LANGUAGE AND LINGUISTICS 6.2:361-380, 2005
2005-0-006-002-000152-1

Vision- and Manipulation-based Signs in Taiwan Sign Language*

Yi-Hsuan Chiu[1], Jen-Chuen Hsieh[21], Wen-Jui Kuo[12],
Daisy L. Hung[1] and Ovid J. L. Tzeng[13]

[1]*National Yang-Ming University*
[2] *Taipei Veterans General Hospital*
[3]*Academia Sinica*

An fMRI experiment was conducted to investigate how iconic elements are represented in sign languages and how such representation affects the linkage between language and brain. Iconic signs are those that clearly resemble the actions, objects, or characteristics they represent. In Taiwan Sign Language (TSL), expressions involve two kinds of signs: vision-based signs and manipulation- based signs. It is proposed that these two kinds of signs impose different processing demands on the signers. In our experiment, deaf signers viewed line drawings and were asked to covertly produce the names of the pictures either in TSL or in Chinese. Brain activities were measured with an fMRI technique. Analyses of the neural images indicated that the neural systems involved in the production of TSL and Chinese words were remarkably similar, in that the dorsal visual route and perisylvian areas were important in processing both languages for our deaf participants. On the other hand, the neural substrates mediating the representation of objects and/or action took different dynamically distributed forms, depending on which sensory/perceptual channels were required to weight the input information for recognition. In addition, results also suggested that the characteristics of signs (i.e., vision-based vs. manipulation-based) correlated with functional arrangements (i.e., visual vs. motor pathway) of the cerebral cortex, indicating that the brain not only represents the structural knowledge of the linguistic categories (syntactic and/or the semantic categories), but also involves the dynamic processes which characterize the interaction between modality and conceptual representation.

Key words: sign language, Taiwan Sign Language, fMRI, iconicity, picture naming

1. Introduction

Sign languages are independent languages in the visual-gestural modality. Most of

* This study was supported by grants from the Taipei Veterans General Hospital (923721, 92348),

the time, signs are provided not only with arbitrary characteristics, but also with iconic properties. A great deal of effort has been made in research on the different phonological processes between spoken and signed languages. What seems to be lacking, however, is an understanding of the different iconic representations of sign languages. It has been shown that for deaf signers the semantic and iconic information of signs had little effect on short-term memory (Bellugi & Klima 1976, Poizner et al. 1981). However, the iconic properties of signs may play an important role for signers in long-term semantic memory. According to their manner of iconic representation, iconic elements of signs generally can be assigned to at least two types: vision-based signs and manipulation-based signs. This contrast offers us a key to understand how the iconic elements are represented in sign languages and how they are processed in the brain, as we show below.

1.1 Comparison between signed language and spoken language

Language processed in specific brain circuits may be organized either according to the tissue's sensitivity to sound and phonetic modality, or to the natural linguistic patterns encoded within it. Studies of natural sign languages can provide key insights into the neural organization for language. Sign language is an independent linguistic system in which formal organization properties are similar to spoken language, but in which phonology and articulation depend on visual and motor gesture systems.

According to Levelt (1989), the difference between signed languages and spoken languages should be especially understood in terms of their relations to the levels of phonology and articulator motor system. If the brain sites underlying the processing of the words and parts of words are specialized exclusively for sounds, then deaf people's processing of signs and parts of signs should engage cerebral tissue different from those classically linked to speech. Conversely, if the human brain processes sensitivity to aspects of the patterning of natural language, then the processing of specific levels of language organization, especially the levels of conceptualization, might engage circuits similar to those observed in hearing speakers.

National Science Council (912314B075069, 922314B075095), Ministry of Education (89BFA221401) of Taiwan, and Tzong Jwo Jang Educational Foundation. Special thanks to Mr. Chi-Cher Chou for MRI technical assistance, members of Chinese Deaf Association, and National Association of the Deaf in the Republic of China for participation in this study; and extra-special thanks to the two anonymous reviewers for their invaluable comments.

1.2 The brain organization for signed language processing

Evidence from studies of brain damage has well established that the left hemisphere has advantages in language processing and the right hemisphere has advantages in visuospatial processing. Further, researchers have used the property of signed language, which makes use of spatial location, motion of the hands, and configurations of the hands in encoding linguistic information, to demonstrate the nature of brain mechanisms. These data showed that signers with left hemisphere damage were impaired on tasks involving the use of visual spatial signals to encode lexical, morphological, and syntax information, but performed well on tasks involving the use of visual spatial signals to encode the spatial relationships. Data from signers with right hemisphere damage, on the other hand, showed the reverse pattern (see Klima et al. 1988, for example). This literature reveals that the neural representation of the human brain is constructed by the natural properties of the signals rather than by the surface modality.

Recent functional imaging studies of the brain have provided important clues of much dynamic and normal processes of cognitive operation. Evidence from sign language production neuroimaging studies suggest strongly left-hemisphere dominant patterns, while studies of comprehension tend to show more bilateral effects (Bavelier et al. 1998, Braun et al. 2001, Caplan 2000, Corina et al. 1998, Corina & McBurney 2001, Hickok et al. 1999, Levanen et al. 2001, Newman et al. 2002, Petitto et al. 2000).

However, in comprehension studies, the observed right-hemisphere activation could reflect dynamic information in the stimulus videos, such as facial expression, prosody, and nonlinguistic gestures (Hickok et al. 1998). In order to avoid these potential confounds, static pictures and words should be employed as stimuli. If the results still show a strong right-hemisphere involvement when deaf signers are confronted with such constrained linguistic stimuli, then we would be in a better position to make the claim that the right hemisphere is indispensable for sign language processing.

1.3 Dynamic representation within language

The visual-gestural modality of sign languages is a good tool with which to investigate the iconic properties of languages. Different iconic properties are expressed differently. Some representation properties of objects are universal to all languages and are little influenced by task demands, such as semantic categories (e.g., animate or man-made items). However, some are affected by content and language properties. It is not only the features of linguistic function, but also iconicity that may influence sign language processing.

Iconic signs are those that clearly resemble the action, object, or characteristic they represent. Take Taiwan Sign Language (TSL) as an example. According to the method of production, it includes two kinds of signs: vision-based signs and manipulation-based signs. The vision-based signs or perception-based signs represent the features of shapes or contours of target objects, such as the sign DOG. On the other hand, the manipulation-based signs or production-based signs represent the way to manipulate or interact with the target object, such as the sign HORSE (see Figure 1).

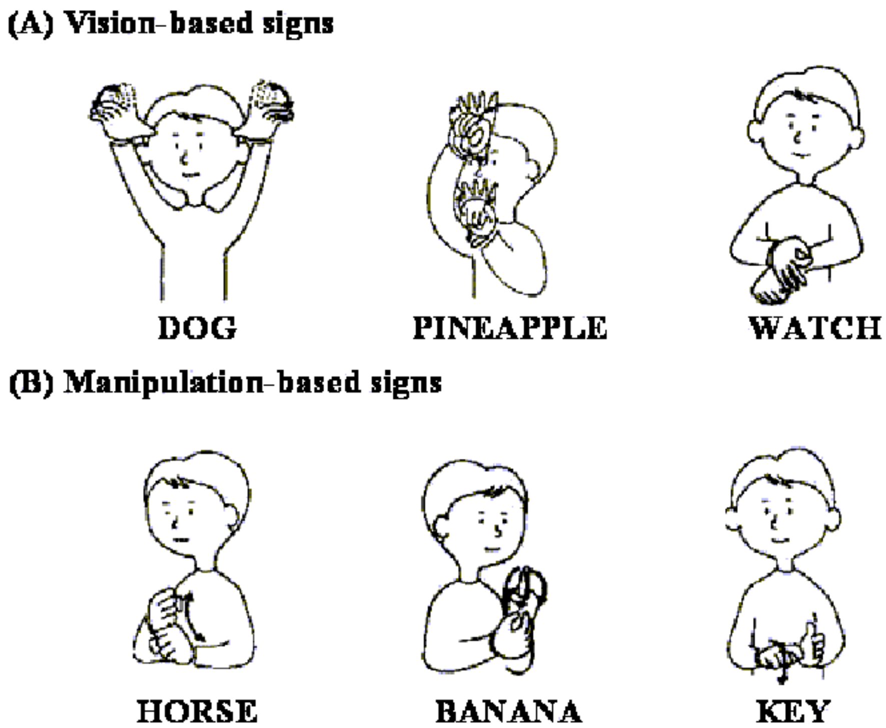

Figure 1: Examples of vision-based signs and manipulation-based signs in TSL. (A) The vision-based signs or perception-based signs represent the features of shapes or contours of target objects, such as the TSL signs for DOG, PINEAPPLE, and WATCH. (B) The manipulation-based signs or production-based signs represent the way to manipulate or interact with the target object, like the TSL signs for HORSE, BANANA, and KEY. (Illustrations from Smith & Ting 1979, 1984).

Both types of representation are iconic, relating to their meanings through physical resemblance, but these two representations capture physical features along different dimensions. They can be viewed as depicting the physical characteristics of a semantic concept from the perspective of either object resemblance or gestural manipulation. In a sense, they invite perceivers' attention to different aspects or perceptual modes.

Each of the two iconic types includes the same semantic categories, such as animals, fruits, and man-made items. Category specific recognition has been documented on numerous occasions in the neuropsychology literature. The knowledge about categories takes a distributed form in the brain, with particular forms of information weighted for the recognition of some but not other categories. However, if the acting out of representation also plays an important role, it would show different brain activation patterns between these two iconic types. While controlling the semantic categories in each condition, the main differences between vision-based and manipulation-based signs could arise from different ways of acting out these representations.

As background to the present experiment, we use phonological components in Taiwan Sign Language as basic analytical tools to examine the impact of these two different types of iconic representation on the underlying neuronal circuitry.

1.3.1 Hand configuration

Vision-based signs may be composed of almost any possible TSL handshapes. The main goal of a vision-based representation is to allow for the recognition of the features of shapes or contours of target objects, such as the sign DOG (Smith 1990, Smith & Ting 1979, 1984). The ease of perception is more important than the ease of articulation. Even though the handshape may not be easy to articulate, such as with the TSL sign GINGER, the handshape is contributive to recognition. That is why we also consider vision-based signs to be perception-based signs. Sign languages can thus create an image of the referent by focusing on the shapes of the articulators themselves and using them to encode images of similar shapes. This has been referred to as substitutive depiction, or shape-for-shape iconicity (Mandel 1977, Taub 2000). Alternatively, the signer's articulators trace out a path in space whose shape resembles the referent's shape. The cognitive strategy is to allow the perception of the shape of the path as a static whole rather than as a moving object. While using this strategy, there is no way to represent the referent's movement through space; the articulator's movement reflects static extent in space rather than movement of the referent over time. The movement is taken as atemporal motion (Mandel 1977). Shape-for-shape and path-for-shape iconicity may also combine in different ways.

Although the contours of the object may also be revealed by handshapes in the manipulation-based sign, the main purpose of a manipulation-based sign is to represent the way to manipulate or interact with the target object, thus revealing its function. The handshapes included in manipulation-based signs depend on ease of articulation, high frequency, or earlier acquisition. Take the TSL sign GLASS for example. The handshape of GLASS does match up with the contours of the glass, but the most important aspect is to exhibit how people hold the glass and thus indicate its container function. In another example, the TSL sign KITCHEN-KNIFE, the handshape reveals not only the cylindrical handle of the knife, but also how people use with the knife, combining both the visual object's configuration and the hand manipulation. The manipulation-based sign also provide some shape-for-shape iconicity, but little path-for-shape iconicity (Taub 2000).

1.3.2 Place of articulation

The location of vision-based signs can be used to indicate the main characteristics of the referents. A good illustration of a vision-based sign is the TSL sign ELEPHANT. The location of ELEPHANT is at the nose, reflecting the location of elephant's characteristically long trunk. Similarly, the location of the TSL sign DOG is at the sides of the head, showing the location of a dog's ears. In sign language, signer's body parts are assigned to represent human or nonhuman body parts based on similarity of shape, function, or higher-level structure between articulator and referent. This can be taken as body-for-body iconicity. If the signer's articulators trace out a path in space whose shape resembles the referent's shape, the location is used in the neutral signing space in front of the signer. The neutral signing space usually adds no meaningful element in a vision-based sign.

The same observation about neutral signing space applies to manipulation-based signs, but not the body-for-body iconicity. Here, the area occupied by the sign maps onto the area occupied by the referent in some mental space. The movements of articulators through various locations in signing space represent the movement of an entity through locations in some real or imagined space. In this situation, the neutral signing space could be assigned meaning, and the area through which the articulators move is usually mapped as part of an iconic landscape. For example, in the TSL sign KEY, the location of the sign is mentally represented at the height of the doorknob.

1.3.3 Movement

The sense of movement offers the key to understanding the difference between vision-based and manipulation-based signs. As mentioned earlier, in a manipulation-based sign, the movements of articulators through locations represent the movement of an entity through locations in some real or imagined space. The movement is intended as a cognitive assessment of greater veridicality, and so represents a "factive" motion (Talmy 1996, 2000). The motion path of the articulator is represented by the mental path, a form of path-for-path iconicity. To put it plainly, the movement of manipulation-based sign is temporally meaningful. By contrast, the movement of a vision-based sign is a kind of "fictive" motion (Talmy op.cit.). The representations of fictive motions are somehow objectively unreal. No matter whether it is shape-for-shape iconicity signs or path-for-shape signs, the movement reflects static extent in space rather than movement of the referent over time, and should be taken as atemporal motion (Talmy 1996, Taub 2001).

Both iconic representation types are motivated but not determined by the actual shapes, locations, or movements of the referents. The form-meaning connection is also constrained by the linguistic system. Take the TSL sign KITCHEN-KNIFE as an example again. The handshape of this sign reflects the cylindrical handle of the knife and the way people use the knife. Phonologically the sign involves a fully closed handshape (Ann 1992), yet when people actually hold a knife, the hand cannot fully close (because of the presence of the knife handle).

More noteworthy is that some entities in TSL can be represented in both a vision-based and manipulation-based way, such as alternative signs for "pineapple" (the vision-based variant is shown in Figure 1). We propose that the retrieval of signs for "pineapple" would be affected by the type of iconic representation. All the information about the signs would be stored in a distributed way. One of the representations would be triggered by the discourse content or environment, and would then mediate the neural processing.

By comparing the results of picture signing in TSL and picture naming in Chinese respectively, we hope to elucidate the convergent and divergent processes of deaf people's language processing when they communicate by sign and by writing. Further, the difference between sign iconic representations should provide a method for probing into the dynamic processes in semantic systems.

2. Method

2.1 Participants

Eight deaf people (three males and five females), fluent in Taiwan Sign Language and literate in written Mandarin Chinese, participated in the present study. The mean age of participants was 38.25 (from 25 to 55 years old). All participants acquired TSL before puberty as their first or prominent language, and had read Chinese since elementary school. Two participants were from deaf families. While using oral language, they were able to produce appropriate lip movements as fluently as hearing people but with nonstandard sounds or no sounds at all. All participants completed at least a senior high school education, and had normal or corrected-to-normal vision.

2.2 Experimental design and materials

Experimental variables included task (covert signing vs. covert naming, that is, forming mental phonological representations without overtly producing them) and sign type (vision-based vs. manipulation-based).

In order to categorize the iconic signs into vision-based and manipulation-based types, we invited three experts who were deaf and acquired TSL before puberty as their first or prominent language. Two of them taught TSL to hearing interpreters for 20 years, and one was a deaf native signer from a deaf family.

Two deaf sign teachers reported relevant experiences from teaching TSL. When they taught hearing non-signers to learn TSL, they would describe some signs by representing the features of shapes or contours of target objects, such as DOG, and some signs by representing the way to manipulate or interact with the target object, like HORSE. In the study, we defined these two iconic representations as vision-based and manipulation-based signs.

Before the experiments, we showed 520 pictures from the study of Bates et al. (2003) to the three TSL experts, and asked them to sign the picture names overtly. The pictures were obtained from various sources, primarily U.S. and British, including 174 pictures from Snodgrass & Vanderwart (1980). Although different sources were tapped to supplement the Snodgrass & Vanderwart set, all were comparable in style (see Table 1).

Table 1: Sources of stimuli

Source	Number of pictures used
Snodgrass & Vanderwart (1980)	174
Alterations of Snodgrass & Vanderwart (1980)	2
Peabody Picture Vocabulary Test (Dunn & Dunn 1981)	62
Alterations of Peabody Picture Vocabulary Test	8
Martinez-Dronkers set (from N. Dronkers)	39
Abbate & La Chappelle (1984a, b) *Pictures, Please!*	168
Max Planck Institute for Psycholinguistics	20
Boston Naming Test (Kaplan et al. 1983)	5
Oxford "One Thousand Pictures" (*Oxford Junior Workbooks* 1965)	25
Miscellaneous	17

We recorded the duration of each sign by digital video camera. The duration of a sign was defined as starting at the time when the expert signer raised his/her hands from the table, and ending at the time when the signers put his/her hands back on the table. The durations of each category did not reveal any significant difference. If we take sign-length as a motor complexity index, these measurements revealed that articulatory complexity was similar in each category.

Then the expert signers had to describe why those TSLs were signed in those ways, and to determine to which of the two categories the sign belonged. Following the ratings of the three experts of the 520 pictures, we selected 48 vision-based signs and 48 manipulation-based signs.

Stimuli were black-and-white line drawings displayed with a visual angle of 3~5º; pictures were presented at a rate of 2,000 msec with 1,500 msec exposure time each (see Figure 2). In a run, two blocks using pictures of vision-based signs and two blocks using pictures of manipulation-based signs were interleaved with control blocks with nonsense pictures. The order of the activation blocks was counterbalanced. For each participant, two runs of the experiment were conducted, comprising 192 whole-brain images in total. Participants made covert signing and naming responses to pictures in different runs. In a signing run, participants were instructed to covertly perform a meaningless pseudo-sign modified from TSL in response to control stimuli, and in a naming run, they were asked to name “di-da” in their mind in response to control stimuli (see Figure 3). Before scanning, practice was given for familiarizing the tasks.

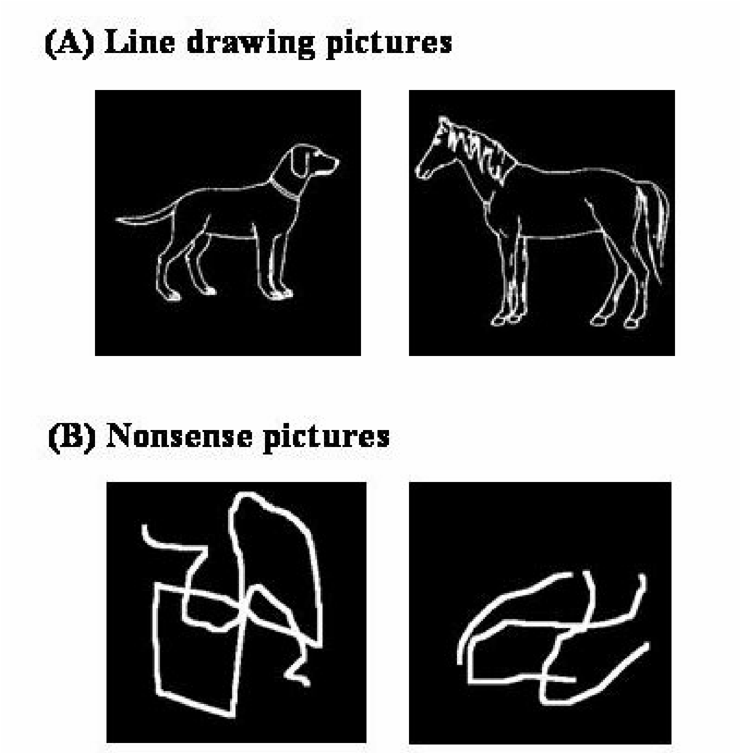

Figure 2: Examples of line drawing pictures and nonsense pictures. (A) The experimental stimuli were black-and-white simple line drawing pictures, such as pictures of a dog and a horse. (B) The control stimuli were nonsense pictures.

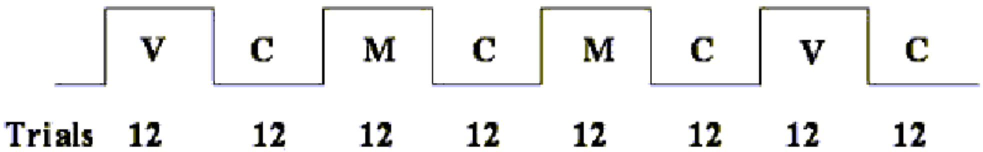

Figure 3: Ordering of stimulus blocks. The orders of the vision-based signs blocks (V) and the manipulation-based signs blocks (M) were counterbalanced. In each run, pictures displayed in blocks were interleaved with blocks of meaningless figures as nonlinguistic controls (C).

2.3 fMRI procedure and image analysis

Functional magnetic resonance imaging (fMRI) scanning was performed using a 3.0 T Bruker MedSpec S300 system (Bruker, Kalsrube, Germany). Participants' heads were immobilized with a vacuum cushion in the scanner. A T2*-weighted gradient-echo echo planar imaging (EPI) sequence was used for fMRI scans, with slice thickness = 5mm, interslice gap = 1mm, in-plane resolution = 3 × 3 mm, and TR/TE/θ = 2,000 msec/ 50 msec/ 90º. The field-of-view was 192 × 192 mm and the acquisition matrix was 64 × 64. Twenty axial slices were acquired to cover the whole brain. Optimization of global field homogeneity was performed by automatic and manual shimming. For each slice, 101 images were acquired in one run. The first five volumes of each run were discarded for signal equilibrium. Each participant's anatomical image was acquired using a high-resolution (1.95 × 1.95 × 1.95 mm), T1-weighted, 3D gradient-echo pulse sequence (MDEFT, Modified Driven Equilibrium Fourier Transform; TR/TE/TI= 88.1/ 4.12/ 650 msec). The total duration of the experiment was about one hour.

Data were analyzed using statistical parametric mapping (SPM99 from the Wellcome Department of Cognitive Neurology, London), running under Matlab 6.0 (Mathworks, Sherbon, MA, USA) on a Sun workstation. The first 5 images were discarded from the analysis to eliminate non-equilibrium effects of magnetization. Scans were realigned, time corrected, normalized, and spatially smoothed with an 8 mm FWHM Gaussian kernel. The resulting time-series was high-pass filtered to remove low frequency drifts in the BOLD signal and temporally smoothed with hemodynamic response function (HRF).

The main effects were studied by contrasting each task with the control condition. Regions of interest were selected from previous studies, and the significance level threshold was set at $p < 0.001$ (uncorrected) with spatial extent larger than 10 voxels.

3. Results

3.1 Activation maps of picture signing and naming

Conjunctions were defined as common areas of activation in a set of task pairs: (picture signing - control) and (picture naming - control). Interactions were defined as significant differences between the individual pairwise contrasts (picture signing - control) versus (picture naming - control). The difference, or interaction, can be attributed to distinctions in the modality-dependent surface features of each language. On the other hand, the conjunctions, or shared activations, can be associated with modality-independent features common to both languages.

In response to pictures, the primary conjunction areas of both languages were the left middle frontal gyrus, precentral gyrus, left inferior frontal gyrus, superior parietal lobe, right superior temporal gyrus, middle temporal gyrus, hippocampus, caudate nucleus, and right cerebellum. Although there was overall greater activation within the same brain areas in picture signing than there was in picture naming, the difference between picture signing and picture naming was not specific to particular brain areas, suggesting similar lexical access processes between these two languages (see Figure 4).

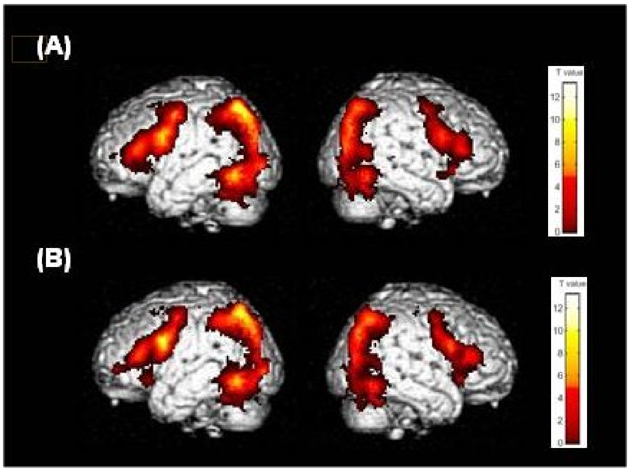

Figure 4: Activation maps of picture signing and naming. (A) Statistical maps of picture signing vs. control conditions. (B) Statistical maps of picture naming vs. control conditions. Clusters surviving an uncorrected $p < 0.001$ with spatial extent $n \geqq 10$ voxels were considered statistically significant. The bar denotes the t value.

3.2 Activation maps of manipulation-based signs and vision-based signs

Comparing the manipulation-based signs to vision-based signs, the primary conjunction areas were the bilateral posterior inferior frontal gyrus, occipito-parietal region, and posterior inferior temporal lobe. In addition, there was more activation in the premotor area and supplementary motor areas (SMA) in the manipulation-based signs relative to vision-based signs ((manipulation - control) - (vision - control); clusters surviving an uncorrected $p < 0.001$ with spatial extent $n \geqq 10$ voxels were considered statistically significant). See Figure 5.

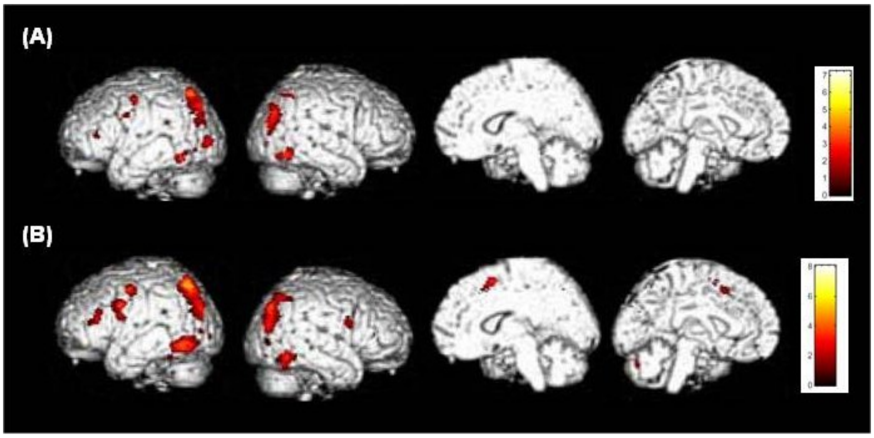

Figure 5. Activation maps of vision-based and manipulation-based signs. (A) Statistical maps of vision-based signs vs. control conditions. (B) Statistical maps of manipulation-based signs vs. control conditions. Clusters surviving an uncorrected $p < 0.001$ with spatial extent $n \geqq 10$ voxels were considered statistically significant. The bar denotes the t value.

4. Discussion

This study aimed to compare the neural correlations of Taiwan Sign Language and Chinese processing, and to test the different iconic representations of semantic systems in deaf people. Deaf signers showed a bilateral increase in activity, both while signing and while naming in oral language, and the main difference in activation areas for manipulation-based vs. vision-based signs were in motor related areas. These two findings are addressed below.

4.1 Different phonological codes

Most deaf signers are bilinguals. In order to communicate with the hearing world, they not only sign fluently, but are also able to read or use some speech. A number of studies of bilingualism showed that the closer in age bilinguals learned their two languages, the more similiar the brain activity between them (Klein et al. 1995, Perani et al. 1998). This is consistent with what we found in our study. In our experiment, the primary conjunction areas of both languages included the left middle frontal gyrus, precentral gyrus, left inferior frontal gyrus, superior parietal lobe, and right superior temporal gyrus, that is, the dorsal visual route and perisylvian areas. The involvement of these areas seems to reflect the visual nature of picture processing. The parietal lobes in both hemispheres are known to be involved in attention and perception of the motion and spatial location of referents (Posner & Petersen 1990). These findings imply that for our participants, the language system has become an integrated sign-language-based system. However, because the stimuli in the study are all high-frequency concrete entities, we may expect little difference between the retrieval of signs and spoken words denoting the same types of entities; by contrast, it is known that when expressing spatial relations, such as classifiers or prepositions, the modality of signed languages can have an impact on neural systems (Damasio et al. 1996, Emmorey et al. 2002).

The difference between picture signing and picture naming was not specific to particular brain areas, but merely showed a different degree of activation. The activation of the right hemisphere that we found cannot explained by prosody, motional facial expressions, or meaningful nonlinguistic gestures (cf. Hickok et al. 2002), since none were present in our experiment. The pattern of right hemisphere activity was not only found with signed language, but also with spoken language. This suggests that the involvement of the right hemisphere is important to processing language in deaf people, regardless of modality.

4.2 Different iconic representation types

Semantic memory is organized by sensorimotor modality, such as visual knowledge or motor knowledge (Noppeney & Price 2002). It is possible that the conceptual knowledge of signed languages in signers may also be influenced according to the different type of iconicity. Our study revealed more enhanced activation for manipulation-based signs than for vision-based signs in the left premotor area and bilateral supplementary motor areas (SMA), which are both associated with motor system processing. Because we included different semantic categories, the main differences between vision-based and manipulation-based signs could not have arisen from semantic category differences, but must be due to differences in action representation.

Previous picture naming studies with hearing participants revealed that activation patterns similar to those with deaf signers (Humphreys et al. 1999, Kremin et al. 2003, Price 2000). Spoken and signed word production activated many of the same cortical regions, particularly those processing auditory and visual inputs (Crone et al. 2001). The trends for differences in the study were mainly based on the sign-forms themselves rather than the semantics of the items.

To try to confirm that the key difference was indeed the type of iconicity and not some other aspect, we examined the manipulation-based and vision-based signs at the phonetic/phonological level and at higher semantic or conceptual levels. According to the standard phonological analyses of sign language, a sign is mainly composed of a spatial location, motion of the hands, and configurations of the hand. At the level of phonological and phonetic processes, there is little difference between manipulation-based and vision-based signs. They were also similar in the complexity of motor processing, the use of one or two hands, the rate of articulation, and the length of the signs. However, it is generally agreed that different kinds of concepts have different associations with visual images and actions. If we traced higher linguistic levels (semantic or concept levels), it would show that among the manipulation-based and vision-based signs, there are indeed different iconic characteristics related to their meanings due to differences in physical resemblance. Thus because of the iconicity in signs, the nature of these forms, given their meaning, is neither fully arbitrary nor fully predictable, but rather motivated.

5. Conclusion

The data and analyses presented in the present study indicate that the neural systems involved in the production of TSL and Chinese words are remarkably similar. When naming concrete entities, the neural processes that mediate language production were shown to be the same regardless of their employing different modalities. On the other hand, the neural substrates mediating the representation of objects and/or action took different dynamically distributed forms, depending on which sensory/perceptual channels were required to weigh the input information for recognition (vision vs. manipulation). At the same time, the characteristics of language processes also shape our knowledge of the world. This calls for further consideration of the structure of semantic systems. The brain not only statically represents the knowledge of linguistic categories such as nouns and verbs, or semantic categories such as animal and man-made items, but it is also mediated by dynamic iconic characteristics.

Investigating iconicity can provide us with a window for looking into the nature of language, the relation between form and meaning, and the relation between language and thought. Early sign researchers had focused on the arbitrary relationships between form and meaning in signed languages and neglected the importance of iconicity (Bellugi & Klima 1976, Hoemann et al. 1976). Actually, iconicity is not a unique feature of signed languages, but also can be found in spoken languages. However, it is not easy to represent the three-dimensional world iconically through the one-dimensional sequential medium of sound. Because of the visual-gestural modality, signed languages have a fantastic potential for iconic expression of the real world and of human thought.

Concept structure and linguistic semantics are neither based on objective reality nor are they completely arbitrary and subjective. Conceptual systems are embodied in our experiences. At the same time, human beings are constrained by our biological equipment. The nature of the human perceptual system has a significant impact on our concepts. To put it simply, the iconicity of languages exemplifies how human beings interact with the world. Through iconicity, people are able to express the possible or real world we sense, and it enables them to refer to the world we conceptualize (Lakoff & Johnson 1980).

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[Received 25 September 2003; revised 14 May 2004; accepted 20 July 2004]

Ovid J.-L. Tzeng
Cognitive Neuropsychology Laboratory
National Yang-Ming University
155, Sec.2, Li-Nong Street
Peitou, Taipei 112, Taiwan.
ovid@gate.sinica.edu.tw

台灣手語中視覺性爲主與操作性爲主手語之研究

邱弈琁[1]　謝仁俊[21]　郭文瑞[12]　洪　蘭[1]　曾志朗[13]

[1]國立陽明大學
[2]台北榮民總醫院
[3]中央研究院

本研究欲探討手語中的視象性 (iconicity) 的表徵方式，以及這樣的表徵方式如何影響語言及腦部的運作。視象性的手語指的是手語中能清楚反應出所欲呈現該事物本身的動作、外型或特性。在台灣手語中，視象性手語包含有以視覺表徵爲主的手語及操作表徵爲主的手語等兩類，手語使用者在運作這兩類手語時，由於不同的表徵方式，因而會有不同的語言及腦部的運作。在本研究中，實驗中呈現黑白圖片給聾人手語使用者看，並要求聾人手語使用者以台灣手語或是中文在心裡默想該圖片的名稱，同時，以功能性磁振造影 (fMRI) 記錄腦部的活動情形。首先，分析結果顯示聾人手語使用者在以台灣手語和中文默想圖片名稱時，腦部活動激發的區域相當一致，主要包含背側視覺路徑 (dorsal visual route) 及 Sylvian 裂周邊的區域 (perisylvian areas)；此外，過去的研究中發現表徵物體外型和動作會有不同的神經激發型態，這主要是在辨識這些事物時，負責處理運作的感官知覺管道比重不同所致，由本實驗結果也顯示，手語的表徵特性（視覺性爲主與操作性爲主）所激發的神經型態，也會與腦部不同區域的功能有關（例如視覺與運動路徑），這顯示腦部的神經運作不僅會反映出不同的語言學類別（語法和語意類別），同時也會因爲不同的型態及概念表徵影響，動態地調整腦部神經運作型態。

關鍵詞：手語，台灣手語，功能性磁振造影，視象性，圖片命名作業