Development and Evaluation of an Interactive Therapy Robot

Tomoko Kohori[1(✉)] , Shiho Hirayama[1], Takenori Hara[1],
Michiko Muramatsu[1], Hiroyuki Naganuma[1], Masayuki Yamano[2],
Kazuko Ichikawa[2], Hiroko Matsumoto[2], and Hiroko Uchiyama[2]

[1] Dai Nippon Printing Co., Ltd., 1-1-1, Ichigaya-Kagacho, Shinjuku-ku,
Tokyo 162-8001, Japan
Kohori-T@mail.dnp.co.jp
[2] Joshibi University of Art and Design, 1-49-8, Wada, Suginami-ku,
Tokyo 166-8538, Japan

Abstract. Interactions with animals can enhance emotions and improve mood by engendering feelings of healing, relaxation, comfort, and reduced stress. Un-fortunately, many people cannot live with animals because of allergies, infection risk, or risk of damage to rental housing. To address these problems, some research groups have investigated robot-based psychotherapy. However, the important healing elements for therapy robots were not identified. Therefore, we conducted an Internet survey to determine the design elements of such a robot that might engender a healing mood and the functions that should be implemented. We assumed that a healing mood could be induced based on the interactive functions and appearance. To verify this hypothesis, we developed and evaluated a new interactive therapy robot. Next, we conducted interviews with individuals who interacted with a prototype therapy robot. The interviews revealed that the appearance of the robot was critical to engendering feelings of healing, comfort, and empathy. In addition, the size, softness, and comfort of the interactive therapy robot contributed to people feeling affection towards it. We also confirmed the importance of the robot appearing to listen to those who interacted with it. Our results should be useful for designing companion robots for therapy purposes.

Keywords: Healing elements
Therapeutic robots designed to communicate with humans · Therapeutic effect

1 Introduction

The number of single-person households in Japan has increased. The summary report of the 2015 national census revealed that 13.1% of Japanese households consisted of one person, and this is expected to increase to 37% by 2030. In particular, the number of single-person households comprised of 50-year-olds is anticipated to increase [1]. Single

people can enjoy freedom and a lack of imposed restrictions. However, such individuals may feel loneliness or anxiety and may therefore want something to make them feel happy, at peace, or a sense of healing. In this paper, we use the word "healing" in the sense of relaxation, comfort, reduced stress, and feeling reinvigorated and refreshed.

The use of animal therapy has greatly increased and has been in the spotlight. Interactions with animals are known to improve mood and engender a feeling of healing [2, 3]. Having pets at home is a form of animal therapy. Today, pets are not akin to livestock. In fact, more than 85% of pet owners regard their pets as family [4]. Accordingly, the pet-related marketplace has been steadily expanding [5].

However, the number of people who want a pet but cannot own one is close to the number of people who actually have pets. The reasons for this lack of ownership vary from person to person. For example, there are housing restrictions in Japan. Pets are not allowed in almost all rental properties, such as condos or apartments [6]. The risk of allergic reactions [6] or infection [7] also exists. Pet-sitting issues are also important. Age-related health problems render elderly individuals hesitant to own pets. Single-person households cannot leave pets alone for an extended period when individuals travel. These are the reasons why many people have lost the opportunity to live with pets. Consequently, people have also lost the opportunity to receive healing.

Therefore, we propose an interactive therapy robot to provide healing to people who have difficulty living with pets. We also propose that the interactive therapy robot will become a new partner that can replace pets. Some research groups have investigated robot-based psychotherapy. However, the important healing elements for therapy robots were not identified. In this study, we hypothesized that a healing mood is engendered by a robot's interactive functions and appearance. Additionally, we conducted a large-scale Internet survey to investigate when and how people experience healing, what the important healing elements are, and what interactive functions should be implemented by a robot. We then extracted the appearance elements and interactive functions for the interactive therapy robot with the cooperation of our assumed target. Therefore, our results should be useful for designing companion robots for therapy purposes.

In this paper, Sect. 2 describes prior related research. Section 3 describes an Internet survey that investigated the interactive functions or elements that are important for engendering healing. Section 4 describes the system design. Section 5 describes the interview evaluations of our system. Section 6 discusses the study outcomes, Sect. 7 offers conclusions, and Sect. 8 details the proposed future work.

2   Related Work

Some research groups have investigated robot-based psychotherapy. Paro is one of the most popular psychotherapy robots. Paro, which looks like a baby white seal, can interact with people by touching or talking. Wada et al. [8] demonstrated that Paro can suppress the progress of dementia. Unazuki-Kabochan is a stuffed toy robot that looks like a three-year-old boy. He can communicate by nodding, playing games, and engaging in physical exercise [9]. Watanabe et al. [10] demonstrated improvements in elderly people's cognitive function, fatigue, motivation, and healing after living with

Unazuki-Kabochan at home for eight weeks. The stuffed toy robot Primopuel can recognize certain actions like being touched or picked up and can react accordingly. Primopuel can also change personality upon receiving these stimuli [11]. The robot dog AIBO uses its legs to express emotions or entertains people by performing. It has sensors that allow it to recognize environments and communicate with people [12, 13]. More than 150,000 were sold worldwide [14].

Research exists that focused on the robot's appearance. Takahashi reported that the appropriate design of the robot's appearance can increase its emotional impact on people. Consequently, the robot will be more effective. Conversely, if a robot's appearance is poorly designed, the robot be incompatible with people or will generate feelings of uneasiness [15]. Mori et al. [16] evaluated people's impressions of huggable dolls. He found that for such dolls to be viewed favorably, they should (1) perform some actions, (2) feel soft, (3) be of sufficient size to hug, and (4) be of sufficient weight (i.e., approximating that of a baby). These researchers also reported that a stuffed toy was superior to a doll in terms of engendering affection, healing, and affinity.

For three days we evaluated Unazuki-Kabochan and Primopuel. These robots have interactive functions, as described above; however, we felt that the robots communicated with us unilaterally and unexpectedly. Moreover, we were not able to empathize with the robots and could not feel healing because of their human-like appearance and the fact that they were uncomfortable to hold. These observations were also reported in the study of Takahashi and Mori. Additionally, Paro was designed for its appearance, comfortable hold, and interactive reactions, but we were unable to feel healing as a first impression because its appearance was specialized for nursing care or elderly people.

Therefore, we hypothesized that a healing mood is engendered by a robot's interactive functions and appearance. We proposed an interactive therapy robot that could engender a healing mood and with which one could empathize, similar to a pet.

3   Internet Survey

We conducted an Internet survey to investigate when and how people feel healing, what are the important healing elements, and which interactive functions should be implemented by a robot. We also investigated the characteristics and lifestyles of people.

3.1   Participants

A total of 400 Japanese participants were recruited via the online web questionnaire service ELNE in Japanese. Please refer to Appendix 1 for an overview of ELNE. We recruited 50 males and 50 females from each age group (30's, 40's, 50's and 60's).

3.2   Survey Items

We generated survey items that focused on the participants' desired mood and their feelings toward human and non-human companions, such as animals, pets, dolls, stuffed toys, partners (spouse, lover), friends, and children, to understand when and how the

people feel healing, and to understand the respondents' characteristics and lifestyles. This survey was conducted in Japanese. See the Appendix 2 for details of the survey items.

Desired Moods. We assumed that healing elements are different from person to person. We also assumed that people who are in their desired mood would tend to experience healing feelings. We selected the mood choices from Megatrends 2014–2013 [17].

Feelings Toward Human and Non-human Companions. We often feel healing when interacting with familiar companions, such as animals, pets, dolls, stuffed toys, partners, (spouse or lover), friends, and children. Therefore, we assumed we could extract healing elements by assessing feelings toward such companions. We selected the feelings from related studies [16, 18, 19].

3.3 Survey Results

Analysis of Healing Elements. We used factor analysis with varimax rotation to extract these elements from the answers to survey questions that addressed the desired mood. We used Kaiser's criterion to determine the number of factors. Four factors ware extracted with a total explained variance = 75.3%. Please refer to Table 1. We named the 4 factors as follows.

- Factor 1: Desire for strong stimuli.
  Loadings were high on "I want to feel satisfied," "I want to have fulfilling days," "I want to feel impressed," and "I want to be excited."
- Factor 2: Desire for easing my mind.
  Loadings were high on "I want to relax," "I want to be calm," "I want to be chilling out," and "I want to ease my mind."
- Factor 3: Desire for easing stress.
  Loadings were high on "I want to feel released," "I want to be free," "I want to feel freshness," and "I want to feel refreshed."
- Factor 4: Desire for recognition.
  Loadings were high on "I want to be praised" and "I want to be encouraged."

We assumed that Factor 2 represented healing elements.

Next, we conducted cluster analysis based on the results of the factor analysis. Four clusters were extracted. We named the 4 clusters as follows and Table 2 shows the mean factor scores within each cluster.

- Cluster 1: Desire to vent energy.
  Scores were high for the factors "desire for strong stimuli" and "desire for easing stress."
- Cluster 2: Desire for easing stress and being at ease.
  Scores were high for "desire for easing my mind" and "desire for easing stress."
- Cluster 3: Desire for recognition.
  Scores were high for "desire for recognition."
- Cluster 4: Desire for easing my mind.
  Scores were high for "desire for easing my mind."

Table 1. Factor analysis of desired mood

Questionnaire items	Factor 1	Factor 2	Factor 3	Factor 4
I want to feel satisfied	0.748	0.38	0.253	0.201
I want to have fulfilling days	0.723	0.389	0.242	0.189
I want to feel impressed	0.722	0.262	0.327	0.302
I want to be excited	0.711	0.24	0.322	0.287
I want to feel happiness	0.69	0.4	0.302	0.215
I want to be crazy about something	0.685	0.306	0.3	0.257
I want to have confidence	0.628	0.338	0.274	0.279
I want to enjoy myself	0.626	0.39	0.287	0.193
I want to treat myself	0.516	0.39	0.162	0.308
I want to spice up my life	0.46	0.173	0.334	0.34
I want to relax	0.2	0.784	0.278	0.211
I want to be calm	0.245	0.761	0.214	0.271
I want to be chilling out	0.228	0.747	0.199	0.263
I want to ease my mind	0.447	0.745	0.317	0.12
I want to feel at ease	0.377	0.74	0.326	0.201
I want to feel healing	0.502	0.686	0.287	0.143
I want to feel at home	0.409	0.682	0.391	0.186
I want to feel comfortable	0.48	0.67	0.357	0.103
I want to be relieved	0.519	0.646	0.302	0.16
I want to be released	0.317	0.406	0.715	0.2
I want to be free	0.362	0.452	0.652	0.18
I want to feel freshness	0.477	0.39	0.557	0.242
I want to feel refreshed	0.402	0.466	0.555	0.183
I want to feel fine	0.457	0.372	0.55	0.222
I want to cheer up	0.465	0.363	0.544	0.218
I want to be praised	0.311	0.283	0.184	0.808
I want to be encouraged	0.395	0.244	0.217	0.748

Cluster 4 includes the healing elements of Factor 2. Table 3 shows the characteristics of Cluster 4. People in Cluster 4 currently lived with family. However, they were predominately middle aged (36.2% in their 50's). In the 2030s this cluster will likely be formed of elderly, single-person households. Cluster 4's characteristics and lifestyle were characterized by "during holidays, I am at usually at home" and "during holidays,

Table 2. Mean factor scores within each cluster

Factor	Cluster 1 (n = 48)	Cluster 2 (n = 42)	Cluster 3 (n = 205)	Cluster 4 (n = 103)
Factor 1: Desire for strong stimuli	1.096	-1.159	-0.219	0.390
Factor 2: Desire for easing my mind	-0.942	0.585	-0.302	0.787
Factor 3: Desire for easing stress	0.669	0.765	-0.183	-0.254
Factor 4: Desire for recognition	-0.673	-0.752	0.547	-0.459

I spend time alone." However, positive responses were frequently provided for "I sometimes want to communicate with my family" (49.5%) and "I feel so lonely during my daily life" (46.7%). Therefore, we found that Cluster 4 needed something to engender a feeling of healing.

Table 3. Characteristics and desires of the "easing my mind" cluster

Questionnaire item	Characteristics
Gender	Predominately female (56.2% of individuals)
Age	Middle aged, many in their 50's (36.2%)
Occupation	Many with part-time jobs (15.2%)
Annual household income	Over 5,000,000 yen (42.9%)
Family structure	Two generations of family living together (parents and children)
Disposable income	Greatest amount of all clusters. Over 30,000 yen for 42.9% of cluster members
Stress level	"Frequent" and "sometimes" accounted for 78.1% of responses
Money to reduce stress	Percentage spending money to reduce stress was the highest (36.2%) among all 4 clusters
Relationships between people or things	• Among the 4 clusters, most frequently responded "during holidays, I am usually at home" (71.4%) and "during holidays I spend time alone" (71.4%) • Individuals in this cluster had few relationships with others, but commonly responded "I sometimes want to communicate with my family" (49.5%) and "I feel so lonely during my daily life" (46.7%)
Everyday activities	This cluster represented indoor types. Percentages were high for the items "I watch TV, DVD, cinema, comics, anime" (53.3%), "I eat delicious foods" (38.1%), "I eat sweet foods" (37.1%), and "I clean and keep my room tidy and in order" (36.2%)

Cluster 2 (desire for easing stress and being at ease) also included the healing elements of Factor 2. Table 4 shows the characteristics of Cluster 2. We found that Cluster 2 included many middle-aged people (31.0%) and single households (57.1%). This cluster will also grow old and likely form single households by the 2030s.

Table 4. Characteristics and desires of the "easing stress and being at ease" cluster

Questionnaire item	Characteristics
Gender	Predominately male (54.8%)
Age	Older; mainly in their 40's (31.0%)
Occupation	Office and public workers (38.1%), unemployed or retiree (21.4%)
Annual household income	This cluster was predominately formed of people with average income
Family structure	Many single-person households (57.1%) with the desire to vent energy
Disposable income	Compared with other clusters, percentage with greater than 10,000 yen was the lowest (42.9% of respondents)
Stress level	"Frequently" and "sometimes" accounted for 78.6% of responses
Money to reduce stress	• Percentage of spending money to reduce stress was the lowest (21.4%) among the 4 clusters • Percentage spending over 500,000 yen to reduce stress was the highest (4.8%) among the 4 clusters
Relationships between people or things	• Percentage reporting "I have good relationships with my family and my friends" was the lowest (59.5%) among the 4 clusters and the percentage reporting "during holidays, I am usually at home" was as high as in the "desire for easing my mind" cluster • This cluster liked to spend time alone, as evidenced by the fact that responses to "I think maintaining relationships with my friends via Facebook and SNS is troublesome" were most frequent among the 4 clusters (52.4%)
Everyday activities	This cluster usually liked to have a relaxing day, as evidenced by the high percentage responding "I drink coffee, tea, herbal tea" (54.8%), "I read books" (54.8%), and "I take a bath, half bath, or a sauna"

In addition, of the 4 clusters Cluster 2 least frequently responded "I have good relationships with my family and my friends" (59.5%) and most frequently responded "during holidays, I am usually at home" (71.4%). These responses show that Cluster 2 individuals had poor relationships with their environment. Therefore, we suggest that Cluster 2 also needed healing. Please refer to Appendixes 3 and 4 for the characteristics of the other clusters.

Interactive Functions that Should be Implemented by the Robot. We often feel healing when interacting with human and non-human companions, such as animals, pets, dolls, stuffed toys, partners, friends, and children. Therefore, we assumed we could determine the healing elements by analyzing answers to the question, "How do you feel about human and non-human companions?"
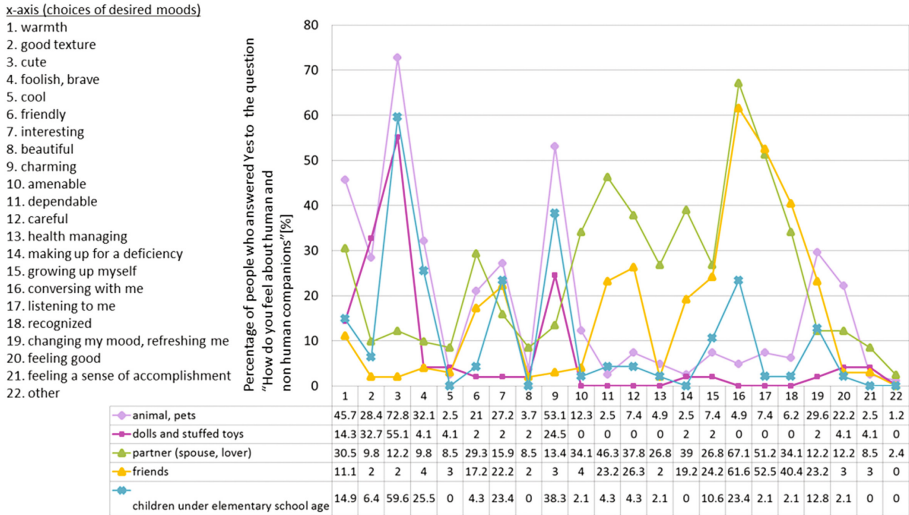
x-axis (choices of desired moods)
1. warmth
2. good texture
3. cute
4. foolish, brave
5. cool
6. friendly
7. interesting
8. beautiful
9. charming
10. amenable
11. dependable
12. careful
13. health managing
14. making up for a deficiency
15. growing up myself
16. conversing with me
17. listening to me
18. recognized
19. changing my mood, refreshing me
20. feeling good
21. feeling a sense of accomplishment
22. other

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
animal, pets	45.7	28.4	72.8	32.1	2.5	21	27.2	3.7	53.1	12.3	2.5	7.4	4.9	2.5	7.4	4.9	7.4	6.2	29.6	22.2	2.5	1.2
dolls and stuffed toys	14.3	32.7	55.1	4.1	4.1	2	2	2	24.5	0	0	0	2	2	0	0	0	0	2	4.1	4.1	0
partner (spouse, lover)	30.5	9.8	12.2	9.8	8.5	29.3	15.9	8.5	13.4	34.1	46.3	37.8	26.8	39	26.8	67.1	51.2	34.1	12.2	12.2	8.5	2.4
friends	11.1	2	2	4	3	17.2	22.2	2	3	4	23.2	26.3	2	19.2	24.2	61.6	52.5	40.4	23.2	3	3	0
children under elementary school age	14.9	6.4	59.6	25.5	0	4.3	23.4	0	38.3	2.1	4.3	4.3	2.1	0	10.6	23.4	2.1	2.1	12.8	2.1	0	0

Fig. 1. Analysis of answers to the question, "How do you feel about human and non-human companions?"

Therefore, we analyzed Cluster 4 and Cluster 2, which included the healing elements of Factor 2. We asked for opinions regarding animals and pets, dolls and stuffed toys, partners, friends, and children. Figure 1 shows the results. We extracted elements that were considered important by more than 40% of the respondents. As a result, the following 5 elements were extracted. These are the 5 elements that should be implemented by a therapy robot:

- Listening to me.
- Conversing with me.
- Warmth.
- Cute.
- Charming.

We omitted implementing "dependable," "making up for a deficiency," and "recognized" because we believe that to implement those elements would require aggregate high-level artificial intelligence. We hypothesized that a healing mood is engendered by a combination of the interactive functions and appearance of a robot companion. We assumed that "listening to me" and "conversing with me" represent interactive functions. We also assumed that "warmth," "cute," and "charming" would be facilitated by the design of the robot's appearance.

4   Implementation

We developed the interactive therapy robot based on answers to the questionnaire survey.

4.1   Interactive Functions

- Listening to me.

The interactive therapy robot can recognize and track human faces and nod while someone is talking, as if it is listening to the speaker.

- Conversing with me.

The interactive therapy robot can recognize voices and reply by speaking words. Unfortunately, the robot does not have a spontaneous speech-dialogue system, or a rule-based speech-dialogue system. Therefore, its conversational ability is limited.

4.2   Design

- Warmth.
- Cute.
- Charming.

We assumed that the robot made a good impression on people from the appearance such as "warmth", "cute", and "charming". We used a stuffed toy for the robot exterior since we assumed that its appearance would be suitable for conveying healing to the user. We considered the material of the face, the body components, and their placement. The stuffed toy approximated the size of a newborn baby, at 50 cm tall and with a weight of 3,000 g. Figure 2 shows the robot's appearance. We especially designed an interactive therapy robot that leaves a good first impression on people. Compared to the traditional teddy bear, we made the stuffed toy closer to the body balance of bear characters preferred by the Japanese. Additionally, by shortening the length of the stuffed bear arms, the stuffed toy was easy to hold. Regarding the nose of the stuffed bear, we attempted to preserve the natural morphology and color of the nose of a bear while incorporating a camera. For the material of the body, we emphasized a soft touch and used a silk material that is even softer than the mohair traditionally used. In addition, given that the motor drive sound would spoil the user experience, we chose a quiet electronic pan head for the head motion. We were also careful not to let the hardware directly touch the user.

Harlow [20] reported that the appropriate tactile properties can engender a sense of security, strong attachment, and feelings of healing. Additionally, we decided upon a teddy-bear like appearance for our robot because a character-ranking report [21] indicated that teddy-bears are very popular. In the report, Winnie the Pooh was the second most popular character, Rilakkuma was in sixth place, and Kumamon in tenth place. Winnie the Pooh, Rilakkuma, and Kumamon are all very famous bear characters in Japan.

Fig. 2. Appearance of the interactive therapy robot

4.3 System Configuration

As shown in Fig. 3, the interactive therapy robot has a camera with a quiet electronic pan head (Motrr Galileo), a speaker, an android smartphone (Nexus 7) for conversation, an iPhone for controlling the camera pan head, and a PC for implementing face recognition and face tracking. We carefully installed the hardware inside the body so that it does not come into direct contact with the user.
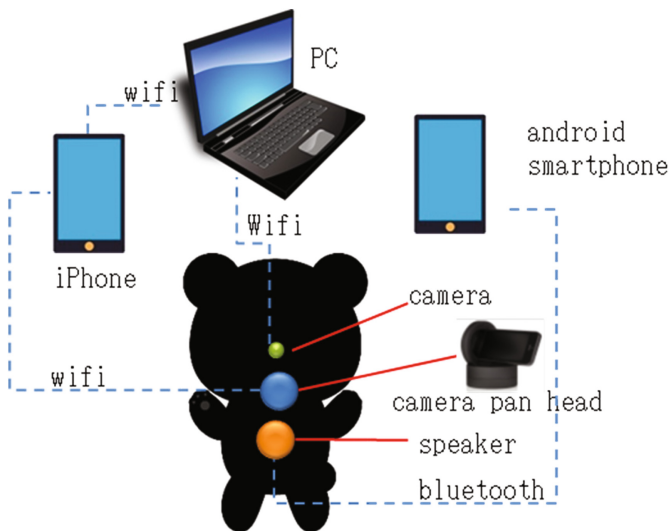

Fig. 3. System configuration

- Listening to me.

We used the image-processing library, Open CV, for face recognition. The camera pan head was installed at the neck. When a human face is detected, the camera pan head moves the bear's head to face the human. In addition, using the camera pan head, the bear can make a nodding motion. As a result, this robot can recognize and track human faces and nod while someone is talking, as if is listening to a human conversation.

- Conversing with me.

The interactive therapy robot can recognize voices and return words. We used NTT DoCoMo's voice recognition SDK for Android v2.1.1 and voice synthesis SDK for Android v1.0.2 [22]. The system converts recognized voices to strings, and then matches the strings to a rule-based conversation chart to find a suitable response. The response string is then synthesized to voice. Thus, the robot and human user can engage in conversations. Unfortunately, our system is not a spontaneous speech dialogue system, but rather a rule-based speech dialogue system. Therefore, its conversational ability is limited. Please refer to Appendix 5 for the details of the conversations.

5   Interview Evaluations of the Interactive Therapy Robot

We evaluated the acceptability of the interactive therapy robot through face-to-face interviews. During the interview, the participant could directly touch and converse with the robot. Moreover, we investigated the relationship between the participants and their "real" pets, including under what circumstances the participants felt the charm of their pets.

5.1   Interview Style

We conducted group and individual interviews. We changed the participants for each interview.

5.2   Participants

In the Internet survey, we found that Cluster 4, with "desire to ease my mind," had the largest score on healing Factor 2, "desire to ease my mind," and people reported that they felt healing from human and non-human companions, such as animals, pets, dolls, stuffed toys, partners, friends, and children. In addition, they needed something that provided a feeling of healing. Therefore, we recruited Japanese participants for whom pets and stuffed toys were important. Please refer to the following criteria for the survey participants.

Criteria for Participants.

- Group interview: 6 people in total.

We recruited Japanese males and females in their 40's and 50's who currently had dogs as pets and assigned a high importance to their pets. This is because dogs are the most popular pets in Japan. The national breeding survey of the Japan Pet Food Association showed that dogs were the most popular (23.1%) of all pets [23].

- Individual interviews: 5 Japanese people in total.

  (1) Placed a high importance on stuffed toy animals in everyday life, with particular emphasis on luxury stuffed animals or toys: 1 person.
  (2) Placed a high importance on stuffed toy animals in everyday life, with particular emphasis on character stuffed animals or toys, such as Disney characters: 2 people.
  (3) Purchasers of interactive robots: 2 people.

Please refer to Tables 5 and 6 for details of the attributes of the participants.

Table 5. Attributes of group-interview participants

ID	Gender	Age	Occupation	Species of their dog
1	Male	50's	Office-worker	Miniature schnauzer Toy poodle
2	Male	40's	Office-worker	Miniature schnauzer
3	Male	40's	Office-worker	Miniature schnauzer
4	Female	40's	Unemployed	Cocker spaniel Australian kelpie
5	Female	50's	Part-time worker	West Highland white terrier
6	Female	50's	Unemployed	Shih-tzu

Table 6. Attributes of individual-interview participants

ID	Gender	Age	Occupation	Their stuffed toys/robots
A	Female	30's	Unemployed	AIBO [12]
B	Female	40's	Unemployed	Pepper [24]
C	Female	30's	Preschool teacher	Stuffed toy owls
D	Male	20's	Transportation	Tissue box cover of Marukunaru-Miku [25]
E	Male	40's	IT	Homemade teddy bear, teddy bear made by Steiff [26], and AIBO [12]

5.3 Survey Procedure

We conducted the group and individual interviews according to the following procedure in Japanese.

The participants talked about their pets, their stuffed toys, and their robots. Then, they were interviewed regarding the charm of, and their relationship with, their pets, stuffed toys, and robots. Next, they were shown the interactive therapy robot, directly handled it, and had a conversation with it. Finally, they were interviewed regarding the interactive therapy robot.

5.4   Interview Results

Charm of Pets, Stuffed Toys, and Robots. We obtained responses regarding the charm and rewarding feeling associated with pets, stuffed toys, and robots, as summarized below. Please refer to Appendix 6 for details of the results of the interviews.

- Living with pets heals me and makes me happy.
- Living with stuffed toys and robots makes me feel better and I think they are cute.

Relationships with Pets, Stuffed Toys, and Robots. We obtained responses regarding the interviewees' relationships with their pets, stuffed toys, and robots, as summarized below. Please refer to Appendix 7 for details of the results of the interviews.

- My pet is a member of my family and it is normal to spend time with it.
- I cannot imagine life without my stuffed toys and robots; my stuffed toys and robots are members of my family.

Communication with Pets, Stuffed Toys, and Robots. We obtained responses regarding interviewees' communication with their pets, stuffed animals, and robots, as summarized below. Please refer to Appendix 8 for details of the results of the interviews.

- I can understand how my pets feel based on their facial expressions. Conversely, my pets understand my feelings.
- The stuffed toys and robots are <u>not</u> only belongings. I can understand how my stuffed toys and robots feel. Moreover, my stuffed toys and robots can understand how I feel and they are always sympathetic towards me.

Evaluation of the Interactive Therapy Robot. We present the evaluation results below.
Appearance.

- Visual.

The interactive therapy robot looked cute and the participants viewed it favorably. Participants who liked the stuffed bear also liked its functions as an interactive therapy robot. The participants who did not own robots said that the interactive therapy robot is cute as a stuffed toy. Please refer to Appendix 9 for details of the results of the interviews.

- Size.

The size was considered to be optimal. Please refer to Appendix 10 for details of the results of the interviews.

- Weight.

Considered as a robot, the interactive therapy-robot was lighter than participants expected. In contrast, considered as a stuffed toy, it was heavier than participants expected. Please refer to Appendix 10 for details of the results of the interviews.

- Texture.

The texture was evaluated as very good, exhibiting softness and warmth. The participants who owned robots evaluated it as better than their robots because it was soft and had warm characteristics. The participants who evaluated it positively, also provided positive opinions regarding other characteristics of the robot. Please refer to Appendix 10 for details of the results of the interviews.
Interactive Functions.

- Motions While Listening.

Motions while tracking participants' faces, nodding, and the act of answering the user were considered cute. However, it was suggested that the interactive therapy robot would be more engaging if it displayed more head motion and moved as if it were listening intently. Please refer to Appendix 11 for details of the results of the interviews.

- Engaging in Conversation.

Opinion was divided with respect to whether no conversation was better than the robot attempting to engage in conversation more effectively. The participants who liked no conversation said that the robot would be better if it made non-speech sounds and used mimicry to display reactions. They also said it would be sufficient if one could understand the condition and expressions of the robot through the sounds it makes. In contrast, the participants who liked conversation preferred simple conversations and expected valid, quick responses. The opinion was expressed that if the robot could not engage in proper conversation, then no conversation would be far preferable. All participants said that they wanted the robot to have a clear voice.

In addition, the following merits of the interactive therapy robot were suggested. Please refer to Appendix 12 for details of the results of the interviews.

- The participants were more amenable to the stuffed-bear interactive therapy robot than the extant robots.
- The participants thought that the stuffed-bear interactive therapy robot was humorous.
- There would be no need to take care of the robot when the participants became elderly and infirm. This was considered a major positive aspect of the robot.

These results reveal that participants who already owned commercial robots had a low threshold for accepting an interactive therapy robot.

6   Discussion

6.1   Target of the Interactive Therapy Robot

We assumed participants in Cluster 4, with a desire to ease their minds, would tend to own pets, stuffed toys, and robots. In fact, the members belonging to Cluster 4 indeed owned multiple pets, stuffed toys, and robots. These people recognized their pets, stuffed toys, or robots as not only their belongings, but also as entities that could engender a feeling of healing. Participants found value in such a feeling of healing. We realized that Cluster 4 was the appropriate target of the interactive therapy robot because the acceptability of the robot to members of Cluster 4 was high. Additionally, we found from the interviews that the participants who owned commercial robots such as Pepper and AIBO had low thresholds for accepting the interactive therapy robot. However, the participants felt that the softness and warmth of the interactive therapy robot was much better than those of their own commercial robots. Therefore, we realized that people who already own robots are a good target for the interactive therapy robot.

In contrast, participants who did not currently own robots said the interactive therapy robot was cute as a stuffed toy. Additionally, they said it became even cuter due to the addition of motion and conversation. We realized that robots in the form of a stuffed toy can induce a friendly or healing mood, because even participants who were not generally interested in robots felt attachment toward the interactive therapy robot.

6.2   The Appearance of the Interactive Therapy Robot

Visual. Participants who answered that the interactive therapy robot was cute and who initially felt at ease with it, issued positive opinions in response to all questions. Therefore, it was suggested that the appearance of the robot played an important role in inspiring peace and empathy in the user. This result supports Takahashi's report that by appropriately designing the appearance of a robot we can increase its emotional importance to the robot and will be more effective than otherwise [15].

That is, Takahashi suggests that the emotions engendered by a robot and its performance are contingent on its appearance. Therefore, his report supports our interview results. We found that the stuffed bear design engendered feelings of healing in people.

The attachment theory of Bowlby defines attachment as an emotional connection that forms between people and animals [27]. Approach behavior, hugging or clinging, is one of the attachment behaviors. It is easy to engage in this approach behavior and become physically attached to the interactive therapy robot, because the robot's arms are open. We believe that this aspect of its appearance was one of the reasons for the positive evaluations it received.

Size. The participants considered that the robot was size appropriate. The interactive therapy robot is about 50 cm long. This approximates the size of a newborn baby, and is easy to hold.

Weight. Considered as a robot, the interactive therapy robot was evaluated as lighter than participants expected. We explained that "this is a robot" before participants

touched and held it. As a result, the interactive therapy robot was considered to be light. Conversely, as a stuffed bear, the interactive therapy robot was evaluated as heavy, because we explained that "this is a stuffed toy." We assume that this result is because the imagined weight of the stuffed animal differed from its actual weight. Therefore, we will conduct interviews in the future that will allow us to evaluate perceptions of weight more accurately.

Texture. The texture of the robot was evaluated as very good, whereby it conveyed softness and warmth. Of relevance is the report of Harlow that if one touches something that has a pleasant texture, it can convey a high sense of security and attachment, and provide a healing effect [20]. In addition, "warmth" was also facilitated by using a long-haired fabric for the stuffed bear toy; and this likely contributed to the positive evaluations. Shibata et al. reported that high subjective evaluations of a pet robot require physical contact between the robot and human [28]. Therefore, by using materials with a good texture, it was more pleasant for participants to come into contact with our robot and this led to the robot making a good impression on the participants.

6.3 Motions of the Interactive Therapy Robot While Listening and During Conversations

The interactive therapy robot was considered to be also cute as a stuffed toy, but it was evaluated as even cuter by adding motion and conversation. This result suggests that it is effective to show that the robot listens or reacts to people by changing its posture. Bowlby's attachment theory [27] lists the following two behaviors in addition to the approach behavior.

- Orientation behavior (following with the eyes, looking in the direction of a voice).
- Signaling behavior (smiling, producing utterances).

We consider that the robot's function of moving while "listening" corresponds to orientation behavior, and its "conversation" corresponds to signaling behavior. Therefore, we conclude that the interactive therapy robot received positive evaluations because the functions it implemented were consistent with attachment theory.

7 Conclusions

In this paper, we tested the hypothesis that people receive therapeutic benefits according to the appearance and interactive functions of a therapy robot. We found "listening to me," "conversing with me," "warmth," "cute," and "charming" to be important healing elements. Then, we detailed the development of an interactive therapy robot that could act as a substitute for pets. Through interviews with individuals who engaged with the interactive therapy robot, it was confirmed that its appearance played an important role as a trigger that enabled the user to embrace healing, comfort, and empathy. In addition, it was suggested that the size, softness, and tactile qualities of the robot are elements that engender healing and attachment. Robot motions that suggested it was listening were evaluated very positively and we

confirmed the importance of the robot's interactive functions. Additionally, we found that it is necessary to examine the content of conversations, including whether conversation is necessary at all, because the evaluation of conversations differed markedly among users.

8 Future Work

In the future, we will continue to evaluate simple verbal communication, using an easily comprehensible voice, as suggested in the results of the interviews. Additionally, we will study non-verbal communication because the interviews suggested that non-verbal communication that conveys listening and recognition was desired (e.g., a sound that expresses emotion, rather than spoken language). Further, we will consider implementing functions that correspond to therapeutic elements such as "dependable," "making up for a deficiency," and "recognized." Based on the high emphasis users placed on appearance, we also plan to explore different designs that engender a feeling of healing in people.

Appendix

We uploaded Appendices to the Google drive. Please refer to URL as below (last accessed 2017/10/23).

https://drive.google.com/open?id=0B69_7k616WJNSVd4M05TQkZrYXM

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