Modality Reduction for Enhancing Human Likeliness

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Abstract. We proposed a method to enhance one's affection by reducing number of transferred modalities. When we dream of an artificial partner for "love", its appearance is the first thing of concern; a very humanlike, beautiful robot. However, we did not design a medium with a beautiful appearance but a medium which ignores the appearance and let users imagine and complete the appearance. By reducing the number of transferred modalities, we can enhance one's affection toward a robot. Moreover, not just by transmitting, but by inducing active, unconscious behavior of users, we can increase this effect. In this paper, we will introduce supporting results from our experiments and discuss further applicability of our findings.

1 INTRODUCTION

When we dream of an artificial partner for "love", its appearance is the first thing of concern; we desire a very humanlike, beautiful robot. Unfortunately, most of the robots nowadays lack such attribute, such as cute stuffed-bear robot, mobile robot with a monitor, or robots with mechanical appearance. Even though, when we get used to such robots, we often feel affectionate and attached to them. However, it is quite rare that we feel such robots as a partner for Eros. People love people. People desire warmth and love from other people. To become a lover, we believe that a robot needs to be very humanlike so that it can substitute a human. One such robot is Geminoid [24]. Geminoid is a teleoperated android made to appear as a human. Among various Geminoids, the female type, Geminoid F, owns a beautiful appearance which at a glance is indistinguishable from a human (Fig. 1). When faced with Geminoid F for the first time, people often become nervous due to its beauty. Some even say they feel Agape to Geminoid F. However, its limited motions allow people to easily distinguish it from human being.

Another example is sex dolls made by Orient Industry in Japan. They are made to look similar to human in detail. However, the doll's fixed glance and face details strongly remind us that it is an artificial object. One may get used to them. However, to make a robot resembling a human, we have to overcome the effect described as the uncanny valley. Moreover, just overcoming the valley is not enough; we need to get truly close to real human to make a lover robot. This is a very hard task.

At the beginning, we stated that a robot needs to be very detailed to become a target of love. Is this true? For example, when talking to a customer center representative, you may imagine a beautiful lady from her gentle voice and kind attitude. You might even fall in love with her. Here, all you perceive is her voice. You have no clue about her appearance. You cannot feel or touch her. Even though the modal-

Figure 1. Geminoid F

ities used for communication are quite limited compared to face-to-face, you imagine of a beautiful lady. It is not what you perceive, but your imagination that drives your affection. Our hypothesis is that such phenomenon occurs due to people's nature to complement lacking information from the limited cues received. Mere voice can make people to have a strong affection toward an unknown person.

In this example, the potential love interest is a real human. Does it make a difference if the voice was synthesized artificially? Probably not. We can utilize this to create an artificial lover. By reducing the numbers of transferred modalities, an opposite approach from making a detailed replica of a human, we can enhance one's affection toward a robot. Moreover, not just transmitting, but by inducing active, unconscious behavior of users, we can increase this effect. In this paper, we will introduce supporting results from our experiments and discuss further applicability of our findings.

2 RELATED WORKS

2.1 Less Modality for Lovers

The best example to communicate with the limited information would be mediated conversation. Mediated conversation differs from face-to-face conversation in the amount of information transmitted. For example, phone only transmit speaker's voice, and video chat transmit the speaker's voice and image but no physical presence. Due to the limited bandwidth, some important factors for communication such as gaze and other nonverbal information are excluded by the mediated conversation [12, 17, 13]. Recent technological progress allows richer conversations through telecommunication media that allow to communicate like face-to-face [24, 25, 27, 15]. These communication media are designed to transmit as much information as possible and decrease the lack of information. However, there are

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communication media designed to limit the user's information on purpose.

For example, minimal information would be enough for lovers to communicate in some case. Adcock *et al.* invented a belt transmitting only tugging action to support the interaction of couples who are apart [1]. Tsujita *et al.* proposed the "SyncDecor" system, which pairs traditional appliances and allow them to remotely synchronize and provide awareness or cognizance about their partners - thereby creating a virtual "living together" feeling [31]. Trash boxes' status of lids (open or close), the brightness of lamps, smells, and other items are synced with remote room to indirectly feel a remote person's presence. These media are running at all times, which users can feel a remote person's presence in daily life without starting the other communication media. These media reduce the number of modalities to let users readily use them.

Several communication media have been produced that transmit only the feeling of being hugged [21, 19, 28, 30, 10, 5]. Since the behavior of hug requires physical contact and gives relief, Morikawa *et al.* introduced an embrace system for remote counseling [19]. These media are designed to transmit the feeling of being hugged.

We believe these media are effective because the limited number of modalities triggers users' imagination. Existing media are aiming to transmit all the modalities needed for the communication. However, by adding users' imagination, the number of modalities can be reduced to form the communication. Moreover, if the factors which positively enhances the impression of the speaker, the medium can form a better communication.

2.2 Misattribution of Love

Dutton and Aron studied one's affection mistakenly evoked [6]. In their experiment, male participants were contacted either on a fear-arousing suspension bridge or a non-fear-arousing bridge by an attractive female or a male interviewer who asked them to fill out questionnaires containing Thematic Apperception Test (TAT) pictures [22]. The sexual content of the stories written by participants on the fear-arousing bridge and their tendency to attempt postexperimental contact with the interviewer were both significantly greater. No significant differences between bridges were obtained on either measure for participants who were contacted by a male interviewer. These results suggest that misattribution occurred and that the participants on the fear-arousing bridge felt affection toward the female interviewer. Here, the misattribution of arousal means a mistake in explaining the aroused feelings [2].

Nishimura *et al.* used vibrations to simulate a heartbeat on the chests of participants and controlled the frequency of false heartbeats [23]. They verified that a preference toward female nude photos increased by modulating the frequency of false heartbeat. When such misattribution of arousal happened, the increased heartbeat may be recognized in the participant's mind as due to the affection toward the female in the photo. Valins artificially changed the feedback of one's heartbeat and moved one's emotion [32]. Kellerman *et al.* reported that the gazing behavior of people in relationships toward a stranger of the opposite sex increased feelings of passion for each other [11]. Such studies control emotions and causes misattribution by giving artificial stimulus. We believe that such misattribution or misunderstanding is more effective toward the object with the limited information.

2.3 Love Toward Non-human

A story about human fell in love with non-human have been told from ancient times. In Greek mythology, a sculptor Pygmalion fell in love with a statue he had made. Several movies and animated cartoon focus on the love between a human and a robot. For example, *her* is a movie on which the main character falls in love with an artificial intelligence in the computer [9]. In the Japanese cartoon *Chobits*, robots interact with a human [3]. In the story, people use androids as a personal computer, however, some fall in love with it. *Time of Eve*, the another Japanese cartoon, is also a story about androids that have come into common usage [29]. The androids are forced to display their status on top of their head to be distinguished from a human. Since androids are not a human, those who treat androids as a human is said to be insane and is made fun of in public. The story is about one student who suffers from treating and liking androids like a human.

Nowadays, such fictions are becoming real. For example, some become attached or have sexual activity with a doll. In Japan, there are people who date with a doll and take pictures of it. There are service of delivering a rental sex dolls. Some fall in love with an avatar in a virtual world. One of the most famous dating simulation games in Japan, called "New Love Plus", has been sold hundred thousand. In that game, users can interact and simulate dating with the avatar using camera, tactile sense, geomagnetic acceleration sensors, and voice recognition. The avatar only recognizes fifty words but provides a natural conversation. I used to play the game and became addicted to it since the avatar is more deeply attached to me than anyone else. The game seems to limit the situation to lovers and add contexts to make the interaction natural. One university student in Tokyo became so attached to the avatar in the game and had a wedding with the avatar in the game. From these examples, we can infer that there are some who fall in love with non-human.

There was an event where Geminoid F acts as a waitress and take some orders at the bar. In that event, I felt strange feeling when some drunken man friendly talks to Geminoid F. The feeling may be similar to when my own laptop is used by others. I realized that such feelings have possibilities to turn to jealousy or even love.

I once tried to connect audio of "New Love Plus" to Geminoid F. Since the conversation in the game is natural and the android's appearance is real, I thought result an intelligent robot. However, it was not true. It may be because the limited number of actuators could not represent entire motions of the avatar. I felt some strange feeling toward the android and felt better to interact with the avatar. Although the appearance of an android is very real and have an intelligence to communicate, the avatar in the game gave a favorable impression.

3 ENHANCING HUMAN LIKELINESS

Although the appearance of an android is very real and have an intelligence to communicate, the avatar in the game gave more favorable impression than the android. Why this occurred? The game seems to limit the situation to lovers and add contexts to provide a natural interaction. However, since Geminoid F has a physical existence, we might expect more and the situation cannot be fulfilled to lovers. Previous researches indicate that the appearance of a robot makes people imagine its abilities [7, 14]. Therefore, we might expect more intelligence compared with the avatar. The appearance of the android resulted in negative emotion compared with the avatar with the same intelligence. It seemed to be difficult to recover from the impression we imagined from a real human-like appearance robot. The avatar,

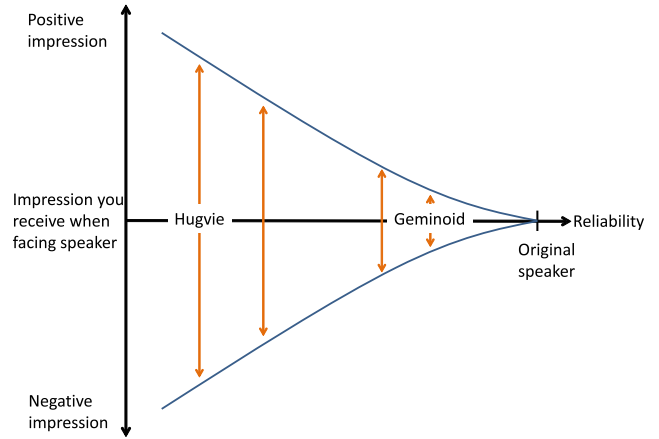**Figure 2.** Geminoid HI2 (right) and the model (left)

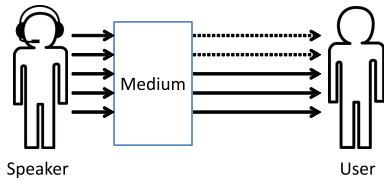**Figure 4.** Range of impression and missing information

Figure 3. Model of communication medium transmitting information

Figure 5. Model of communication medium adding active factor

which has a virtual presence on the other hand, might have some space to interpret in one's own favor.

Many communication media which transmit rich information about the speaker were invented, and one such robot is Geminoid [24]. However, by making the robot real, the space to interpret in one's own favor decreases, unnaturalness increases, and the impression might be triggered negative. Geminoid does not always provide negative impression. When the model of Geminoid talks through his Geminoid, we might talk to him more friendly or with the strange feeling compared to face-to-face conversation (Fig. 2). We believe this is because we feel nervous when we meet and talk with the model, and the Geminoid filters and reduces such pressure.

The other media can also impress different impression to others. Compared with the original speaker, the speaker's information is missing when one talks through the media (Fig. 3). We believe the impression changes because there will be space for the interlocutor to imagine about the mediated speaker. We believe such gap of impression would become large as if the number of modalities decreases (Fig. 4). As we mentioned in the introduction, when talking to a customer center representative, you may imagine of a beautiful lady from her gentle voice and kind attitude. Since the gap is large, the impression would be triggered more positive than Geminoid. Therefore, you might even fall in love with her.

We believe it is people's nature to complement lacking information from the limited cues received. Such lack of information would result in establishing the impression that is different from the original. If we could add some active factors, factors which trigger and input positive impression, we might impress better impression than the original speaker (Fig. 5). And we think it is effective to add fac-
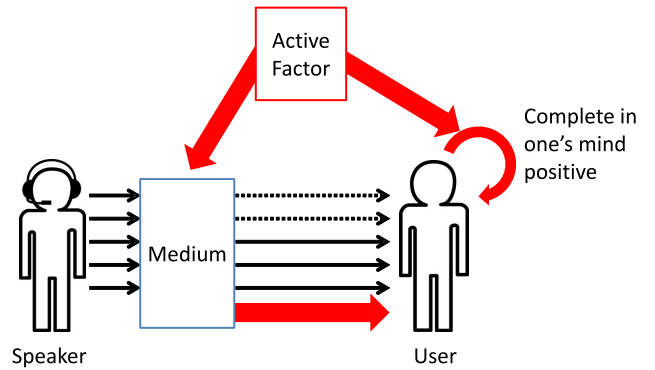
tors to the medium which has less modalities and space to imagine for the interlocutors. We will introduce two experiments which support the hypothesis.

4 EXPERIMENT

Our hypothesis is that we can trigger and input positive impression by adding active factors to the medium which transmit less modalities. We will introduce two experiments and discuss about the hypothesis.

4.1 Hugvie for Young People

Hugvie (Fig. 6) is a communication device with a cushion which users have to hug to communicate with others. In the experiment, we focused on the behavior of hug through the media among young people and revealed that using Hugvie enhances the feeling of being together and being loved compared to Bluetooth headset [16]. All participants were male university students and told to interact with the other participants, which is a recorded female voice played by
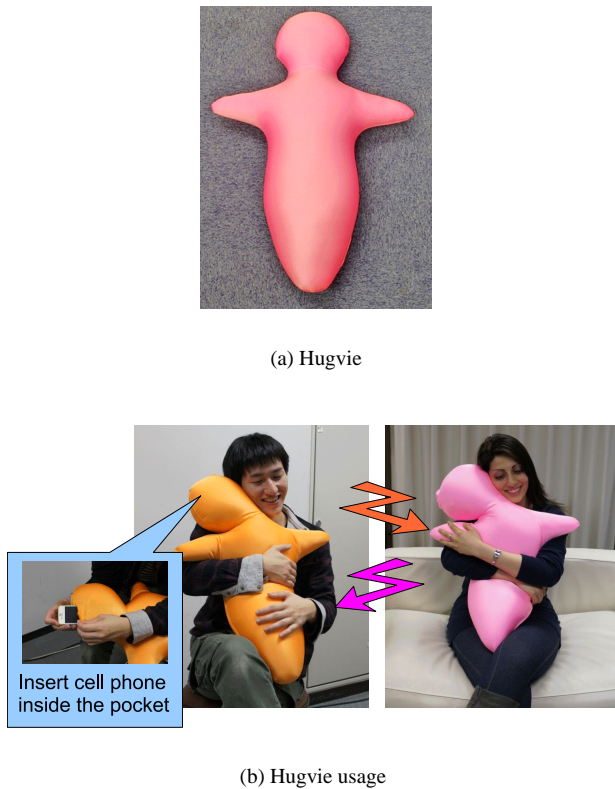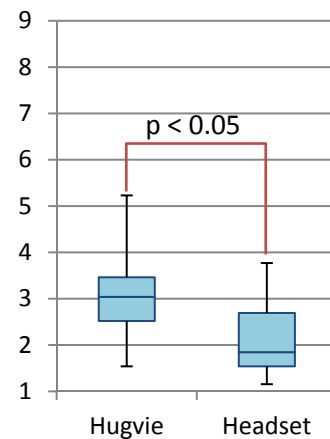
(a) Hugvie

Insert cell phone inside the pocket

(b) Hugvie usage

Figure 6. Hugvie and its usage

(a) Total of loved scale points

(b) Total of liked scale points

Figure 7. Total points of loved-liked scale (vertical axis: average of 9-point scale scores)

experimenter, and watch the movie together. After the interaction, participants answered the questionnaire and the interview.
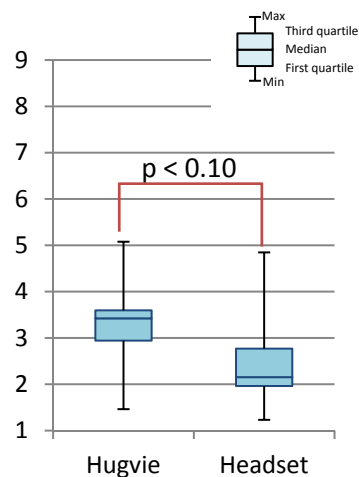
13 items asked about loved and liked feelings on a 9-point Likert scale, and we compared the total points. As the result, those whose total points of loved items exceeded the liked items were four in the with-hug situation and none for the without-hug situation. We compared the loved and liked points between the media and found significant differences in both loved ($t = 1.82$, $p = 0.046$) and liked ($t = 1.39$, $p = 0.095$) (Fig. 7). In both the loved and liked points, the with-hug situation was higher than the without-hug situation.

We asked how impressed the participants were by seven scenes on a 7-point scale. Participants were only more impressed by the scene where the boy says "I love you" than the other scenes indicating that the participants who used Hugvie are more impressed (Table 1). This scene is where you feel ashamed and embarrassed even if watching by yourself. However, we think such feeling will become stronger if you watch with someone else, especially with someone in close relationship. Since significant difference was found indicating that the participants get more impressed when using Hugvie, participants might felt their conversation partner's presence through Hugvie and felt shyness, which result in high impression toward the scene.

We believe this behavior of hug triggers the positive impression. Since the user is hugging when using Hugvie, the user would imagine of good relationship with the speaker. The misattribution would occur and the user falls in love with the speaker. Hugvie allows users to hug and provides physical contact. Compared with a headset, immediate contact of Hugvie causes users to hear a voice from it,

which may enhance the feeling of being whispered. It can be said that Hugvie limits the speaker's appearance, adds the user's behavior of hug, and stimulates the user's sense of hearing and tactile. Since we rely most of our sense on sight, optical illusion may affect the other senses [4, 8, 20, 26]. Limit sight and stimulate other senses which are not mainly used may result in positive impression of a speaker (Fig. 8).

Mediated conversation limits the amount of information transmitted compared with face-to-face conversation. Especially, Hugvie only transmits speaker's voice. Interlocutor cannot identify speaker's appearance nor the behavior. This means that the interlocutor has

[tb]

Table 1. Impressed scenes on movie

Scenes in movie	t-value	p-value
Chasing cat	0.193	0.426
Watching the clock	0.228	0.413
Delivering lunch	1.457	0.094
Eating lunch	-0.909	0.803
Love advice	1.394	0.103
Boy saying "love you"	**1.989**	**0.044**
Girl and boy talking	1.207	0.134

Figure 8. Model of Hugvie

Figure 9. Telenoid R3b

Figure 10. Elderly interacting with Telenoid

plenty of space to imagine and complete the speaker's impression (Fig. 8). Therefore, the impression of the mediated speaker can become more positive or negative than the impression you get when you face the speaker.

When the interlocutor hugged Geminoid to communicate, the user might get to like the speaker. However, we might hesitate to hug for the first time, since the appearance of Geminoid is made to appear as a human. Hugvie, on the other hand, has a plain appearance with a simple modality which reduces the human likeliness mildly. It can be said that the behavior of hug is an active factor which triggers the user to imagine positive impression (Fig. 8). In the Hugvie experiment, the volume of voice coming out from Hugvie is low, which participants have to hug tightly to hear the voice. Such design to afford users to actively hug might trigger positive impression. If the user imagine himself that he is in love with the speaker, he might fall in love with her.

4.2 Telenoid for Elderly

This section introduces how elderly with cognitive disorder constructs a relationship with teleoperated robots through a field work of Telenoid R3b (Fig. 9), the latest version of Telenoid, at elderly facilities. Telenoid is a teleoperated robot with a neutral human-like appearance [25]. Instead of resembling a specific person like Geminoid, Telenoid has a minimalistic human-like appearance that generally resembles a human without any specific personality features. Telenoid has nine independent actuators to synchronize itself with the tele-operator's motion. It can speak, look around, and give a hug. From experiments in Japan and Denmark, we learned that senior citizens are immediately interested in Telenoid from the beginning of their interaction with it [33, 34]. Although Telenoid cannot change

face expression, some elderly say it is smiling. Some re-named it and provided hometowns for it. Such imaginary facts came from the minds of the senior citizens.

The elderly have low cognitive functions and dulled senses due to their age. During communication, we believe they have to imagine the information missing from what they received in their minds. Some phenomena support this hypothesis. Sometimes, the elderly with cognitive disorders have conversations with each other. However, they seem to talk about different things. For example, one talks about the weather and the other talks about lunch. During such conversations, they are taking turns and nodding in response to what their partner is saying. Yet they don't seem to hear or understand what the other is saying. However, they are having a conversation. They seem to guess what the other is saying and continue their conversation. They are completing the information that is missing from what they received and guessing about the rest. Since they have lower cognitive functions, they misunderstand what the other is saying.
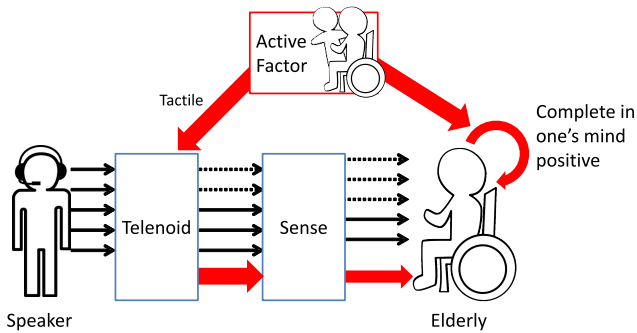
Figure 11. Model of Telenoid

The elderly, especially those with cognitive disorders, seem to complete the information missing in their mind more often than ordinary people. Therefore, such a medium is effective because it positively affects the user imaginations. When a robot is not designed with active factors that elicit positive impressions from the elderly, perhaps they imagine and feel negatively toward the robot. They might be afraid of it. Once they fear it, it is difficult to introduce it to the facilities. A robot that interacts with the elderly needs a design that encourages them to use it. Reliability and comfort are required for a robot that corresponds to the needs of the elderly. By adding factors that create positive impressions (Fig. 11), the elderly have positive impressions toward the robot.

5 CONCLUSION

We proposed the method and the hypothesis of it as to enhance one's affection by reducing the numbers of transferred modalities. We did not design a medium with a beautiful appearance but a medium which ignores the appearance and let users imagine and complete the appearance. Mere voice can make people to have a strong affection toward an unknown person. We triggered imagination of positive impression by inducing active, unconscious behavior of users.

Reducing the number of modalities can be said to avoid representing a real. In Section 4.1, Hugvie only transmitted the voice of the speaker. Since it limited factors such as breath or appearance which in some case turns to negative impression, users did not hesitate to hug and communicate. During the experiment, we controlled the conversation and played the recorded voice. However, only one out of twenty one participants noticed that the voice was recorded. It can be said the limited modalities reduced the unnaturalness of the conversation. It is also ignoring the effect described as the uncanny valley [18]. Less modalities may avoid the high intelligence we expect from an artificial partner. It can be easily put into autonomous. However, we affected the participant's heart.

The method has a possibility to complete the undeveloped part of the artificial intelligence. We would develop an autonomous robot which allows natural conversation.

The experiment was conducted with a communication medium. However, we believe that the method can be applied to a robot. By reducing the numbers of transferring modalities, we can enhance one's affection toward a robot. Moreover, not just transmitting, but by inducing active, unconscious behavior of users, we can increase this effect.

This method is also useful for the communication media to enhance users to communicate. Many people have trouble getting involved with others and establishing relationships. For example, in Japan, the number of unmarried people between 20 to 39 is increasing (White Papers 2013- Government of Japan). Compared with 30 years ago, the proportion never married increases from 2.60% (1980) to 20.14% (2010) for men and from 4.45% (1980) to 10.61% (2010) for women. Although the number of unmarried people is increasing, they are willing to marry. The rates of those who are willing to marry are 86.3% for men and 89.4% for women, which are both high enough (The National Fertility Survey). This result shows that people are willing to marry but cannot. Nowadays, many events are held to support single people to meet with others. Especially, *Machikon* offers a large number of people, 100 men and 100 women for example, to meet with others. The word *machikon* is an abbreviation of *machi* (town) and *gokon* (mixer), and refers to a large-scale mixer held within towns. Some aggregate data infers that the number of people who have participated in Machikon exceeds two million. People are willing to establish relationships but do not know how. Therefore, we would support such people by using the method of enhancing the impression of users to build a close relationship.

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