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# The Formation of Mutual Understanding in Conversation: An Embodied Approach

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***Abstract*—**The mutual understanding in conversation is very important for human relations. This study investigates the mental function of the formation of mutual understanding between two people in conversation using the embodied approach. Forty people participated in this study. They are divided into pairs randomly. Four conversation situations between two (make/listen to fun or pleasant talk, make/listen to regrettable talk) are set for four minutes each, and the finger plethysmogram (200 Hz) of each participant is measured. As a result, the attractors of the participants who reported "I did not understand my partner" show the collapsed shape, which means the fluctuation of their rhythm is too small to match their partner's rhythm, and their cross correlation is low. The autonomic balance of both persons tends to resonate during conversation, and both LLEs tend to resonate, too. In human history, in order for human beings as weak mammals to live, they may have been with others; that is, they have brought about resonating characteristics, which is called self-organization. However, the resonant feature sometimes collapses, depending on the lifestyle that the person was formed by himself after birth. It is difficult for people who do not have a lifestyle of mutual gaze to resonate their biological signal waves with others'. These people have features such as anxiety, fatigue, and confusion tendency. Mutual understanding is thought to be formed as a result of cooperation between the features of self-organization of the persons who are talking and the lifestyle indicated by mutual gaze. Such an entanglement phenomenon is called a nonlinear relation. By this research, it is found that the formation of mutual understanding is expressed by the rhythm of a biological signal showing a nonlinear relationship.

***Keywords*—**Embodied approach, finger plethysmogram, mutual understanding, nonlinear phenomenon.

## I. Introduction

IN conversation, people convey messages to others; at the same time, people grasp others' meaning and understand them cognitively and emotionally. In the process, when they promote a better understanding to each other, they can build mutual understanding, which is called rapport. The mutual understanding is very important for human relations. This study investigates the mental function of the formation of mutual understanding between two people in conversation using embodied approach. In performing this study, it is necessary to confirm the following points: (1) human beings have biological rhythm, (2) the parameters of biological signals, and (3) when human beings reach mutual understanding through conversation, the biological rhythms of each person would synchronize.

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### *A. Human Beings Have Biological Rhythm*

Human beings have biological rhythms, such as circadian rhythm [1], [2], heart rate rhythm [3], and walking rhythm [4]; rhythm has important properties that seemingly contradict: stability and responsiveness. Stability means the state of being stable; responsiveness means "being able to react quickly" and ability to make adjustments to new conditions or new information [5].

The stability of rhythm can be shown by maintaining a similar attractor or same attractor in the phase space; the responsiveness can be shown by changing an attractor. The stability of rhythm has been important in the field of heartbeat rate; for example, the responsiveness of rhythm can be shown by fluctuation in the phase space [6]. In recent years, less fluctuation has come to be thought to mean that death is close [7].

### *B. Parameters of Biological Signals*

The autonomic nervous function balance by sympathetic and parasympathetic nerves, the reaction responsiveness to stimulation, and gaze are influential in constructing the biological signal. Thus, those are considered as parameters of biological signals.

High frequency power (HF: 0.15-0.40 Hz) seems to reflect vagal activity to the heart, whereas low frequency power (LF: 0.04-0.15 Hz) represents vasomotor activity and has been reported to reflect both sympathetic and parasympathetic modulation [8], [9]. Thus, in this study, LF/ (LF+HF) is used as the indicator of activity of the autonomic nervous function balance [10].

While the autonomic function balance is an indicator of stimulation sensing during conversation, the reaction responsiveness to stimulation can be shown by the fluctuation in the phase space which is indicated by the Largest Lyapunov Exponent (LLE) [11].

During conversation, eye movements are thought to have a big meaning psychologically. Understanding the psychological action of the eyes facilitates the development of cognitive and emotional construal processes leading to social cognition, especially daily interaction with others [12]-[15]; therefore, eye-gaze is considered a parameter of human biological signal. Baron-Cohen [12], [13] suggested that the eye-direction detector deals with gaze detection and interpretation and plays an important role in the development of social cognition: eye-direction detector attributes the mental state of seeing to the gazer. In short, during conversation, when people are interested in the story of the other person, confirming the contents of the story, and saying their own opinion, people tend to gaze the

other's eyes. Especially, mutual gaze is a fundamental human behavior with important cognitive, emotional, motivational, and social interactions.

*C. The Biological Rhythm of Each Person Would Synchronize When Two Persons Reach Mutual Understanding through Conversation*

Precisely, cardiomyocytes of the human heart are activating separately if they are present separately; however, when those cells are collected and a cell becomes a pacemaker, all of the cells become synchronized at the same cycle [16], [17]. Then, due to the synchronization phenomenon of the myocardium, the regular human heartbeat and continuous blood flow to the whole body are created [17], [18]. When rhythmic blood flow occurs, autonomic nerves, such as sympathetic nerves and parasympathetic nerves, act, and in conjunction with other nerves, the mind is self-organized. Likewise, when humans reach mutual understanding through conversation, the rhythm of each person's biological signal would become synchronized.

## II. Method

*A. Participants*

Forty college and graduate students (female, 27; male, 13) participated in this study. They were divided into pairs randomly.

*B. Situation*

Four conversation situations between two people (make/listen to fun or pleasant talk, make/listen to regrettable talk) were set at four minutes each, and a finger plethysmogram as the biological signal of each participant was measured. For the comparison, each participant was individually measured by a finger plethysmogram in rest situation (without conversation) for four minutes.

*C. Measuring Instrument*

Lyspect 3.6 software (Chaos Technology Research Laboratory: 200 Hz) was used as a measuring instrument for the finger plethysmogram as the biological signal. Then, in order to clarify the psychological effect which changes with time, an attractor was drawn on the phase space by applying Takens' theorem [19] to the measured finger plethysmogram. The autonomic nervous function balancing of the sympathetic and parasympathetic nervous, as well as the reaction responsiveness to stimulation were measured by Lyspect 3.6.

Eye movement and gaze were measured by Talk Eye Lite (Takei Instrument Company: 30Hz). The definition of gaze is assumed that eye movement is slower than 5 deg/s in both the horizontal and vertical directions [20]. The target gaze range around the eyes is shown in Fig. 1.

*D. Procedure*

First of all, the purpose of this study was conveyed to participants. Then, after having the participants respond to the psychological test POMS (Profile of Mood States) [21], they had a conversation. Finally, participants were asked to review introspection whether the conversation was easy.

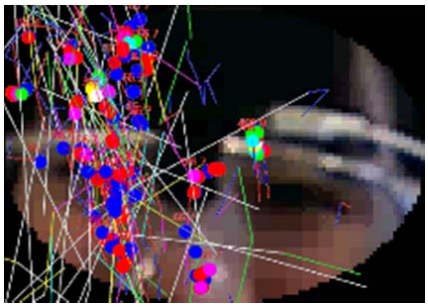

Fig. 1 Target gaze range around the eyes and trace of the partner's eye movement

## III. Results

In the introspection report after the conversation, most of the participants ($N$=36) answered "we talked well each other, and it was easy for me to talk;" only four participants answered "we did not talk with each other, and it was hard for me to talk." Actually, the attractors of the finger plethysmogram of the participants who answered "I did not understand my partner" are collapsed (see Fig. 2), and the cross correlation of the other party is low. Even though many participants reported "we talked well with each other," in fact, it seems that there are few cases where a mutual understanding was been reached. Therefore, from now on, the formation of mutual understanding is discussed in detail.

*A. Contents of Conversation*

Considering the content of conversation, there seems to be three stages in conversation: (1) *confirming stage* – two parties are trying to confirm the point during conversation by making questions, (2) *consistent stage* - then the conversation gets to mesh with each other when the confirmation works well, and (3) *inconsistent stage* - or, if the confirmation does not go well, the conversation does not mesh.

The following conversation is about "fun stories" of participants A and B. In the conversation, they did not interact well with each other. Participant B could not grasp participant A's point because of a lack of explanation by A; although B was asking questions, the reaction to the questions was unclear. The conversation between participants A and B is an example of *inconsistent stage* conversation.

A: In high school, all the classmates in my class were all good; there were various things that happened.
B: So? (B was in trouble; B did not understand what happened, even after being told various things.)
A: My high school was not a so-called advanced school, but only one class was an advanced class. I was there, and we were saying, "Let's work hard together."
B: Yup.
A: When I was in elementary school, I had six children who were good friends. At that time, I had blood type instructions.
B: Yup. (B did not know the expansion of the story of the other party, and B had nodded in the meantime.)

After the conversation experiment was over, A reported introspection that "it was hard to talk." In this conversation, actually, the talk did not match.

The following conversation is a representative example of c*onfirming* conversation which the two participants C and D make echoic responses and ask questions to organize points.

C: Even now this feeling continues, but my boyfriend gradually seems to be moving away from me. The department people we belong to often go somewhere together.
D: They often go out together. But I do not go out and do not spend with them often, either.
C: I want to make friends with everyone, but I do not go because I do not know what to talk about with friends. However, my boyfriend is going. Previously, I thought my boyfriend did not like going out with his friends like me; however, recently it has changed.
D: Hmm. It has changed?
C: I thought that my boyfriend had the same feeling, but it changed… I have been feeling that my place is gone. I told him that.
D: How did it go?
C: I told him that twice. My hazy feeling has remained. That was October. Finally, I found my boyfriend did not need me. I was able to blow him out.
D: Hmm.

It seems that the talk continues, and it is not at the stage where the conversation does not match or does match. Furthermore, two examples of a conversation in which the talk matched are described below. The E and F conversations below are c*onsistent*, because the listener grabs points from the talk of a speaker, understands the meaning, and responds.

E: When I was a sophomore in high school, my classmates were good friends. Male and female relations were also good.
F: Yes, yes.
E: My teacher was young; it was customary that we went to a restaurant or a bowling game together at a class meeting.
F: Your teacher was young? It sounds fun.
E: I enjoyed it. The teacher changed, and the custom was gone. It remained that way until junior high school.
F: The unity of classmates in high school is better than in junior high school, isn't it?

Both speak in turn while understanding the contents of the conversation.

The following G and H conversation is also a *consistent* case.

G: I started college and went to hang out with my friend, which was fun.
H: Where did you go?
G: We went to see a movie or something. But really, I do not like to go out so much.
H: You can relax better at home rather than outside, can't you? Me, too. Even though I want to laugh, I can't laugh at a movie theater. Do you hang out with the other guys in the department?
G: Hang out with the other four guys? I don't really think so.
H: Because there are only few guys in the department, I thought that you would hang out together.

For H, a different story is developing than they expected. However, H is doing a new discovery from the development of a different story from G's prediction. As a result, it seems that the talk matched. By the way, the above case of G-H is entering the next stage that the party found a new fact from their conversation. However, the stage is taken as a *consistent* case, because it is assumed that the conversation was consistent.

Through all conversation cases, in the case of parties tending to talk to each other, they are talking only based on the atmosphere of each other while talking about a fun or pleasant story; however, in a sad or frustrating story, the amount of talking is reduced, because their psychological activity of grasping the conversation point becomes heavier. Table I shows the proportion of conversation that showed *consistent* or *inconsistent*, and so on. The proportion of *consistent* cases is higher in the scenes of talking about regrettable or sad stories than in the scenes of talking about fun or pleasant stories. This is because it is easy to grasp the point of a regrettable or sad story. It becomes difficult for parties to share points when a party tends to talk about their story without thinking other's thought. These conversational features are considered to indicate the stage. In other words, it is necessary to proceed to the "understanding others (including sharing emotions)" stage from the "topic submission-other person does not understand the speaker, even after asking questions (talk-question)" stage or "the speaker speaks on their own (unilateral chatter)" stage when people reach mutual understanding in conversation.

TABLE I
PROPORTION OF CONVERSATION STAGE

| Stage | Pleasure Story (Conversation 1 & 2) | Regrettable Story (Conversation 3 & 4) |
|---|---|---|
| *Inconsistent* | 9 (22.5%) | 5 (12.5%) |
| *Confirming* | 22 (55.0%) | 18 (45.0%) |
| *Consistent* | 9 (22.5%) | 17 (42.5%) |

*B. Wave and Attractor of Finger Plethysmogram*

The finger plethysmogram of the participants during their conversation is shown in Fig. 2, for example. As a biological signal, the finger plethysmogram wave shows the psychological movement of the two persons. One person speaks, and the other responds to it.

Fig. 3 shows the attractor movement in the phase space using Takens' theorem [19] to the finger plethysmogram wave described above. In Fig. 3, the movement of each attractor corresponding to the above-mentioned conversation is shown in the phase space. For comparison, their attractors at rest (i.e., when not talking) were also shown.

Fig. 3 shows that in the case of pairs A and B who were in the *inconsistent stage*, their attractors in the conversation are not similar at all, but are similar to their attractors at rest, respectively. The attractors in the conversation of pairs C and D who were in the *confirming stage* seem to be somewhat similar compared to their attractors at rest. The attractors during the

conversation between pairs E and F who were in the *consistent stage* are clearly resembled, even though their attractors at rest are not similar at all. In addition, in the case of pairs G and H who newly noticed from the conversation, their attractors in the conversation can be seen to be particularly fluctuating on the attractor of H.

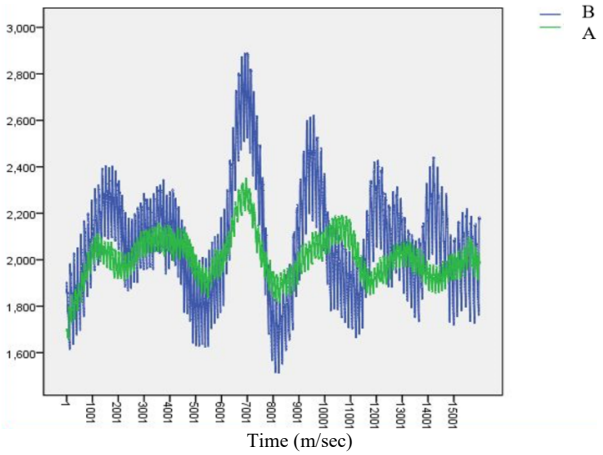


Fig. 2 Finger plethysmogram of participants A and B

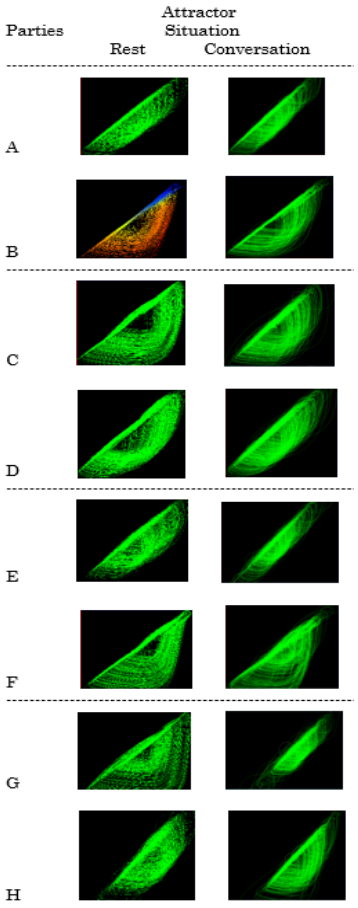


Fig. 3 Attractors of pairs at rest (left) and in conversation (right)

*C. Cross Correlation of Biological Signals – Fingertip Plethysmogram*

In order to investigate whether both parties who are in conversation are resonating in the situation of pleasure talking (Conversation 1 & 2) and in the situation of regrettable talking (Conversation 3 & 4), the cross correlation of the biological signals of the two, that is the finger plethysmogram was calculated.

In Conversation 1, the cross correlation of the *consistent stage* group is the highest, and the cross correlation of the *inconsistent stage* group is the lowest (see Table II; $F$ (2, 37) =12.59, $p$<0.01; significant difference between the *consistent* stage and *inconsistent stage* by Tukey HSD).

TABLE II
CROSS CORRELATION IN CONVERSATION 1

| Stage | Mean | Standard Deviation | Number of Parties |
|---|---|---|---|
| *Inconsistent* | 0.131 | 0.053 | 10 |
| *Confirming* | 0.207 | 0.081 | 20 |
| *Consistent* | 0.334 | 0.135 | 10 |

In Conversation 2, the cross correlation of the *consistent stage* group is the highest, and the cross correlation of the *inconsistent stage* group is the lowest (see Table III; $F$ (2, 37) =5.98, $p$<0.01; significant difference between the *consistent stage* and *inconsistent stage* by Tukey HSD and between the *consistent stage* and *confirming stage*).

TABLE III
CROSS CORRELATION IN CONVERSATION 2

| Stage | Mean | Standard Deviation | Number of Parties |
|---|---|---|---|
| *Inconsistent* | 0.136 | 0.059. | 8 |
| *Confirming* | 0.174 | 0.087 | 24 |
| *Consistent* | 0.293 | 0.145 | 8 |

In Conversation 3, the cross correlation of the *consistent stage* group is the highest, and the cross correlation of the *inconsistent stage* group is the lowest (see Table IV; $F$ (2, 37) =9.82, $p$<0.01; significant difference between the *consistent stage* and *inconsistent stage* by Tukey HSD and between the *consistent stage* and *confirming stage*).

TABLE IV
CROSS CORRELATION IN CONVERSATION 2

| Stage | Mean | Standard Deviation | Number of Parties |
|---|---|---|---|
| *Inconsistent* | 0.078 | 0.020 | 4 |
| *Confirming* | 0.169 | 0.059 | 20 |
| *Consistent* | 0.237 | 0.085 | 16 |

In Conversation 4, the cross correlation of the *consistent stage* group is the highest, and the cross correlation of the *inconsistent stage* group is the lowest (see Table V; $F$ (2, 37) =10.18, $p$<0.01; significant difference between the *consistent stage* and *inconsistent stage* by Tukey HSD and between the *consistent stage* and *confirming stage*).

In every conversation situation described above, if the cross correlation of the *consistent stage* group is the highest, then the confirming stage group is high, and the *inconsistent stage*

group is the lowest. From these results, it is conceivable that the cross correlation of the finger plethysmogram becomes high; that is, the biological signals of the two resonate with each other when the talks and the mutual understanding progress in conversation.

TABLE V
CROSS CORRELATION IN CONVERSATION 4

| Stage | Mean | Standard Deviation | Number of Parties |
|---|---|---|---|
| *Inconsistent* | 0.091 | 0.030 | 6 |
| *Confirming* | 0.146 | 0.076 | 16 |
| *Consistent* | 0.261 | 0.116 | 18 |

TABLE VI
CROSS CORRELATION OF THE PARTIES' AUTONOMIC NERVOUS BALANCE DURING CONVERSATION

| Pair | Conversation Situation | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| *1* | -0.377 | -0.317 | 0.621 | 0.353 |
| *2* | 0.751 | 0.423 | 0.579 | -0.585 |
| *3* | -0.359 | 0.624 | 0.575 | -0.725 |
| *4* | 0.698 | 0.397 | 0.398 | 0.464 |
| *5* | 0.543 | -0.288 | -0.804 | 0.625 |
| *6* | 0.414 | -0.674 | -0.280 | 0.456 |
| *7* | 0.709 | 0.301 | 0.826 | 0.590 |
| *8* | 0.606 | -0.292 | 0.418 | 0.673 |
| *9* | -0.619 | -0.586 | -0.610 | -0.185 |
| *10* | 0.306 | -0.529 | -0.109 | 0.386 |
| *11* | -0.203 | 0.742 | 0.544 | 0.640 |
| *12* | -0.389 | -0.245 | 0.659 | -0.411 |
| *13* | -0.184 | 0.494 | 0.676 | 0.602 |
| *14* | 0.407 | -0.480 | 0.344 | 0.370 |
| *15* | -0.582 | 0.242 | 0.831 | 0.368 |
| *16* | 0.489 | 0.347 | 0.406 | 0.551 |
| *17* | 0.633 | 0.331 | -0.527 | 0.689 |
| *18* | 0.388 | -0.766 | -0.533 | -0.363 |
| *19* | 0.559 | 0.439 | -0.335 | 0.350 |
| *20* | 0.549 | -0.722 | 0.655 | 0.746 |

### *D.Autonomic Nervous Function Balance*

Regarding the autonomic nerve which is considered as one parameter of the biological signal, the autonomic nervous function balance index measured in this study is significantly higher in the conversation situations than in the rest situation ($F(4, 156) = 33.27$, $p<0.01$; autonomic balance score at rest: 5.61, $\sigma$=1.17; autonomic balance score in conversation 1: 7.37, $\sigma$=0.98; autonomic balance score in conversation 2: 7.39, $\sigma$=1.08; autonomic balance score in conversation 3: 7.20, $\sigma$=1.20; autonomic balance score in conversation 4: 7.44, $\sigma$=0.99). That is, sympathetic nerves work more when people have a conversation than when they are alone. The autonomic nervous function balance is an indicator to sense a stressor [18]; therefore, the data shows that the conversation itself is a stressor and that people incorporate information through conversation. In addition, for the parties' autonomic nervous balance during conversation, a very high cross correlation has been found in most of pairs (-0.804 to 0.826: see Table VI). The numerical value of this correlation seems to suggest a synchronization phenomenon. The synchronization phenomenon is a phenomenon in which the frequencies coincide, and is also called frequency synchronization [5]. That is, there is a phase synchronization in which the timing of the two oscillators fits perfectly and an anti-phase synchronization in which the timing of two oscillators occurs alternately, and they both are synchronized phenomena [5]. However, it is found that there is no significant difference in autonomic nervous function balance among inconsistent stage group, confirming stage group, and consistent stage group in any conversation situation. Basically, autonomic nervousness works when encountering a stressor such as conversation, and may not be directly involved in the mental action of understanding the contents of the conversation and understanding the emotion of the other party.

### *E. Largest Lyapunov Exponent*

The Largest Lyapunov Exponent (LLE), which means adaptability to a situation and is measured as an indicator of responsiveness to a stressor, is significantly higher in the four conversation situations than at rest ($F(4, 156)=5.394$, $p<0.01$; LLE at rest: 5.40, $\sigma$=1.56; LLE in Conversation 1: 6.15, $\sigma$=1.36; LLE in Conversation 2: 6.12, $\sigma$=0.98; LLE in Conversation 3: 6.38, $\sigma$=1.56; LLE in Conversation 4: 6.27, $\sigma$=1.23). Therefore, the participants are considered to respond to the sensed stressor in the flow of the conversation. In other words, it is considered that people have features which respond to sensed information. In addition, for the parties' LLE during conversation, very high cross correlation has been found in most of pairs (-0.566 to 0.649: see Table VII). However, it is found that there is no significant difference in LLE among the *inconsistent stage* group, *confirming stage* group, and *consistent stage* group in any conversation situation.

TABLE VII
CROSS CORRELATION OF THE PARTIES' LLE DURING CONVERSATION

| Pair | Conversation Situation | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| *1* | 0.292 | -0.554 | -0.327 | -0.153 |
| *2* | 0.588 | 0.385 | 0.478 | 0.137 |
| *3* | -0.544 | -0.501 | 0.369 | -0.508 |
| *4* | 0.331 | 0.141 | 0.520 | -0.438 |
| *5* | -0.222 | -0.558 | -0.418 | -0.228 |
| *6* | -0.351 | -0.566 | -0.440 | -0.563 |
| *7* | 0.649 | 0.628 | 0.502 | 0.342 |
| *8* | 0.175 | 0.297 | -0.523 | -0.260 |
| *9* | -0.144 | 0.501 | -0.324 | -0.511 |
| *10* | -0.406 | 0.459 | 0.578 | 0.436 |
| *11* | 0.397 | 0.362 | 0.304 | 0.314 |
| *12* | -0.196 | 0.434 | -0.515 | 0.473 |
| *13* | 0.524 | 0.318 | 0.239 | 0.182 |
| *14* | -0.346 | -0.436 | 0.546 | 0.529 |
| *15* | 0.439 | 0.468 | -0.311 | 0.497 |
| *16* | -0.293 | 0.292 | -0.426 | -0.253 |
| *17* | 0.212 | 0.406 | 0.180 | 0.154 |
| *18* | -0.219 | 0.273 | 0.334 | 0.306 |
| *19* | 0.186 | 0.262 | 0.287 | 0.334 |
| *20* | 0.350 | 0.288 | -0.403 | 0.590 |

*F. Gaze*

During conversation, the gaze time of seeing the other's eyes did not show any difference in any conversation situation or any group. By verifying whether the eyes of the conversation partners are in line with each other, which is called mutual gaze, it was found that in Conversation 1, the *confirming stage* group showed mutual gaze the most, while the *inconsistent stage* group showed the lowest ($F$ (2, 37) = 3.90, $p$<0.05); in Conversation 4, the *confirming stage* group showed the most while the *inconsistent stage* group showed the lowest ($F$ (2, 37) = 3.94, $p$<0.05). There was no significant difference with respect to mutual gaze in Conversation 2 and 3.

## IV. Discussion

From the results of the present study, during the conversation, as shown in Figs. 2 and 3, rhythms shown as biological signals occur in humans, and it is found that the mental activity of mutual understanding of both persons in conversation would be established by the coordination of stability and responsiveness of the biological signal represented by the finger plethysmogram of each person. In other words, mutual understanding might be indicated as a degree that two parties in a conversation act as one psychological system, that is, if the movement of the biological signals of two parties in a conversation resonates, it would be possible to think that it comes together as one psychological system.

The results of this study revealed that the autonomic nervous function of most people resonates during the conversation, and the responsiveness system expressed by the LLE resonates. However, in many cases, the biological signal represented by the finger plethysmogram does not resonate with the partner in the conversation. At this point, it is necessary to consider mutual gaze. Mutual gaze is an emotional interaction which shows that people are interested in their conversation partner. Although there was no statistically significant difference, the *confirming stage* group had the highest gaze time to the surrounding of the party's eyes and the *inconsistent stage* group had the lowest tendency found in all conversation situations, which means gaze time might indicate a posture to listen to the story of the other party. People in the confirming stage group were watching the party's eyes while asking questions about what they were talking about. The *consistent stage* group was at a stage to ask questions and confirm, then tried to understand their partner. It is based on the *confirming stage*, so after gazing at the conversation partner, entering the stage of expressing their opinions and impressions, maybe the gaze time tends to be less than the *confirming stage* group. On the other hand, the *inconsistent stage* group did not convey what they want to say to the party, and even if they tried to ask or confirm, the answer at the expected level was not returned, and the point was not grasped by either party. Therefore, people at this stage cannot be helped, even if they are talking with their partner regardless of having something to gain, looking at their eyes, or mutual gaze, they are losing interest in the other party.

The autonomic nervous balance, that is, the stressor sensing index and the responsiveness or repulsion to the stressor indicated by LLE, are originally corresponded or correlated in the form of adaptation to the situation. However, the correlation between the autonomic nervous balance and LLE is not high (Conversation 1, $r$=-0.123; Conversation 2, $r$=-0.261; Conversation 3, $r$=0.272; Conversation 4, $r$=0.036). In Conversation 1 of this study, it was found that LLE of the *consistent stage* group was the highest, LLE of the *inconsistent stage* group was the lowest, and there was a significant difference; however, there was no significant difference on the autonomic nervous balance among the *consistent stage* group, *confirming stage* group, and *inconsistent stage* group. There was no significant difference on the autonomic nervous balance or the LLE in conversation situation 2, 3, and 4 either. Moreover, gaze time and mutual gaze do not seem to work well during conversation.

Considering the mental state of the participants, several relationships were found in the mental state of participants measured by POMS and their state during conversation. The higher the Anxiety scale of POMS, the lower the cross correlation of the parties' finger plethysmogram in conversation situation 2; the lower the Anxiety scale, the higher the cross correlation between the parties' finger plethysmogram ($r$=-0.361, $p$<0.05). In addition, the higher the Fatigue scale, the lower the mutual gaze of the two people in the conversation situation 1; the lower the Fatigue scale, the more often the parties gazes match ($r$=-0.463, $p$<0.01). The similar trends were found in conversation 2 ($r$=-0.344, $p$<0.05). The higher the Confusion scale, the lower LLE correlation of the two people in the conversation situation 3; the lower the Confusion scale, the higher LLE cross correlation of the two people ($r$=-0.342, $p$<0.05). From these facts, the formation of mutual understanding in conversation is considered as follows. Despite the fact that human beings basically have the characteristic that the autonomic nervous balance of the two parties resonates and LLE resonates, because there is "a line of sight that reflects the person's mental state" (mutual gaze) which is involved, it is thought that the resonance of the biological signal represented by the finger plethysmogram of the two persons is influenced.

While people make conversation, their mutual understanding could occur. Between the two, a phenomenon called "coupling" [22] occurs. Such a relationship can be expressed as Marshal [23] described, "nonlinear relationship". Nonlinear relationship is a phenomenon which cannot be pursued or considered for researchers who have studied in the linear theory so far; however, in this research, the formation of mutual understanding in conversation will occur through biological signal rhythm of two people. Therefore, it will be possible to find the rule that the biological signal rhythm during conversation resonates and synchronizes.

## V. Conclusion

This research examined how mutual understanding, which is also called rapport and is very important in human relations, is formed. Naturally, mutual understanding is a mental phenomenon that arises from mutual involvement. Because humans have a mental rhythm, it is possible to resonate and sympathize with the conversation partner. Even if they differ in

terms of stability, which is one aspect of rhythm of each person, it is possible to compromise by responsiveness which is another aspect of rhythm. Moreover, during conversation, if both persons resonate, their mental rhythm would be similar or one. Actually, it turned out that it is not so easy to form mutual understanding by reflecting the mental state there, as shown by eye gaze.

Finally, the formation of mutual understanding in conversation can be seen from the rhythm of the biological signal, and it is thought to be indicated by moving or changing in the direction of unifying so that the rhythm of each of the parties is similar.

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