Pocketable-Bones: Self-Augment Mobile Robot Mediating Our Sociality

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Discussions on human–robot interactions abound in the fields of human–agent interaction and human–robot interaction. Although studies on communication through conversations and physical actions have been conducted, many of these studies focus on robot gaze while neglecting human gaze. In this study, we developed Pocketable-Bones, a mobile robot that can move with the human gaze in mind. This robot can fit in a breast pocket and follows and turns in the same direction a person faces. Notably, we have been investigating the realization of joint gazing in which two persons share interests and concerns through gazing. This study's experiment results showed that Pocketable-Bones' gazing behaviors satisfied the components of self-determination theory in well-being, notably autonomy, competence, and relationship.

Keywords: relational theory approach, mobile robot, eye-gaze behavior, shared intention, well-being

1. Introduction

When walking alone, we tend to concentrate on the scenery in front of us. However, when strolling with another person, we can converse, share each other's perspectives, and gain a somewhat broader perspective of our surroundings, feeling a rapport, commonality, sociality, community, bonding, and a sense of contentment. This kind of expansion of capabilities that were limited when we were alone, by doing them together with someone, has been attracting attention in recent years as self-augmentation in sociality.

Sharing each other's eye gazes while looking at something with participants improves each other's internal, social, and sense of connectedness. We constructed a mobile robot called "Pocketable-Bones" to replicate this phenomenon with a robot (Figure 1). Through fieldwork in which users used Pocketable-Bones in real-world setting, we obtained feedback from them such as "I feel happy when I am with Pocketable-Bones," "It's like a partner," and "It's reassuring."

The purpose of this study is to discuss the mechanisms that give users such unique sensations through qualitative analysis methods. We believe that revealing these mechanisms will expand the application range of mobile robots to psychological aspects and contribute to the development of new assessment methods for mobile robots.

Fig. 1. Walking with "Pocketable-Bones"

In this paper, we describe the background (Section 2), concept and interaction design (Section 3) of Pocketable-Bones, and the results of case studies conducted in three different situations (Section 4). Based on the results, we discuss the principle of designing a mobile robot that extends individual and mediates human sociality (Section 5) and outline future studies and perspectives (Section 6).

2. Background

When a user goes out with the robot, the robot offers the user even more advantages. Ropot, a mobile robot, can alert a child to safety while walking. The shoulder-riding robot NIN_NIN can share its vision with a visually impaired person through a camera or its voice through a speaker for a person who is not fluent in English. The shoulder-riding telepresence robot TEROOS is an anthropomorphic small robot that can be operated remotely to communicate distance. Robohon, a combination of a humanoid robot and a smartphone, allows the user to hang Robohon in a carrying case. This enables users to receive a new service experience of going out with the robot.

While research on such mobile robots has been growing, our proposal "Pocketable-Bones" is a mobile robot that can share and coordinate eye gaze with its user based on side-by-side relationships.

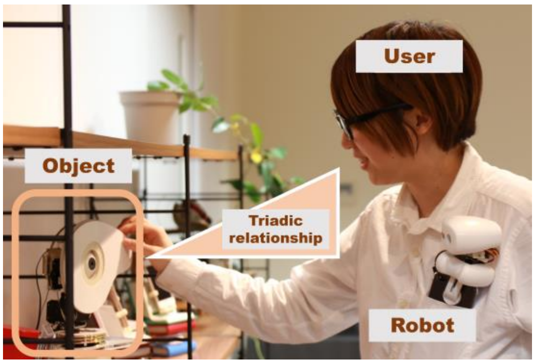

Fig. 2. Triadic relationship between user and robot

Fig. 3. Appearance of "Pocketable-Bones"

2.1. Side-by-side Communication

Many circumstances reveal a side-by-side relationship, such as when a mother and child read a picture book together or when walking in the park with a friend. A side-by-side relationship is one in which people direct their intentions toward a certain target and coordinate with each other, and it is a state in which a sympathetic state is constructed by mutual attachment based on the body within a relationship where common things or events exist between two individuals [3].

For example, when walking in a city with a friend, the exchange of "there's a delicious-looking restaurant there" and "you're right! Let's take a look" is not a confrontational relationship where one conveys their impressions to the other party but a side-by-side relationship where the individuals mutually understand each other's feelings. In addition, side-by-side relationships are formed through conversation and slight body movements. The acts of looking at the same scenery while appreciating the same exhibit or walking alongside each other are all side-by-side relationships.

"We-mode" is a way of thinking that is related to side-by-side relationships [4-5]. In we-mode, interactions in joint actions are not divided into the two categories of "me" and "you" but the single category of "we." In addition, by sharing a singular purpose as "we," the two individuals gain a sense of psychological connection, resulting in happiness and enjoyment. Therefore, communication in a side-by-side relationship is characterized by being able to see things in we-mode.

2.2. Social relationships in joint attention

Joint attention, which seeks to find what other people are looking at, what they are interested in, and how they feel while being attached to the other person, can also be said to be an important process in side-by-side relationships.

Joint attention is the ability to coordinate behavior in order to pay attention to things or topics of common interest with others [6]. The definitions of joint attention differ among researchers, and their definitions are separated between the concepts in a narrow sense and a broad sense.

Butterworth and Jarrett defined the concept in a narrow sense and referred to joint attention as the state in which the infant and other individual are looking at the same place [7]. Meanwhile, Tomasello defined the concept in a broad sense and referred to joint attention as when two people are simply looking at the same object while also monitoring each other's attention [8]. Currently, the broad definition is generally used for joint attention.

Notably, the act of sympathetically understanding the intentions and feelings of others by referring to each other is called social referencing. It is believed that there is a clear intention to refer to information, making this a crucial behavior for establishing social communication.

Joint attention includes not only responsive actions such as eye-tracking and pointing comprehension but also peripheral actions such as an alternating gaze. Alternating gaze is an act in which the eye gaze moves back and forth between the other person and a third object in a triadic relationship. This plays an important role in understanding other people's intentions, such as following the other's attention or trying to change the other's focus of attention [9]. A joint gaze occurs when joint attention is achieved by gazing behavior (Figure 2). In this way, mutual eye contact plays an important role in achieving communication in a side-by-side relationship.

2.3. Social facilitation by robots

Have we ever had the experience where writing in a laboratory or café, where other people are present, was more productive than writing at home by oneself? Social facilitation refers to the phenomenon in which the work we are trying to achieve is made easier by the presence of others nearby [10-11].

A study linked social facilitation with robots [12]. This study involved measuring social facilitation by a robot placed behind the subject and showed that a social facilitation effect existed for simple assignments [13].

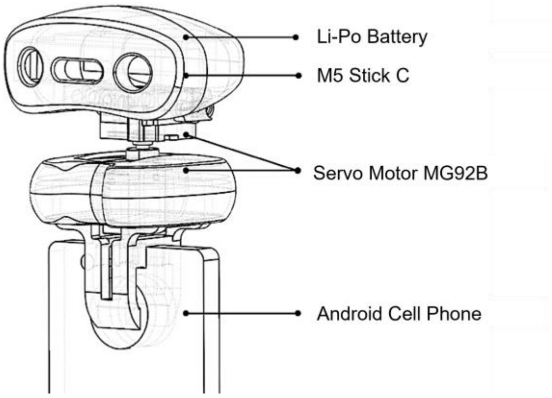

Fig. 4. System configuration

The presence of a robot in the background was shown to have a social facilitation effect similar to that of humans.

However, the social facilitation effect was not observed for complex assignments. Furthermore, the robot made encouraging remarks to the participants, suggesting that the experimental conditions had a large effect. Careful consideration of such factors is a topic for future study, and confirming the effectiveness of a robot's social facilitation in a more convenient environment is necessary.

3. Pocketable-Bones

3.1. Concepts

We constructed Pocketable-Bones as a platform for this research. Figure 3 shows the appearance of Pocketable-Bones. Pocketable-Bones is a robot that can be attached to a smartphone and placed in a breast pocket. The user can carry it to various fields and look at something with the robot.

Pocketable-Bones can share and adjust its eye gaze with the user based on side-by-side communication. When the user looks to the right, the robot looks to the right; when the user looks to the left, the robot looks to the left. When the robot detects a person in front, it autonomously turns its gaze toward the detected person to show its interest. The level of interest is determined by the ratio of smiling detected by the camera. When the user looks at the robot, the robot also returns its gaze to the user and constructs a mutual gaze for communication.

3.2. System Construction

Pocketable-Bones comprises three components: (1) sensing unit JINS-MEME, (2) networking unit Android smartphone, and (3) body unit Pocketable-Bones.

The user wears JINS-MEME, and the 6-axis sensor in JINS-MEME measures the user's eye direction. 20 Hz measurements are transmitted to the Android smartphone via Bluetooth LE. The robot and human gaze direction is calculated by comparing the difference between the Android smartphone's 6-axis sensor values and the JINS-MEME's 6-axis sensor values.

Fig. 5. An Example of interaction with Pocketable-Bones

The entire system is controlled by the Android smartphone, which sends serial data to M5 Stick-C to control the Pocketable-Bones' motors and other devices. The camera, speaker, and 6-axis sensor used in Pocketable-Bones are from the Android smartphone.

We assumed implementing two main modes in the robot, i.e., the tracking and autonomous modes. Here, the tracking mode always follows the direction of the user's head. In the autonomous mode, in addition to the tracking mode, the robot detects a pedestrian and turns its gaze in that direction and to the user. However, the focus of this paper was to qualitatively analyze the effectiveness of the tracking mode as a baseline; thus, we plan to verify the effectiveness of the autonomous mode in future experiments.

3.3. Hardware specifications

Figure 4 shows the CAD design of Pocketable-Bones and its components. More specifically, it comprises a Li–Po battery, M5 Stick-C, two servo motors, and an Android smartphone.

The Android smartphone is connected wirelessly to the Internet and M5 Stick-C via Bluetooth LE. Note that we are actively considering future expansion and want to make the robot behave in a locationally aware manner; thus, we utilized a smartphone to take advantage of several functions provided by such devices, e.g., GPS and cloud services. This will be addressed in future work.

The servo motor is an MG92B with low power consumption. The servo motors are used in the pitch and yaw directions to move the head up, down, left, and right (Figure 5).

The head houses the circuit board and Li–Po battery, a thin DTP603450 Li–Po battery. The battery is mounted inside the head of Pocketable-Bones and supplies power to the servo motors. The battery can run continuously for 3–4 hours.

An Android smartphone is used to control the entire system. The Android smartphone is a Huawei P10 lite (WAS-LX2J).

JINS-MEME ES is used to measure the wearer's eye-gaze direction and is equipped with a three-point eye-potential sensor, an acceleration sensor, and a gyro sensor.

Data acquired from the sensors can be sent to Android and iOS devices via Bluetooth LE.

M5 Stick-C is an ESP32 development board that receives control information from Android via Bluetooth LE and controls Pocketable-Bones.

4. Experiment

4.1. Aim

The purpose of this experiment was to clarify how users feel when they interact with the mobile robot "Pocketable-Bones."

The experimental method was to have the participants interact in one of the following three situations with "Pocketable-Bones" in their breast pockets.

Three experimental situations were (1) walking together, (2) viewing exhibits, and (3) existing in conversation.

The participants were then asked to describe the robot's impressions in depth through free descriptions and semistructured interviews and to attempt to describe them using the Steps for Coding and Theorization (SCAT) method.

We can examine the differences in the robot effect between outdoor and indoor interactions (e.g., 1 vs. 2 and 1 vs. 3) and between individual and multiparty communications (e.g., 1 vs. 3 and 2 vs. 3).

4.2. Evaluation Method

SCAT is a method developed to overcome the following problems of analytical difficulties [14-15]: qualitative data mainly include open-ended statements from interviews and questionnaires, and analyzing qualitative data to derive theories is challenging for uninitiated tasks and may lead to leapfrogging statements.

SCAT consists of describing segmented data in a matrix, coding each of them in four steps, and describing a storyline by weaving together the themes and concepts that comprise the storyline from which the theory is described. The storyline describes the latent meaning and significance of the events detailed in the data extracted together from the constructs.

4.3. Participants

Table 1 shows the attributes of the participants in this experiment. As indicated in the "Situations" section in the right column of Table 1, the participants participated in one or two of the situations (the experimental task).

A semistructured interview was conducted at the end of the experiment. The results of the interviews were described using SCAT. The obtained storylines are presented in Section 5. They are presented for each participant's situation. The sample semistructured interview questions and the process of analysis using SCAT are summarized in the Appendix of this paper.

1) Task A: Walking together

Figure 6 shows a participant of this experiment strolling around our university. The task was set up to investigate the feelings that users experience when they bodily interact with the same scenery or view together.

Fig. 6. Task A: Walking Together

Fig. 7. Task B: Viewing Together

Fig. 8. Task C: Mutual Conversation

Table 1. Participants

User	Sex	Age	Situation
User A	Female	21	Walking
User B	Male	21	Walking
User C	Female	22	Walking
User D	Female	20	Walking + Viewing
User E	Female	17	Talking
User F	Male	17	Talking

2) Task B: Viewing together

Figure 7 shows a participant in the experiment viewing an exhibit. This task was set up to investigate the feelings that users experience when they gaze at the same object in an exhibition room with a variety of exhibits.

3) Task C: Talking together

Participants were fitted with a robot on their pockets and engaged in a brief conversation, including selfintroductions. The task was set up to examine how the robot intervened in the human verbal exchange. Figure 8 shows the environment room in which the experiment took place.

To carry and use the robot, the participants were asked to wear a jacket with a chest pocket, and we confirmed that this requirement did not interfere significantly with the user's natural behaviors. In the following, we present the storylines obtained using SCAT for the results of the user's semistructured interviews in each situation.

5. Results and Discussion

5.1. Task A: Walking together

1) Storyline 1: User A

The box below contains User A's storyline.

When I first saw the robot, it was simple, and I had a good feeling about it. The appearance of a robot, designed with its minimalist design, is sure to appeal to everyone; however, when I placed it in my chest pocket, the method of securing this huge-headed robot seemed unstable. The sound of the servo motor was also a concern. When I walked outside, I was first worried about how passing pedestrians looked at me at the beginning of the walk. However, I soon became accustomed to the stares of those around me over time. As I gradually understood that the robot was gaze-following, I recognized it as another person; a feeling that I was not alone was created, and the sense of loneliness was lost. I also became concerned about the robot and thought that darting my gaze around too much would not be such a good idea. One reason for this was that I was worried about breaking the unstable robot simply by putting it in my chest pocket.

Gazing at the same view together created in us a sense of shared purpose, and this resulted in a sense of closeness and togetherness. Perceiving the robot's movement in the chest pocket in my peripheral vision caused me to feel like I was gazing at the same scenery, as well as feeling curious about what the robot was looking at and wanting to check. It is similar to a pet, but there are differences: you feel a sense of security that the robot will follow you, which is not found in a pet. However, in terms of their willingness to communicate, they are similar to pets. You can sense their intent through collaborative gazing. It was a 10-minute walk, but in terms of the time experienced, it was approximately 8–9 minutes. However, within the margin of error, the experience time decreased due to familiarity with the robot and the reassuring feeling that one was not alone. Because the method of securing the robot was unstable, I supported it with both hands while taking a walk. Combined with its presence in my chest pocket, the feeling of physical contact increased. I did not constantly want to support it, and the distance I felt was just about right, wanting to support it at times. It was easy to interact with the robot because it was at just the right height where I could react quickly if something happened to it.

I said in the beginning that I recognized the robot as being somebody else but not a complete stranger. For example, it is like "two people" when you are walking with somebody else. If walking with a dog, it is like "1.5 people," so walking with a robot feels like "1.7 people." This is because, compared to walking with a dog, you feel a stronger psychological connection when they follow you toward the same goal. This, coupled with the robot's size and design, gave me a sense of familiarity. It was also impressive how it did not immediately follow the direction of my face; there was a time gap, and the tracking movement occurred slightly later. The feeling of the robot "doing its best to follow me" created affectionate feelings and made me want to protect it, something akin to motherhood.

I would like it to follow me when I go on trips on my own in addition to when walking. It does not need to be functional and guide me. It just needs to be there. Another interesting thing was when it was attached to staff at an amusement park. The children were delighted, saying "What is that?" It seemed that the usual obstacles to talking were removed. Regardless of whether or not you are communicating with somebody for the first time, being in their line of sight will lower the barriers to communication. That is to say, it may play the role of a social mediator.

The theoretical descriptions derived from this storyline are presented below.

- A-① Robot eye-tracking makes the user feel not alone and reduces the sense of loneliness.
- A-② The act of looking at the same scenery leads to a shared purpose and creates a sense of closeness and togetherness.
- A-③ It makes me curious to see where the robot is facing.
- A-④ Being in the breast pocket increases the sense of presence due to physical touch.
- A-⑤ Feel the will to communicate with others like a pet.
- A-⑥ The fact that the motion is a slight following motion gives a sense of "she is doing her best to follow me," and a sense of affection and motherhood is generated.
- A-⑦ Act as a social mediator to mediate communication by making movements that match the other person's eye level, regardless of whether they are only meeting for the first time.

2) Storyline 2: User B

The box below contains User B's storyline.

The first impression of the robot was that it was small and cute with a huge head. When I first put it into my chest pocket, I felt uncomfortable with the sound and vibration of the servo motor. In particular, I was more concerned about sound than vibration. However, while walking, any feelings of discomfort gradually disappeared as I became more familiar with its movements over time. It was more stimulating than walking alone, and I was able to walk comfortably without feeling much fatigue. The walking time felt like 3–4 minutes as I was walking with the robot. The vibration was transmitted directly when it was inside my chest pocket. This was easier to understand than only by confirming visually within my field of vision. I can see where the robot is looking in my peripheral vision, but it is not clear. This makes me want to occasionally look directly at the robot to check the direction in which it is looking. A good relationship was created in which I occasionally felt like I wanted to be aware of it. The route I took did not differ from the usual just because the robot was there. As time passed, the sense of discomfort that I felt at first gradually decreased, and it felt as though I was wearing one thing with a shared body.

To take advantage of the robot's good points, I think that there are situations other than walking that take advantage of eye-tracking and have motion. For example, in a zoo—a place where you can choose what to look at—the advantages of the robot will be more effectively demonstrated. I have walked with a dog before, and the robot's response was similar to that of a pet. However, unlike dogs, which suddenly start running or pulling you, the robot gives you peace of mind by not behaving unexpectedly.

The theoretical descriptions derived from this storyline are presented below.

B-①Walking with a robot is more stimulating than walking alone, and one can take a pleasant walk without feeling fatigue.

B-②Since it is placed in the breast pocket, it is easier to receive than to check it only with the field of view due to the transmission of vibration.

B-③Occasionally, I want to look directly at the robot to see how it is doing.

B-④A relationship is established just enough to be aware of it from time to time.

B-⑤Wear one thing and feel as if you are sharing a body.

B-⑥In a situation like a zoo where you can choose what to look at, the robot's advantages can be better demonstrated.

3) Storyline 3: User C

The box below contains User C's storyline.

When I saw the robot for the first time, it was bigger than I had thought, and I got the impression that it often made movements. It looked cute, but the servo motor was very noisy. I could see the face, but the question arose as to which part of its body, other than the face, could belong to an animal. There was no sense of stability in the method by which it was secured, and I was worried about the robot falling. When I started walking, it was discomforting to have things move around in my chest pocket. However, because it was different from what was usual, I started to wonder what would happen to the robot. When I started walking, I tended to look around more than usual. Because the robot moved in accordance with my movements, I felt like I wanted to find out where it was looking. The robot's movements were a little delayed compared to my own. It was because of the delay that I noticed the robot was facing in the same direction when I looked around. Although this was hard to discern when facing downwards, it was easy to understand when climbing stairs. This time, we were viewing scenery, but watching TV or reading a book together might make me happier. The feeling of doing something together rather than alone may be created more by doing this than by walking. On a walk, there is no set object to look at, so I tend to wander around and look at various places. If it is clear what the object to be viewed is, the robot will be more effective. As the walk progressed, the feeling of discomfort that I experienced on first feeling the robot in my chest pocket was reduced. At first, I was anxious about the robot falling, so I supported it while looking at it, but gradually, I no longer needed to do this. I am not saying I was completely relaxed, but I felt it was something I could be with. We keep cats and goats at home. Robots are similar to pets because we cannot communicate verbally with them. In addition, until we know that they will turn in the same direction, there is a common element of not being able to read their behavior. Differences from pets include the fact that their appearance is different and that they are less of a nuisance to others. Also, you would not pat their heads like a pet's. The robot seemed closer to other people than to pets. I would not say that we were really close, but our relationship was like that of a classmate I had spoken to several times. The walking time seemed like 7–8 minutes.

The theoretical descriptions derived from this storyline are presented below.

C-①Become concerned about robots.

C-②When they start walking, they look around more than usual.

C-③The camera moves in accordance with the user's movements, making the user want to look for where he/she is looking.

C-④The robot can be more effective in situations where the object to be viewed is clear.

C-⑤Robots are good to be with.

C-⑥Unlike pets, they are less likely to cause problems for others.

C-⑦Relationships are established with it as friends of classmates.

4) Discussion 1:

The 10-minute walk seemed shorter, less tiring than a normal walk, and less boring. Some users were approached by acquaintances during the walk. They talked to the robot, asked "What is that?," and other communication was mediated. We believe that the robot plays a role as a social mediator [16] that mediates social communication between people, extending the social nature of people.

5.2. Task B: Viewing together

1) Storyline 4: User D

The box below contains User D's storyline.

When I first saw the robot, it was small in size and had a cute appearance. I felt discomfort when I tried putting it in my chest pocket. Usually, I would not put anything other than a smartphone or a small accessory in my chest pocket, and I would never put anything in that move. As I walked, I gradually became less concerned about it, and I was able to walk naturally. Furthermore, as we were looking in the same direction together, I felt that it was feeling the same way I did, and gradually had a feeling of attachment. The difference between such a walk and walking alone is that there is a feeling of wanting to be concerned about the robot. I felt that attaching it to my bag would be more suitable than carrying it. The walk felt like it took about 5 minutes.

In the exhibition room, it felt more like we were looking in the same direction than when we had been walking. This is because, when walking, there are many objects to see and a wide field of view, whereas the objects in an exhibition room are clear, which makes it possible to concentrate on the details. For example, when I was reading something in the exhibition room, it was easier to understand that the robot was also looking in the same direction as me when I read down to the second and third lines.

The theoretical descriptions derived from this storyline are presented below.

D-① Natural viewing even with robots.

D-② By looking in the same direction together, I feel that they feel the same way and gradually become attached to me.

D-③ Feelings of caring about the robot.

D-④ In the exhibition room, the object to be viewed is clear, so there is a strong sense that they are looking in the same direction.

2) Discussion 2

In the exhibition room, the robot had a clear object to look at, so it felt more like it was looking in the same direction than when walking outside. In particular, when the robot read the text on the exhibits, it seemed as if it was reading the same text.

When people take a walk, they do not consciously pay attention to what they see but often walk while looking at things vaguely. It is thought that there are situations in which people look at things carefully during a walk, but there were no such situations during the 10-minute walk.

However, in the exhibition room, where there was a clear object to look at, the robot and the subjects felt a greater sense of joint gazing. This result suggests that when a person is performing a task and the robot is looking at an object together with the person, it elicits a we-mode perception that the robot is also looking at the object together with the person.

5.3. Task C: Talking Together

1) Storyline 5: User E

The box below contains User E's storyline.

By putting the robot in my chest pocket while having a conversation, I felt as if I was not alone. When the user nods, the robot also follows and nods, giving them a sense of affirmation and reassuring them that they understand them. The conversation was more relaxed and less tense than my usual state during one-on-one conversations with other people. Moreover, even from the viewpoint of the other person, a sense of being spoken to by two people was created, and this seemed to improve the ease with which the message was conveyed. The motion of the robot in my chest pocket could somehow be recognized in the peripheral field of view. As its movements were unstable, it felt dangerous. One of the reasons for this may be that it was only secured by being placed in my pocket rather than fixed tightly. However, because of feelings of danger, there are times when you want to support it with your hand. As the vibration of the servo motor is communicated to the user's body, this provides a feeling of connectivity and harmonization. However, the sound and vibration of the servo motor sometimes bothered and distracted me. It also felt heavy because I do not usually put something as heavy as a robot in my chest pocket.

The theoretical descriptions derived from this storyline are presented below.

E-①Gives the feeling of not being alone.

E-②When I nod my head, the robot follows suit and nods, giving me a sense of affirmation that it understands me.

E-③Having a less tense conversation than in a one-on-one situation.

E-④I feel like I can get my story across more easily.

E-⑤Vibrations are transmitted directly to the body, and a sense of connection and synchronization is felt.

2) Storyline 6: User F

The box below contains User F's storyline.

The robot looked at the other person with eye-tracking movements and nodded, making it feel as if there was another person present, even though it was not participating in the conversation. The number of people nodding and listening, increasing to two, provided positive affirmation and made it easier to talk. When concentrating on the conversation, the robot did not interrupt the conversation, and it was not necessary to worry about it. When the conversation faltered, it alleviated the awkwardness and was a reassuring presence. When I was having trouble keeping my eyes fixed on their lines of sight during conversations, I could relax by looking at the robot. However, when trying to look at the other person's line of sight and talk, I felt as if I had to turn my line of sight toward the robot and occasionally felt unsure. Combined with its appearance and size, the way it looked around while peeking its face out of my breast pocket was cute. I did not have any special feelings about the robot, but it did not force its way into the conversation, and it had an acceptable level of separation. However, the way it moved while peeking around sometimes made it appear restless.

The theoretical descriptions derived from this storyline are presented below.

F-① Although the robot is not actually talking to me, I feel as if there is another person.

F-② Increasing the number of others nodding to you to two people gives you affirmation and makes it easier to talk.

F-③ They are reassuring and reduce awkwardness when conversation breaks down.

F-④ When I have trouble finding a place to look, I can relax by looking at the robot.

F-⑤ Robots do not forcibly intervene in conversations.

3) Discussion 3:

These results showed that Pocketable-Bones could mediate people's sociality since they were able to converse with less tension than usual when they had the Pocketable-Bones in their breast pockets, and the awkwardness when the conversation was interrupted was reduced, suggesting that a person's sociality would be extended and communication in conversational situations would be facilitated.

5.4. Overall discussion

Experiment participants were asked questions in a free-response format and semistructured interviews and gave descriptions by SCAT for the following three intersections: (1) taking a walk, (2) appreciating exhibits, and (3) face-to-face conversations.

First, for the (3) conversation scene, (a) the robot did not forcefully intervene in the conversation and was a presence with a moderate sense of distance that the user may or may not notice. In addition, (b) the user was able to have an affirmative feeling of being understood, could talk without being nervous, and felt that they could more easily communicate their stories. In other words, the user felt a sense of affirmation and reassurance. It is thought that this created a worthwhile sense for the user with regards to their actions. Furthermore, (c) the users felt something like the feeling that the robot was listening to the story together and sympathizing with them. It is thought that the users felt a sense of connection and sympathy and that they were not alone.

Next, for the (1) walking scene, users were able to determine their own paths to walk without being forced by the robot and that the robot was a presence that the user did not need to concern themselves with, and concurrently, the user would sometimes want to check where the robot was facing, so (a) the user was able to decide the actions toward the robot of their own will, without being forced to do so by the robot. The (b) feeling that the user could take the robot with them and that the robot is doing its best to follow them can be said to motivate or "make worthwhile" the user's own actions for the robot. It is also thought that the users felt (c) the feeling of sharing the same scenery with the robot. It is thought that this reduced feelings of loneliness, not being alone, and being physically touched.

Finally, for the (3) exhibit appreciation scene, the users similarly had the following impressions: (a) users can appreciate the exhibits naturally, (b) users felt an attachment, and (c) users felt like they were looking at the same object.

As described above, users felt the three types of sensations (a), (b), and (c) by carrying Pocketable-Bones in their breast pockets while talking, walking, and appreciating exhibits. The three sensations listed here correspond to the components of self-determination theory in well-being, specifically autonomy, competence, and relatedness.

Well-being is the state of being in a physically, mentally, and socially "good state" [17-18]. A good state can be rephrased as a lively and happy state in which one's abilities are fully utilized in relation to one's surroundings.

Well-being includes the three areas of "medical well-being," "hedonic well-being," and "eudaimonic well-being." When simply describing "well-being," this is mainly referred to as the third area of eudaimonic well-being. Eudaimonic well-being is the state of being able to demonstrate the potential of the mind and body and to be in a lively state relative to one's surroundings. Here, this eudaimonic well-being is described as well-being.

Self-determination theory states how the components of "autonomy," "competence," and "relatedness" are important to both motivation and well-being [19]. To achieve self-determination, one must first feel that the results of one's activities are due to one's own intentions (i.e., autonomy). Second, one must have the confidence to perceive oneself as competent and to have the ability to resolve issues (i.e., competence). Third, one must feel a sense of security and connection with other people (i.e., relationship).

Because these three factors were confirmed to be satisfied, the interactions with Pocketable-Bones improved user well-being and people felt a sense of inner richness, such as finding actions worthwhile.

6. Conclusion and Future Works

In this study, we conducted experiments with Pocketable-Bones, a mobile robot that fits in a breast pocket and shares the same gaze direction with the user, and clarified the characteristics of its interaction with the user using a qualitative analysis.

In our fieldwork, when we performed demonstrations, people who interacted with the Pocketable-Bones expressed feelings of happiness, partnership, and reassurance. However, we were not able to explain in detail why these feelings arose. Therefore, this study attempted to explore changes in the feelings of users who experienced the robot in depth through semistructured interviews. As a result, we found the hypothesis that the robot mediates people's sociality and that the three elements of self-determination theory in well-being (autonomy, competence, and relationship) are satisfied, which may lead to changes in people's internal states, such as feeling rewarded when they are with the robot. Interestingly, these feelings were similarly observed in both eye-gaze communication and verbal interaction situations.

In the future, we plan to develop a social mediator that expands the possibilities of communication with others for children who have difficulties in verbal and physical communication with others, such as in autism rehabilitation, by placing Pocketable-Bones in their breast pockets, as well as to construct a media aimed at improving the well-being of infants and children that has the effect of lowering barriers to communication, and to work on its social implementation in various fields.

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