient echo echo-planar T2*-weighted images with blood oxygenation level-dependent (BOLD) contrast of 20 axial slices. The parameters of the sequence were set as follows: TR = 3000 ms, TE = 40 ms, Flip angle = 90°, FOV = 240 x 240 mm, Matrix = 64 x 64, slice thickness = 4 mm, slice gap = 0.8 mm. The data were analyzed by SPM5.

III. Results

1. Behavioral results

The mean reaction times for each type of sentence were 1225.6 ms for the literal sentence condition, 1918.6 ms for the metaphor sentence condition, 1733.4 ms for the simile sentence condition, 1545.4 ms for the anomalous sentence condition, and 1697.2 ms for the anomalous simile sentence condition. A one-way ANOVA correlating the reaction time to the sentence type revealed a significant main effect (F (4, 99) = 69.40, $p < .0001$). Tukey-Kramer post-hoc tests yielded significant differences in the reaction times among the five types of sentences (HSD (4) = 2.73, $p < .01$). The mean reaction time for metaphor sentences was significantly longer than those for simile, literal and anomalous sentences.

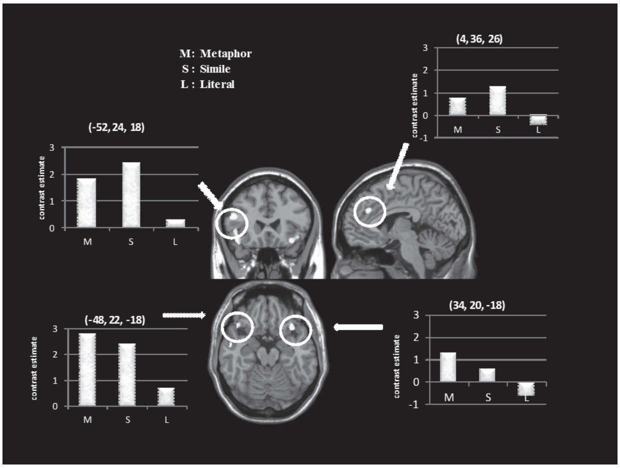
2. Imaging results

In the metaphor sentence condition minus the literal sentence condition, this contrast revealed higher activation in the right IFG (BA 47), left STG (BA 22), and left MTG (BA 21). We also analyzed the differences between the simile sentence condition and the literal sentence condition. In the simile sentence condition minus the literal sentence condition, this contrast revealed higher activation in the bilateral IFG (BA 45/47), left MPFC (BA 9), left STG (BA 38), and left PHG. In the metaphor sentence condition minus the simile sentence condition, this contrast revealed higher activation in the right IFG (BA 47), MPFC (BA 9), and middle frontal gyrus (BA 6). In the simile sentence condition minus the metaphor sentence condition, this contrast revealed higher activation in the left MPFC (BA 10), left superior frontal gyrus (BA 9/10), right STG (BA 22/42), right precentral, and right postcentral (Table 1). We delineated the regions activated during both metaphor and simile sentence conditions relative to the literal sentence condition (M+S–2L). This contrast revealed higher activation in the bilateral IFG (BA 45/47), the left MTG, STG, and the right anterior cingulate cortex (ACC). Especially, metaphor and simile sentences induced the greater activation in the left IFG (BA 45/47) than literal sentence ($p < .001$, uncorrected, extent threshold of 10 voxels) (Figure 1, and Table 1).

Table 1
Cerebral regions showing significant BOLD signal increases of the metaphor sentence condition versus the literal sentence condition, the simile sentence condition versus the literal sentence condition, metaphor sentence condition versus simile sentence condition, and the opposite contrast. Brain regions activated during both the metaphor and simile conditions versus literal sentence condition (Meaphor + Simile - 2 Literal sentence).

Region of activation	Left/Right	Brodmann area	Cluster size	MNI cordinates			Z value
				X	Y	Z	
Metaphor sentence condition>Literal sentence condition							
Inferior Frontal	R	47	17	34	20	-18	3.59
Middle Temporal	L	21	22	-54	-4	-20	3.59
Superior Temporal	L	22	18	-62	-26	0	3.92
Simile sentence condition>Literal sentence condition							
Inferior Frontal	R	47	23	30	28	-16	4.40
Inferior Frontal	L	45	60	-44	24	-20	3.19
Medial Frontal	L	9	29	-16	36	22	3.90
Superior Temporal	L	38	60	-48	18	-12	4.06
Parahippocampal	L	28	29	-14	-14	-12	4.19
Metaphor sentence condition>Simile sentence condition							
Inferior Frontal	R	47	19	40	38	-8	3.57
Medial Frontal	R	9	31	22	36	30	4.51
Middle Frontal	R	6	13	30	2	40	3.61
Simile sentence condition>Metaphor sentence condition							
Medial Frontal	L	10	14	-8	64	14	3.50
Superior Frontal	L	9/10	11	-6	52	26	3.44
Superior Temporal	R	22/42	57	62	-26	8	3.78
Precentral	R	6	18	30	-24	68	3.36
Postcentral	R	43		56	-20	16	3.40
Meaphor + Simile - 2 Literal sentence							
Inferior Frontal	L	45	78	-52	24	18	4.09
Inferior Frontal	L	47		-48	20	-8	3.41
	R	47	50	34	20	-18	3.97
Middle Temporal	L	22	10	-54	-38	4	3.21
Superior Temporal	L	38	63	-48	22	-18	3.59
Anterior Cingulate	R	32	31	4	36	26	3.61

p < .001, uncorrected



IV. Discussion

1. The sentence pattern or the properties of words?

The imaging results showed that when subjects were tested using metaphor and simile sentences, activation was seen in the left IFG (BA 45/47) (Table 1 and Figure 1). Previous neuroimaging studies (Ahrens et al., 2007; Eviatar & Just, 2006; Kircher et al. 2007; Rapp et al., 2004; Stringaris et al., 2007) indicated that novel metaphor comprehension induced activation in the left IFG. Rapp et al. (2004), Kircher et al. (2007) and Stringaris et al. (2007) used simple novel sentences similar to our stimuli, and showed similar activation patterns in the left IFG. Based on previous and present results, activation in the left IFG may play a key role in the processes of metaphor and simile comprehension.

Here, we recount our imaging results and experimental materials. In this study, we selected the materials based on these mean comprehensibility ratings (metaphor: 6.70, SD = 1.11, simile: 6.73, SD = 1.02, literal: 8.95, SD = 1.60, anomalous: 1.22, SD = 1.11, anomalous similes: 1.21, SD = 1.02). There were obviously qualitative differences among the three sentence types (metaphor/simile, literal, and anomalous/anomalous simile). The degree of the comprehensibility might affect activation patterns. In the metaphor and simile sentence condition, sentences do not literally express a class inclusion relation or an attribute relation as well as in the anomalous and anomalous simile sentence condition. To understand the meanings of these sentences, semantic processes such as detection of semantic deviation are needed (Hagoort, Hald, Bastiaansen, & Petersson, 2004; Ni et al., 2000). On the basis of the previous studies, our results suggest that semantic processing is related to the left IFG activation.

2. Does simile comprehension differ from metaphor comprehension?

To examine activation patterns under metaphor and simile sentence conditions more closely, we delineated the regions activated during both metaphor and simile sentence conditions relative to the literal sentence condition (M+S–2L), and condition-specific parameter estimates (Figure 1 and Table 1). This contrast revealed higher activation in the bilateral IFG (BA 45/47), left MTG, STG, and ACC. This also showed that similes elicit more activation in fronto-medial regions, whereas metaphors induce more right-sided prefrontal activation (Table 1). Several neuroimaging studies have indicated that the medial frontal region is important for coherence processes in language comprehension and for coherence building (Goel et al., 1997; Ferstl & von Cramon 2002; Zysset et al., 2002). Thus, activation in the medial frontal region in the simile sentence condition might reflected the inference process necessary to establish semantic coherence.

The contrast of both metaphor and simile sentence conditions relative to the literal sentence condition (Figure 1) also indicated that metaphors elicit more activation in the right IFG than do similes. Relating to the activation of RH in the metaphor sentence condition, previous studies have indicated RH involvement in metaphor comprehension while searching for a wider range of semantic relationships, or for novel, non-salient metaphoric meanings (Mashal et al., 2005; Stringaris et al., 2006). On the other hand, two previous experiments performed in our laboratory (Shibata et al. 2007a,b) concluded that the metaphoricity judgment task elicited higher activation in the right IFG with metaphor sentences, compared with literal sentences, while a semantic judgment task did not elicit activation in RH. On the basis of these results, one possibility indicated that activation in the right IFG may be influenced by the difficulty level of the sentence patterns, since the extraction of features from topic and vehicle are involved.

In this study, we investigated the neural substrates involved in the comprehension of metaphor and simile, using the same materials as used in the study of Shibata et al. (2007a, b). Our result showed similar cortical activation patterns in the left IFG under metaphor and simile sentence conditions. On the other hand, condition-specific parameter estimates showed that similes elicit more activation in the medial frontal region and the right temporal regions which might be related to inference process, whereas metaphors elicit more RH prefrontal activation which might be affected by the difficulty level of the sentence patterns.

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