Eye Gaze and Eye Movement in Japanese Sign Language

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Abstract

Eye gaze and eye movement in JSL (=Japanese Sign Language) are linguistic elements, as they are in American Sign Language (Thompson 2006) and German Sign Language (Hosemann 2009). But the linguists have not yet clarified the system and rules of these elements.

I conducted eye tracking experiments to examine how 10 native signers and 10 non-native signers produced eye gaze and eye movement while they were signing the same sentences. Firstly, I tracked their eyes by the head mounted eye-tracking technology, Eye-mark Recorder ("EMR-9", ***nac*** *IMAGE TECHNOLOGY*, inc.), and at the same time, I also developed a way to record positions and movements of pupils in the images on the TV monitor by auto-tracing device of animation software (PV Studio 20, L.A.B.inc). I found the distinctive eye movements of native signers; gazing the recipient, tracking the hand movements and gazing or tracking the trace of the hand signs previously made. Using the descriptions and measurements by the above two devices, I analyzed eyes of JSL on images of ELAN, the software which creates complex annotations on video resources.

I found the following eye grammar. Signers gaze at the manual sign and move eyes along classifiers or the trace of the manual sign, when the sentence implies the signer is/was experiencing what the sentence states. Signers gaze at the recipient if the signer is/was not experiencing by himself/herself what the sentence states. There are eyes as free morpheme, eyes as prosodic morpheme, and eyes as bound morpheme.

Key words: sign language, eye gaze, eye movement

INTRODUCTION

Eye gaze and eye movements in JSL (=Japanese Sign Language) are linguistic elements, as they are in ASL (=American Sign Language) (Thompson 2006) and DGS (=Deutschen Gebardensprache , German Sign Language) (Hosemann 2009). For example, Yasuhiro Ichida pointed out that if the signer's eyes tracks the movement of his/her own little finger which means /SHE/ while he/she signs /SHE/ /came/, the sentence means "I saw she came," and it represents the ***act of looking*** at the woman (=/SHE/) (Ichida 1997). Capitalized English like /SHE/ stands for the lexical sign which represents "she" and small letters like /coming/ stands for lexical classifiers.

Linguistic device using eyes is regarded as the most difficult part to master for late learners of sign language. Non-native signers often fail to move eyes adequately and the native signers notice that they

are late learners. But the linguistic nature of eyes in JSL and the grammatical rules of eye gaze and eye movement have not become clear.

In this article, the background, including previous studies on ASL and DGS, is introduced in Chapter 1, following the description and analysis of eye gaze and eye movement of JSL. In Chapter 2, the evidences of eyes being linguistic function in JSL are discussed using 20 subjects (10 native signers and 10 non-native signers). I have measured their eyes by eye-tracking technology, Eye-mark Recorder ("EMR-9", nac IMAGE TECHNOLOGY, inc.), and at the same time, developed a way to record positions and movements of pupils in the image on the TV monitor by auto-tracking device (PV Studio 20, L.A.B.inc). After confirming that eye gaze and eye movement of native signers are almost uniformly observed, and hence eyes are a part of grammatical rules, I will explore, in Chapter 3, the grammatical functions of eye gaze and eye movement. The findings are; there are eyes as free morpheme, prosodic morpheme and bound morpheme, and their grammatical functions are pronoun, adverb, role shift, and subject-verb agreement.

Measurement and description using Eye-mark Recorder and PV Studio 20 were reported in TISLR 11 (The 11th International Conference of Theoretical Issues in Sign Language Research) with my fellow researcher Dr Naotake Tsukidate on 10th July 2013 in London. The analysis using ELAN was conducted by myself after 2014.

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1. Background: Eyes in Human Communication and Eyes in Sign Languages

There are eyes for looking and eyes for showing or making someone look at. The latter is eyes for communication. Another is the unconscious reflexive eyes, which reflect emotions and thoughts. Eyes for communication is also sometimes unconscious. For example, caregivers (eg: mothers) use eyes to direct or redirect the attention of a baby/child, often unconsciously. And this eye gaze, which can be called "eye pointing", is mostly accompanied with hand pointing. By this, caregivers make infants notice and remember names of things. Ability of tracking others' eye develops in early infancy, which is regarded as an evidence of "theory of mind". Infants also have a skill called "referential looking", that is, the infant after looking at an item, he/she looks at the caregiver.

The most sophisticated eye gaze and eye movement as communication skill is those used in sign language of deaf people. For example, as I mentioned in "INTRODUCTION," JSL /SHE//coming/ with eye gaze to the finger means "I saw she came," while the same sequence of manual signs with eye gaze to the recipient means "she came" or "I know/heard she came".

Although eye grammar of JSL has not been thoroughly clarified, there are several research results about ASL and DGS. Benjamin Bahan (2000, PhD dissertation 1996) and Carol Neidle et al. (2000) emphasized that eye gaze is an independent agreement marker occurring with verbs in ASL. On the contrary, Robin Thompson et al. (2006, 2009) concluded that eye gaze was part of an agreement circumfix, because eye gaze in ASL functioned as an agreement marker only when accompanying manual agreement; it marked the object in agreeing verbs and the locative argument in spatial verbs. Jana Hosemann conducted an eye-

tracking experiment and the results differed from Thompson et al's; eye gaze with agreeing verbs in DGS did not occur as systematically as in ASL (Hosemann 2013).

In the following, I will investigate eye functions in JSL. Eye gaze and eye movement are difficult to analyze, because the signers might "look at" something or someone while signing. In order to distinguish eyes for communication from eyes for looking, I will first extract sentences in which the native signers commonly use eye gaze and movement. Next, I will compare those with non-native signers' eye, using auto tracing device and eye tracker (Eye-mark Recorder), to ensure that the native signers' eyes in JSL are linguistic eyes. And lastly I will analyze eye gaze and movement to find JSL eye grammar.

2. Evidence of Linguistic Functions of Eye Gaze and Eye Movement in JSL

I conducted eye tracking experiments to examine how 10 native signers and 10 hearing non-native signers produce eye gaze and movement while they are signing the same sentences. Firstly, I tracked their eyes by the head mounted eye-tracking technology, Eye-mark Recorder, and at the same time, I recorded their signing and describe the positions and movements of pupils in the image on the TV monitor by auto-tracing device. I found the distinctive eye movements of native signers; gazing the recipient, tracking the hand movements and gazing the trace of the hand signs previously made.

2-1. Assumption and Example Sentences

I chose the VTR image of a native signer's signing from the DVD of "*Syuwa no Gokui --- Nyumon-hen* 2 (=Secrets of Sign Language --- the Introduction 2)" (by Syuwa Bunka Mura, date of publication unknown) which is a highly evaluated DVD for JSL teachers and learners. The DVD consists of native signer's (CODA= Children of Deaf Adults) demonstration of JSL sentences and the comment of the teacher, Akihiro Yonaiyama, who is a native signer and a famous sign actor and director of JSL drama s and movies. He has high reputation as an educator of JSL. He comments and explains, one by one, after the native signer demonstrates JSL sentences. I picked up the sentences which had the same or similar eye gaze and eye movement between the native signer demonstrator and Yonaiyama. There are 13 such sentences, all of which will be analyzed in Chapter 3. I assumed, before conducting experiments, that those 13 sentences would comprise some rules of JSL eyes.

The 13 sentences I have picked out are as follows. / / with capitalized alphabets, as I introduce in Chapter 1, stands for a morphological sign, while / / with small alphabets stands for a lexicalized classifier. Classifiers are the characteristics of deaf sign languages as JSL and ASL; they are not fixed morphemes, but close to gestures, although certain hand shapes are used in each sign language. [ ] shows a functional sign, for example, [past] is the sign of both hands moving down with the palms down, which is an indicator of past tense. [PT] is the pointing. It functions sometimes as pronoun and sometimes as adverb. Pointing up at slant angle functions as the third person pronoun or sometimes an adverb "there", meaning the place the signer previously mentioned.

(1-a) (1-a) /TREE//growing/[past] (= I grew the tree.)

(1-b) /TREE//growing/ [past] (=The tree grew.)

(2-a) /RIGHT//CORNER//walking//POST OFFICE/ /BE/ (=If you turn right you'll find the post office.)

(2-b) /RIGHT//CORNER//walking//POST OFFICE/[PT] (=When I turned right, I found the post office.)

(3-a) /HOUSE//drawing/ (=I draw the picture of the house.)

(3-b) /HOUSE//drawing/ (= I draw the picture on the house.[on the wall of the house.])

(4) /COLD//LIGHT//BE-CAREFUL//NEED/ [PT] (=You should still be careful even if it's just a cold.)

(5) /MEDICINE//EAT//effect/ [PT]/BODY//BREAK//POISON//BE/(=Medicine sometimes effect as poison.)

(6) /RAIN//FALL/[PT] (=Is it raining much?)

(7) [PT]/MOVIE//WANT/ (=I want to watch that movie.)

(8) /WOMAN//LOOK-DOWN/ [PT] (=Don't look down on me, because I am a woman.)

(9) /YAMADA/[PT]/nodding//TANAKA//GO/[past]/SAY//SUZUKI/[PT]/TANAKA//GO/ /NOT/ /SAY//WHICH/ (=Yamada said that Tanaka went there, while Suzuki said that Tanaka did not go there. What happens?)

(10) /YAMADA//grasp-bag/[PT]/SUZUKI//BUY//ME/[PT] (=The bag Yamada carries is my bag Suzuki bought for me.)

Next I picked up the four sentences among the above 13 sentences (two pairs of very similar sentences), recorded the eye of 20 subjects, and compared the native signers' eye with non-native signers' eye.

2-2. Comparing Non-native Signers' Eyes with Native Signers' Eyes; Procedure

In order to proof linguistic nature of eyes in JSL, I chose four sentences (two pairs of the similar sentences) among the 13 sentences, recorded the performances and described and measured the eyes of each subject. I experimented using 20 subjects, 10 native signers and 10 non-native signers, to confirm that the eye gaze and movement are characteristics of JSL native signers and a part of JSL grammar. I picked up the four sentences from the DVD and showed them to 20 subjects. Each pair consists the same manual signs and ***the eye*** causes the difference of the meanings; (1) "I grew the tree." vs "The tree grew." and (2) "If you turn right you'll find the post office" vs "When I turned right, I found the post office."

I asked them to imitate the sentences. I video-recorded their signing images and at the same time I measured the eye gaze and eye movement by Eye-mark Recorder. Next, I marked the eye gaze and eye movement on the recorded images by PV Studio 20, and I also analyzed the data of measured eye-tracking.

The following two pairs of two sentences indicate characteristics of eyes in JSL. Notice the sequence of manual signs in (1-a) and (1-2) is the same. The only difference is movement of classifiers and eye movement.

(1-a) /TREE//growing/[past](= I grew the tree.)

(1-b) /TREE//growing/ [past](=The tree grew.)

(2-a) /RIGHT/ /CORNER/ /walking/ /POST OFFICE/ /BE/ (=If you turn right you'll find the post office.)

(2-b) /RIGHT/ /CORNER/ /walking/ /POST OFFICE/〔PT〕(=When I turned right, I found the post office.)

I chose the above four sentences, because distinctive eyes are observed. The sentence (1-a) and (1-b) both consist of the same sentence structure with /TREE/ and /growing/ ***with different eye movements***. (1-a) means "I grew the tree" and (1-b) means "the tree grew". Although the sentences (2-a) and (2-b) are also very similar, consisting of the same signs, /RIGHT/ /CORNER/ /walking/ /POST OFFICE/, ***the eye movements are different***. The meaning of (2-a) is "If you turn right you'll find a post office" and that of (2-b) is "When I turned right, I found the post office".

The following are the procedures of the measuring and describing the performance of the subject.

(i) I asked 10 native signers to look at the above four sentences by the demonstrator of the DVD, and then I asked to imitate the demonstrator's signing. Avoiding the possible different expressions and nuances, I reminded them of demonstrator's eye gaze and eye movement. They tried to sign with the same sentence structures and the same lexical items first without Eye-mark Recorder and then repeated to sign with Eye-mark Recorder. I video-recorded their signing and I measured their eyes by Eye-mark Recorder.

(ii) I asked 10 hearing non-native signers to look at the same four sentences, and to imitate them in the same way as (i) above. They have no eye gaze and eye movement like native signers. Therefore I asked to practice to imitate native signers' eyes. They practiced for approximately 15 minutes until they remembered the eye gaze and eye movement.

(iii) They (hearing non-native signers) tried to sign with the same sentence structures and the same lexical items. I video-recorded their signing without head mounted Eye-mark Recorder and then measured

their eyes by Eye-mark Recorder.

2-3. The Result: Description by Auto-Tracing Device

I marked positions and movements of pupils in the image on the TV monitor by auto-tracing device of PV Studio 20. As mentioned 2-1 above, non-native signers practiced to imitate the native signer (demonstrator) in the DVD teaching material. However, their eye gaze and eye movement were still different from those of native signers. The movement was small and not as distinctive as that of native signers.

I recorded the movement of pupils of 20 subjects signing the above four sentences (1-a), (1-b), (2-a) and (2-b) The following charts show the eye movements of the demonstrator of the DVD teaching material.

Chart 1. The demonstrator's eye movement of /growing/ in (1-a).

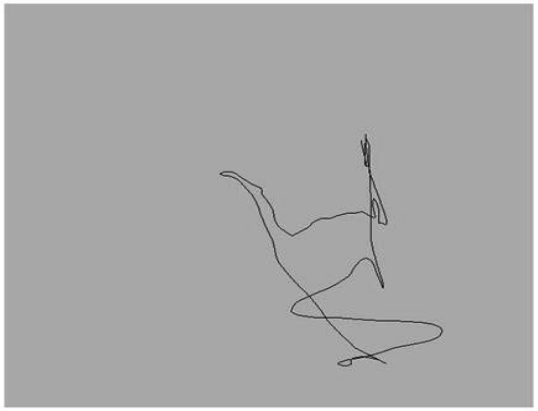
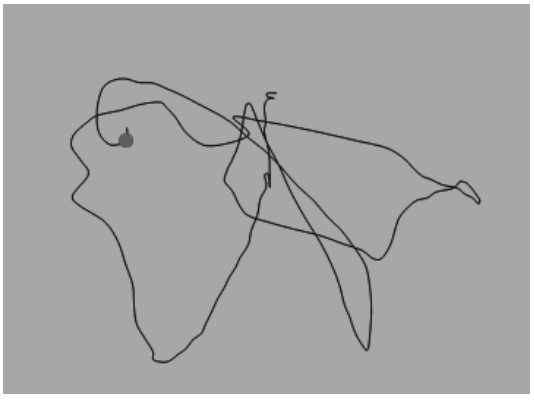


Chart 2. The demonstrator's eye movement of /growing/ in (1-a).



As an example of the analyzing process, I will explain one sentence signed by three subjects; the sentence (2-b); "when I turned right, I found the post office," signed by the demonstrator of the DVD teaching material who is a native signer (Image 1), one subject who is a native signer (Image2) and another subject who is a hearing non-native signer (Image 3). Movement of pupils and hands were traced using PV Studio 20. The following images show the last part of the sentence, /POST OFFICE/ [PT]. I will explain the relationship between the hand signing and the eyes later in 2-4. Here the eyes of native and non-native signers will be examined first.

Image 1. The Demonstrator's eye movements of /POST OFFICE/ [PT] in the sentence (2-b)

Image 2. Native Signer A's eye movements of /POST OFFICE/ [PT] in the sentence (2-b)

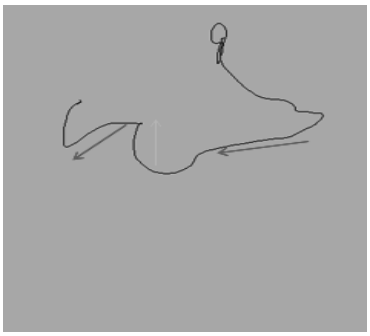
Image 3. Hearing Non-native Signer K's eye movements of /POST OFFICE/ [PT] in the sentence (2-b)

The following are the charts which extract the eye trace of the above three images. The charts show the traces of eyes at the last part of the signing, /POST OFFICE/ [PT]. The two native signers' movements are not exactly the same, but both have up-and-down movement. The non-native signer's eye goes down, but it has no up-and-down movement as indicated the two short bold arrows.

This description matches with the measurement by Eye-mark Recorder as the following 2-4.

As other subjects, the charts of 8 native signers and 2 non-native signers have the distinctive movement like the above native signer A and B. The 2 non-native signers are sign interpreters and long-time sign users. On the other hand, 8 non-native signers do not show the distinctive movement. The characteristics

Chart 3. The eye movements of /POST OFFICE/ [PT] in the sentence (2-b).



The Demonstrator

Native Signer A

Hearing Non-Native Signer K

of native signers' eyes are distinctive vertical movement which is clarified in the experiment using Eye-mark Recorder as follows.

2-4. The Result: Measurement by Eye-Mark Recorder

I used Eye-mark Recorder, to trace signers' eyes during signing. It is a device to measure subjects' point of visual focus. I measured eye movement of subjects during the subjects weared the head mounted Eye-mark Recorder. Data of optical flows from the EMR-9 are synchronized with the motion capture systems and also can be reviewed and analyzed.

Table 1 below indicates the horizontal movement and vertical movement of the last part of the sentence (2-b). The native signer subjects show the correlations between eye movement and horizontal/vertical finger motion. Horizontal finger motion has stronger correlations than vertical motion. This indicates that the eyes of the native signers are a bound morpheme which obrigatorily appears, although this eye grammar is difficult to master for non-native signers.

Table 1. Partial correlations for eye movement and finger motion controlling for face direction in the last part of the sentences (b-2). (r= partial correlation p= p value)

Native signers

	RIGHT CORNER WALK/CL POSTOFFICE PT			
	Horizontal movement		Vertical movement	
	partial		*partial*	
Participants	*r*	*p*	*r*	*p*
Naitive singner				
Signer A	-.61	.00	.36	.02
Signer B	-.51	.00	-.22	.14
Signer C	-.38	.01	-.39	.01
Signer D	.34	.01	-.08	.59
Signer E	.36	.00	.85	.00
Signer F	-.80	.00	-.50	.00
Signer G	-.34	.00	.38	.00
Signer H	-.22	.07	-.30	.01
Signer I	-.58	.00	.31	.00
Signer J	-.50	.00	.74	.00

Non-native signers

	RIGHT CORNER WALK/CL POSTOFFICE PT			
	Horizontal movement		Vertical movement	
	partial		*partial*	
Participants	*r*	*p*	*r*	*p*
Hearning person				
Signer K	-.75	.00	-.09	.25
Signer L	-.03	.81	-.43	.00
Signer M	-.61	.00	-.18	.13
Signer N	.32	.01	-.06	.64
Signer O	-.07	.57	.58	.00
Signer P	-.06	.61	.59	.00
Signer Q	.19	.09	.07	.50
Signer R	-.13	.20	.57	.00
Signer S	.53	.00	.05	.63
Signer T	.98	.00	.97	.00

The above numerical values shows that the vertical movement of native signers are much larger than that of non-native signers. P values indicate that the correlations for eye movement and finger motion in native signers are stronger than in non-native signers. The problem of Eye-mark Recorder is that the head movement interferes with the recording and measurement, and therefore distubs the numerical values. However it is better than the stationary type, because if the signers fix the head, it is impossible for them to sign naturally. A few ways of controlling have been conducted, but it is still difficult to subtract the head movement from the whole movements. Also, the timing of movement of the linguistic eyes in the same sentence is slightly different even among the native signers. These are solved in the next step of descriptions and analyses on the image using ELAN in Chapter 3.

2-5. Relationship between Hand Signing and Eye Gaze and Eye Movement

In contrast to the sentence (2-b), eye gaze of (2-a) is not toward the position of hand, but the recipient. The eyes track the movement of the index and middle fingers expressing "walking" by a lexical classifier in both (2-a) and (2-b). However, in (2-a), the eyes swerve the track of the classifiers and gaze to the recipient at the last part of the sentence. The following descriptions show it by GR (= gazing at the recipient), TH (= tracing the signing hand) and GH (= gazing at the signing hand).

(2-a)' /RIGHT/ /CORNER/ /walking/ /POST OFFICE/ /BE/
GR-------TH----------GH----------GR
(=If you turn right you'll find the post office.)

Compare it with the (2-b).

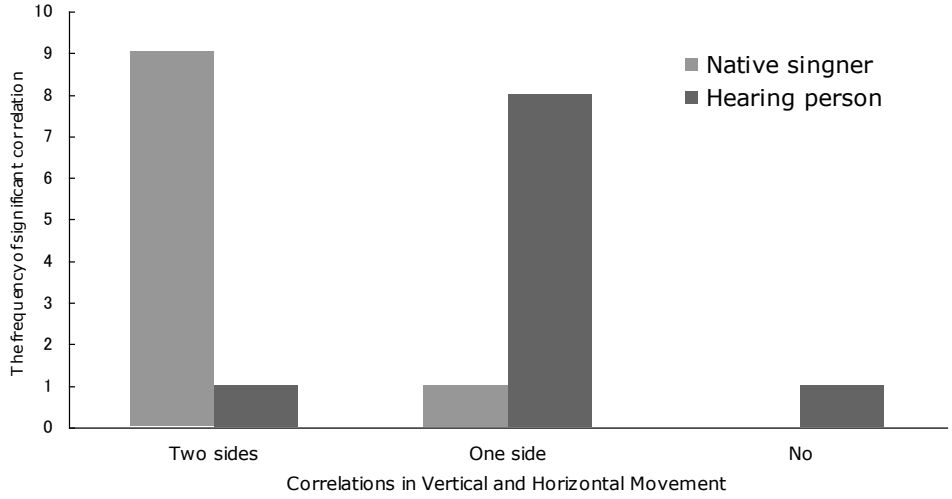
(2-b) /RIGHT/ /CORNER/ /walking/ /POST OFFICE/〔PT〕
GR-------TH----------GH
(=When I turned right, I found the post office.)

Although the signer's eyes are tracking the movement of classifier /walking/ in both sentences, the crucial difference is, in (2-b), the signer is gazing at the pointing place which symbolizes the location of "the post office", while in (2-a) the signer is gazing at the recipient, not that location. The sentence (2-b) is telling that the signer found the post office by herself sometime in the past. This corresponds to what Ichida points out; signers' eyes represent the ***act of looking*** itself (Ichida 1997), which I have introduced in "INTRODUCTION" of this article. On the other hand, the sentence (2-a) implies that the signer has already known the location of the post office when she is notifying it to the recipient. In this case, eyes are used as tense markers; historical present (2-a) and past (2-b). This is shown in the following Graph 1. It shows the results focused on the frequency of significant correlation between eye movement and finger motion and the relationship between the type of participant, native signers and non-native signers, and the frequency of significant correlation in horizontal and vertical movement.

These figures indicate the correlation of eyes and vertical and horizontal movement of the hands. Graph

1 shows that native signers keep on tracking the hand movements in (2-b); nine of the ten native signers show the correlation of eye and both vertical and horizontal (= “two sides”) movements of the hands. Only one hearing non-native signer shows the same correlation. Eight non-native signers show horizontal movements (= “one side”), and one shows no correlation.

Graph 1. The frequency of significant correlation in horizontal and vertical movement in the sentence (2-b).



The problem is, the above method of analysis cannot explain the difference between (1-a) and (1-b). In the case of native signers, the relationship between the hand movement and eye movement is almost the same between (1-a) and (1-b). The teacher Yonaiyama mentions in the DVD teaching material, that eyes are important to produce the sentences (1-a) and (1-b). Although he demonstrates how to sign the sentences drawing the learners’ attention to the eye movements, he does not explain how different the eyes of (1-a) and (1-b) are.

In this Chapter, I compared eyes of native signers’ with those of non-native signers’ while both are signing the same sentences in JSL. The characteristics are the distinctive vertical movements and the close relationship with the hand movements; whether eyes track the signing hand(s) or swerve clearly the signing hand(s). These are the linguistic elements acquired only by native signers.

But the problem is either the auto-tracing device or the Eye-mark Recorder cannot describe the complex combinations of manual signs and non-manual signs. It is difficult to grasp the timing of appearance of each element and gazing period. In the next chapter, I will clarify further the grammars by analyzing native signers’ eyes, using ELAN, the software which adds annotations.

3. The Grammar of JSL Eye Gaze and Eye Movement

In the previous chapters, the linguistic nature of JSL native signers’ eyes became clear by comparing them with non-native signers’ eye movements. In this chapter, on the premise that the native signers’ eye gaze and eye movement are a part of JSL grammar, I will analyze the sentences with characteristic eyes,

using ELAN which is a software for the creation of complex annotations on video images. It can add annotations to video streams. The annotations can be written on multiple tiers below the image. Image 4 and Image 5 below are the examples; the sign /CORNER/ and [PT] in the sentence (b-2). The tiers flow from right to left, as the image is moving. By this

devise, it became easy to grasp the period of gazing and also the timing of movements.

Image 4 Native Signer A signing /CORNER/ in the sentence (2-b)

Image 5. Native Signer A signing [PT] the Sentence (2-b)

Based on this kind of data, I will describe the organic links between manual signs and eyes in the sentences presented by native signers and clarify the eye grammar of JSL in the next section.

3-1. Description and Analysis using ELAN

Using ELAN, the relationship between manual sign and eyes of the sentences (1-a), (1-b), (2-a) and (2-b) which I used for the experiments in Chapter 2 can be described as follows. The locations of the manual signs are annotated on the second line under the vocabulary symbol / / and [ ]. The eyes are annotated in the third line; GR stands for gazing at the recipient, TH stands for tracing the signing hand(s) and GH stands for gazing at the signing hand(s).

(1-a) /TREE/ /growing/[past]
L front---upward--front
GR -----TH-------GR
(= I grew the tree.)

(1-b) /TREE/ /growing/-------/[past]
front---below-upward-front
GR--------TH-------GR
(= The tree grew.)

In (1-a) the classifier /growing/ is presented lower than the chest level by both hands and it moves upward just like the plant is growing, while in (1-b) the classifier /growing/ is presented by moving both hands upward higher than signer's head. In both sentences the signer keeps on looking at the hand movement. Whether the verb is transitive or intransitive is represented using the location and movement of the classifiers, ***and*** the eyes accompanying them. In other words, the English structures SVO and SV are not universal, but they happen to be the device of one ***phonetic*** language. The subjects who are native signers told that if the signer fails to move eyes properly, the meaning does not change nor the sentence become ungrammatical. Nevertheless, native signers' hand movements and eyes are correlated as indicated in Chapter 1. Hence, eyes in JSL, in this case, are a prosodic morpheme.

Next, the difference between (2-a) and (2-b) is explained as follows.

(2-a) /RIGHT/ /CORNER/ /walking/ /POST OFFICE/ /BE/
front----------rightward----------
GR-------TH----------GH----------GR
(= If you turn right you'll find the post office.).

(2-b) /RIGHT/ /CORNER/ /walking/ /POST OFFICE/[PT]
Front----------rightward----------
GR-------TH----------GH
(= When I turned right, I found the post office.)

In (2-a) and (2-b), the level of the hands are the same in front of the signer's chest and they are moving rightward. The only difference is the last manual sign /BE/ (the palm down) and [PT] and the eye gaze

with them, which I have already explained in Chapter 2. In these cases the eyes are a bound morpheme which decides the tense. It is not clear if [PT] with averted eyes is possible and/or grammatical, in (2-b). Neither is it clear if /BE/ with gazing is possible and/or grammatical in (2-a). If it is possible and it changes the meaning, this kind of eyes are semantically bound morphemes.

Other examples in which eyes have important roles will be explained in the following sections.

3-2. Grammatical Analysis of Eyes

The following two sentences consist of the same sequence of manual signs. But meanings of the two sentences are different. They have the sequence /HOUSE/ and /drawing/. However, because the eyes are different, the two sentences have different meanings.

(3-a) /HOUSE/ /drawing----------/
right---------front----------
GH ----------GT/HOUSE/----GR
(= I draw the picture of the house.)

(3-b) /HOUSE/ /drawing----------/
ront----------
GH------TH---------- GR
(= I draw the picture on the house. [on the wall of the house.])

In (3-a), the signer signs /HOUSE/ in the right side and keeps on signing the classifier /drawing/ in front of her chest. While the signer produces manual signs, /HOUSE/ and lexicalized classifiers, the eye gaze is to the both hands signing /HOUSE/ and moves downward to the hands /drawing/ as if she actually draws a picture, and moves upward to the trace of /HOUSE/ (the hands are not really there, but they were there when signing /HOUSE/) as if she looks at the house while drawing, and finally gazes at the recipient. On the other hand, in (3-b), the signer's eye is tracing her signing hands /HOUSE/ and /drawing/. (3-a) shows the signer is expressing that she draws, while ***looking at the house***, without which she cannot express she is drawing the picture ***of the house***. Hence it is a free morpheme. On the other hand, if she swerves her eyes from the signing hands, it possibly means drawing ***on the house***. To clarify this function of eyes, more experiments and native signers' introspections are necessary. In both (3-b) and (3-a), Ichida's theory, that eyes express the ***act of looking*** is adoptable.

(4) /COLD//LIGHT//BE-CAREFUL//NEED/ [PT]
GR----------slant down----------
(= You should still be careful even if it's just a cold.)

The eye movement indicates that the signer addresses to "you" and the signer shows ***no*** manual sign. The slant down eyes show the second person pronoun. It is a free morpheme which functions as a

pronoun. The following eyes are also a free morpheme.

(5) /MEDICINE/ /EAT/ /effect/ [PT] /BODY/ /BREAK/ /POISON/ /BE/
front----------upward—front----------
GR -------down (eye closed)----------GR
(= Medicine sometimes effect as poison.)

Here the closed eyes mean the state in which the signer feels the medicine working gradually. It is not ungrammatical if she opens her eyes. It is an independent adverbial morpheme.

In the following (6), the eyes express that there is no ***act of looking***.

(6) /RAIN//FALL/[PT]
front----------
GR----------
(= Is it raining much?)

The signer keeps on looking at the recipient. The signer is not looking at the manual sign of "rain". The discussion so far has clarified that native signers' eyes move along classifiers or the trace of the sign which appeared previously, when the sentence implies the signer is/was actually ***looking***, while native signers' eyes gaze at the recipient if the signer is/was not looking at or she does/did not experience by herself. Here the signer does not know whether it is raining or not, but she thinks the recipient has the information. The following sentence (7) is similar to (6).

(7) [PT]/MOVIE//WANT/
front----------
(= I want to watch that movie.)

In (7), eyes are always set toward the recipient. The meaning here, the signer is not watching nor has watched "the movie". In (8) below, the most striking grammatical device appears.

(8) /WOMAN//LOOK-DOWN/[PT]
Right-------left---------- right
Right ----- left----------right
(= Don't look down on me, because I am a woman.)

The first eye gaze rightward means the signer expresses "I am a woman," and leftward movement of eyes and face means that the recipient looks down on the signer. The signer here assumes the recipient on her right side, and only when she signs /LOOK-DOWN/, she plays the role of the recipient, and then quickly her face turns rightward again and she accuses the recipient. It is called "role shift". Although it

is the striking indigenous device of signed languages, the eyes of role shift have not been studied enough. The subject of /LOOK-DOWN/ is not the signer, but the recipient. Only when the signer is signing / LOOK-DOWN/, the eye moves leftward. This kind of movement is hardly mastered by non-native signers. The next sentence is similar, although it is not role shift in a strict sense.

(9) /YAMADA/ [PT] /nodding/ /TANAKA/ /GO/ [past] /SAY/
Front ---------- right
GR------ down close----*(close)down--------- rightward------ GR

/SUZUKI/ [PT] /TANAKA//GO//NOT//SAY//WHICH/
Front---------- left------front
Left--------- down---------- left------ GR
(= Yamada said that Tanaka went there, while Suzuki said that Tanaka did not go there. What happens?)

The signer here assumes Yamada and Suzuki in front of her; Yamada rightward and Suzuki leftward. While the signer tells “Tanaka went there” and “Tanaka did not go there”, she lowers her eyes. Only when she signs /SAY/, her eyes move rightward or leftward, and the eyes means “Yamada said” and “Suzuki said” respectively. Eyes function as subject-verb agreement. It is prosodic, because the direction of movement when the signers produces /SAY/ is clearly indicate the subjects, the hands moving from the location of Yamada to the signer, and next the hands moving from the location of Suzuki to the signer. The eyes are just accompanying that manual sign, which must be a prosodic morpheme functioning subject-verb agreement. The sentence (10) has the similar eyes.

(10) /YAMADA/ /grasp-bag/ [PT] /SUZUKI//BUY//ME/ [PT]
Right---------- left----- front
GR---------- down----------GH--------- down------ Trace- BAG
(= The bag Yamada carries is my bag Suzuki bought for me.)

In (10), the signer assumes Yamada and Suzuki in front of her, Yamada rightward and Suzuki leftward. The signer does not play the role of Yamada nor Suzuki. The role shift does not happen. But eye gaze to the assumed locations (Yamada right and Suzuki left) functions as the third person pronouns, with the verbs /grasp-bag/ and /BUY/.

In this chapter, I proved that eye gaze and eye movement function as free morpheme, prosodic morpheme or bound morpheme, sometimes functioning as pronoun, sometimes as adverbs. They also characterize the signed language, here JSL, by role shift and subject-verb agreement which use the nature of visual language and also space oriented language.

CONCLUSION

This article clarified the eye grammar of JSL, which has been said to be the most difficult to explain and be nearly impossible for non-native signers to master. The experiments using the auto-tracing device and the Eye-mark Recorder showed that there were common eye gaze and eye movement native signers make, which non-native signers can hardly make.

Considering the results of the experiments, I analyzed eyes in JSL sentences on ELAN images. The following eye grammars are found.

Firstly, signers gaze at the manual sign and move eyes along classifiers or the trace of the manual sign, when the sentence implies the signer is/was experiencing what the sentence states. Signers gaze at the recipient if the signer is/was not experiencing by himself/herself. Secondly, there are eyes as free morpheme, eyes as prosodic morpheme, and eyes as bound morpheme. An example of free morpheme is eye gaze functioning as pronoun or adverb on its own. An example of prosodic morpheme is eye movement showing subject-verb agreement where the direction of movement clarifies the subject, therefore the meaning does not change if the eye movement is missing, but .it is unnatural. An example of bound morpheme is eye gaze functioning as pronoun with pointing and it is ungrammatical if the signer fails to gaze. Eye gaze functioning case marking with predicate verbs (agreement) should be called functional morphemes, which is another example of bound morpheme. The most striking characteristic of eyes in JSL is eye gaze functioning "role shift", which is ingeniously presented by using spatial relationship of the persons involved. Sometimes it is used like direct or indirect speech of phonetic English and sometimes it changes the view or angle within one sentence, showing syntactic relationship like English case markers.

Thus eye grammar of JSL has been clarified in this article. Remaining problems are as follows. The sample sentences were picked up from the 45 minutes DVD. Therefore other eye grammars might be found in different materials. Also, eyes regarded as bound morpheme need further verification using native signers' introspections; what if the signer failed to produce it in the same sentence and whether recipient misunderstands or not. Another problem is what the relationship between eyes and other non-manual signs such as tilting head and body, nodding, raising eyebrows and opening/closing mouth is. There might be eyes bound by other non-manual signs. The relationship between eyes and other non-manual signs might be sometimes complementary distribution or they might be free variations in other occasions. Further research is needed to investigate these problems.

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