Affective Movement Design for a Robot Pet through Bodystorming Workshops

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Abstract: The advent of automatic technology and artificial intelligence causes huge impact on people's daily life. Statistics show that domestic service robots for household chores, entertainment, or other social purposes have gradually become a common scene in our modern life. In order to cope with the demands of affective and natural communication in human robot interaction (HRI), this study proposes an exploratory approach to develop intuitive and pleasant movements for robot pets, a robotic rabbit in this case. The aim of this study is to demonstrate how co-design workshops can be used to explore participants' emotional responses evoked by robot gestures as well as to enhance creativity for generating ideas for bodily movements of robots. This paper also includes a summary of the results of a pilot study utilizing collaborative design workshop and bodystorming techniques. We conclude with a reflection on how bodystorming workshop can function as an HRI design tool and implications for future work.

Key words: Kansei Design, Human-Robot-Interaction, Generative Technique, Bodystorming

1. Introduction

Nowadays, smart devices of different forms and shapes exist virtually everywhere in our daily lives and traditional computer and HRI (Human-Robot Interaction) interfaces are already obsolete. As robotic technologies become mature, the focus of robotic technologies is gradually shifting from industrial applications to purposes of home care, education and entertainment. As the residential robot market continues to grow in recent years, this market seems ready for a massive adoption of robotic products [1].

From an analysis of human evolution and development of robotic technologies, Brooks [2] claimed that robots will be one of the key players in the next wave of technology revolutions! However, the major difference between robotic products and computer products or information services is the former’s mobility and ability to convey semantic and affective messages that evoke our feelings toward their sociability and vitality through body movements [3]. As suggested by somatosensory products such as Wii, Kinect and Aibo that emphasize body movements and interactions, body movement not only is an effective means of communications, but cal also allow us to more easily grasp the meanings of communications expressed through bodily movements to engage in natural, pleasant and social HRI interactions.

Thus, the initial purpose of this study is to identify a design approach that can effectively discover the relationship between robotic movements and emotions and, for social electronic pets in particular, to explore how they can convey different emotions through their bodily movements and that they can be used to exchange messages with users in real time. The co-design workshop that emphasizes user participation has been massively

adopted in the study of interactive designs and processes and creative development to supply designers with direct and effective design insights and spark new and innovative ideas [4, 5, 6]. Thus, it is the goals of this study to continue the previous study of the robot rabbit Nabaztag [7], conducted using the Kansei Engineer Approach, to 1) further plan and implement the bodystorming design workshop; 2) explore the possibility and effects of user participation in the design process of robotic pet movements; and 3) compare the results of user participation-based designs with those in the previous study to propose recommendations for similar Kansei movement design studies and workshops in the future.

2. Related Work

2.1 Movements of Robot Pet and their Meanings

Breazeal [3] pointed out that the major difference between robot products and computer products or information services is their mobility and ability to convey semantic and affective messages that evoke our feelings toward their sociability and vitality through bodily movements. To design or develop smart products or services that truly capture the heart of users, well-conceived interactive experiences and emotional exchanges are imperative. The shift to such focus in the field of Human Robot Interaction (HRI) has gradually aroused the interests of the public on the semantic and emotional messages conveyed through movements by robotic products. Li, J. and Chignell [8] have utilized simple robot pets to study how humans interpret different robot movements and their subjective impressions. Their results revealed that even a simple movement combination between the head and hands can solicit different emotional responses for the test subjects.

The research team conducted a study on the emotions conveyed through ear movements of Nabaztag, a robot rabbit [7]. All ear movements were analyzed using the Kansei Engineer Approach to define five dimensions: initial position (Figure 1), movement range, speed, directional change, and symmetry. The study results confirmed that the movement characteristics indeed correlate to emotional perceptions of the test subjects. Some of the Kansei vocabulary combinations strongly perceived by the test subject in the previous study are listed in Table 1.

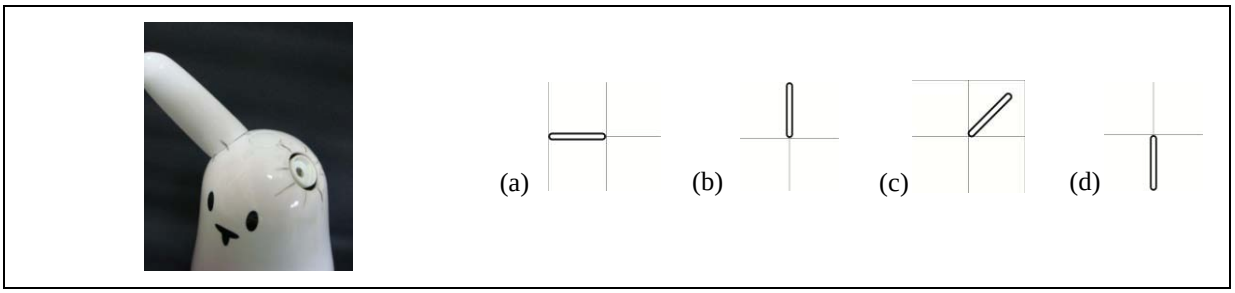

Figure 1. Eight initial ear positions in the previous study – example: (a) front; (b) up; (c) down rear; and (d) down

2.2 Co-design

In the product design process, exploratory techniques such as questionnaires, interviews or focus group discussions are frequently chosen to probe into the needs of users. This knowledge and user needs are converted along with the designers' creativity to produce a design solution. However, for the study of brand-new fields such as forms of interactions and HMI experiences, as the interviewees do not possess relevant knowledge, their needs as well as perceptions, as required by designers, are difficult to obtain with this type of techniques. Sleeswijk

Visser [4] pointed out that our experiences are usually determined by tacit knowledge and latent demand. Tacit knowledge is the knowledge that we can act upon, but are unable to verbalize and latent demand is the need that does exist but we are unaware of. Thus, they proposed the co-design approach that emphasizes user participation in the design process as the exploratory technique to discover experiences and needs of human beings. Through co-design and the use of appropriate creative tools, users can more effectively participate in the product design process to discover their needs and further externalize their internal needs with tangible and specific visualization techniques. This will ensure that the final design can truly meet users' needs in real life, inspire designers' creativity and prevent them from falling into a trap of their own assumptions [5].

Table 1. The most perceptive combination between Nabaztag's ear movements and Kansei vocabularies

Item / Kansei Vocabularies	Initial position	Range	Speed	Directional Change	Symmetry
Happy	Front	Upper half circle	Fast	Fixed	Completely opposite
Gentle	Front down	Front half circle	Medium	Single return	Single movement
Angry	Front	Upper half circle	Fast	Fixed	Asymmetric movement
Depressed	Front down	Lower half circle	Medium	Single return	Single movement

2.3 Bodystorming

Bodystorming, or the body version of brainstorming, is a movement design technique derived from co-design. It combines the role play and simulation techniques to spark inspirations through empathy and improvisation to create a prototype [9]. Through observations and learning, participants can brainstorm with their teammates and generate ideas with improvised performance, and this can avoid creativity restrictions imposed by conventional meetings. Gray, Brown and Macanufo [10] pointed out that bodystorming has three phases --

(1) Go Observe: field observation is very important. Participants should not be limited to discussions in a meeting room, but should be encouraged to observe real interactions in the places where they occur.

(2) Try It Out: using items or role play to develop ideas. Through improvised performances, new ideas or thoughts will be generated as the body moves. In this way, simple and important questions that might have been overlooked can be discovered.

(3) Reflect on What Happens, and Why: in the brainstorming process, participants can naturally discover new possibilities, spot new issues (or opportunities), and examine if ideas are feasible. The entire process and the data collected during the process and analyzed after the process are equally important, as new insights may be identified.

3. Method

Before planning for the workshop, its purpose needs to be defined first and expected goals of tasks carried out in the movement design workshop developed. According to the movement vocabularies (movement message)

defined in the previous Kansei movement study [7], the interactive messages exchanged between the residential social robots and users can be classified into the following three types: pro-active message, reactive message and status message. Two meaningful Kansei vocabularies are selected from each of the three types for the Nabaztag HMI: greeting, warning, acknowledging, disagreeing, thinking and resting. From the Kansei vocabularies in the previous study (Nabaztag Ear Movement Study)[6], four vocabularies are chosen based on the tension and tendency dimensions: happily and gently (positive emotions) and angrily and depressedly (negative emotions).

Through the combinations between movement and Kansei vocabularies, 12 Kansei messages, such as happily greeting, gently greeting, angrily warning, depressedly warning, etc., are conceived as the movement messages conveyed in the workshop, as shown in Table 2. In other words, those 12 Kansei messages are the main tasks for participants to convey in this workshop and they need to accomplish the goals of those 12 Kansei messages utilizing the bodystorming technique.

Table 2. 12 Movement vocabularies chosen for this bodystorming workshop

Movement / Emotion	Greeting	Warning	Acknowledging	Disagreeing	Thinking	Resting
Happily	○		○		○	○
Gently	○		○			
Angrily		○		○		
Depressedly		○		○	○	○

Based on the goals listed above, the movement design workshop is mainly divided into three parts: workshop preparation, workshop implementation and data analysis. The preparation period is about 2~3 weeks and workshop details, site, participants and items need to be confirmed one week prior to the workshop; workshop processes need to be briefed to the on-site staff (research team) three days prior to the workshop to ensure that they sufficiently understand the workshop and confirm if the details of the workshop need to be modified. The workshop is scheduled for only one day and the analysis step of the qualitative data collected during the workshop are finished in 1~2 weeks after the workshop.

4. Workshop Preparation

The tasks carried out in the preparation period include: participant recruitment, site planning, tool design, on-site staff training and task assignment.

4.1 Participant recruitment

Considering the purpose of this study, the main criteria for participant recruitment are that participants can be fully involved in the workshop and are willing to achieve the goals of bodystorming and co-design utilizing their creativity. Thus, eight outgoing and active students from the National Taichung University of Science and Technology (NTUST), the school of the first author of this paper, who are willing to cooperate in the bodystorming workshop are selected as the participants of this study using the purposeful sampling approach.

4.2 Site Planning

The site chosen for bodystorming workshop must offer plenty of space for participants to carry out the tasks and accommodate all equipment and environmental decorations. For example, the site must be large enough for the mirrors used for participants to observe their movements and conduct group discussions, to accommodate a stage for presentations and result demonstrations and to offer spaces for filming the workshop sessions. Thus, the photography studio at the College of Design, NTUST has been chosen for this study. Besides the vest space, available furniture, computer and hardware facilities, this studio can also provide filming equipment and the environment required for this workshop.

4.3 Tool design

In terms of tools utilized for this workshop, to encourage participants to perform the ear movement of the robot pet as expected, we designed the following tools:

(1) Ear simulation tool: to facilitate the bodystorming process for participants to conceive movement designs with rabbit ears, white long balloons are adopted to simulate the ears of robot rabbit Nabaztag (as shown in Figure 2).

(2) Face mask: in our previous studies [11, 12], it has been verified that the facial expressions of the performers will interfere with audience interpretations of the movements. Thus, face masks are introduced to hide the face of the performers (Figure3) and eliminate this interference.

Figure 2. White balloons are used as ear simulation tools

Figure 3. Face mask

(3) Recording tool: because the design results of this bodystorming workshop or because the rabbit pet movements are not permanently available, in order for participants to jot down their design drafts and ideas anytime they prefer, simple sketch papers are prepared for the participants to write or sketch their ideas or record the movement.

(4) Movement design element hint: participants do not have related movement design training or experiences about developing robot products. For them to more effectively grasp possible design directions and stimulate diverse and rich creativity, hints are thus provided. We also created posters that illustrated the movement elements and Kansei design guidelines indentified from the previous Nabaztag Kansei study. These are put up in the workshop site as reference for participants (but they are not required to brainstorm following the

guidelines and elements in the posters.)

4.4 On-site Staff Training and Task Assignment

The research team has hosted co-design and context mapping workshops before this workshop. For this workshop, the second author of this paper was assigned as the host of this workshop. Three experienced graduate students from the NTUST Multimedia Design Department who have participated in design workshops in the past were recruited as the on-site staff. Through presentations of the study background and workshop process, all on-site staff thoroughly understood the workshop details and their task assignment were checked to verify their appropriateness. The on-site staff was required to assist in workshop preparation (site planning and tool design) to ensure that they truly grasped the essence of this workshop.

5. Workshop Implementation

Before the workshop, on-site staff needed to confirm that all the equipment, the site, desserts and tools have been prepared. On-site record keepers need to be arranged to collect all data and documents for discussions and reviews after the workshop. One of the staff members needs to take on the responsibility as the host to lead all participants step by step along the way until the end of the workshop. The process of the bodystorming workshop is shown in Table 3 and each step is detailed in following paragraphs.

Table 3 Workshop Process

Time Length	Activity	Description
15 Minutes	Self-introduction and group assignment	Participants become acquainted with one another to ease their jitters
10 Minutes	Topic introduction	
15 Minutes	Ice breaker	
10 Minutes	Break	
15 Minutes	Activity introduction	Brainstorm new ideas using the bodystorming technique
30 Minutes	Movement brainstorming	
10 Minutes	Break	
20 Minutes	Performance and vote	Vote for movements and scenario-based performance
5 Minutes	Break and vote counting	
30 Minutes	Movement review and scenario-based performance	
20 Minutes	Interview	Gain an insight into the perceptions of the participants during the workshop

Figure 4. Site arrangements

Figure 5. Reception desk at the workshop

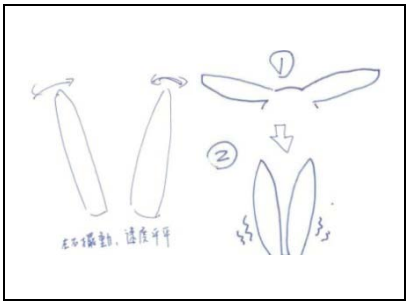

Figure 6. Sample of participants' movement log

(1) Workshop preparations: workshop posters are put up in the workshop site illustrating workshop details. Snacks and drinks are prepared to ease jitters of the participants, the sketch papers and chairs are placed inside the studio and all the recording equipments are prepared and tested (Figure 4). Mirrors are placed on four corners of the site for participants to observe their own movements.

(2) Participant check-in: participants need to sign in to keep track of their attendance (Figure 5) and name tags are provided for the participants to become acquainted with one another.

(3) Warm up: participants are divided into groups after their self-introduction for them to become familiar with one another and two on-site staff members are assigned to assist each group during the workshop and film the entire process.

(4) Icebreaker: a balloon inflation exercise is set as the contest where both teams compete. After the exercise, each team is rewarded with snacks/drinks to enhance the bond among the team members.

(5) Movement introduction: the workshop topic "Nabaztag Ear Movement Design" is described and 12 movement samples are introduced.

(6) Brainstorming movement: each group uses the rabbit ear balloons to bodystorm the 12 movement designs and jots down their ideas on the sketch papers provided by the on-site staff (Figure 6) and on-site staff members also record the brainstorming process and movements that are performed utilizing cameras and camcorders.

(7) Performance and vote: both groups perform the same movement (Figure 7) and after the on-stage performers are finished, the remaining team members immediately vote to decide if the movement design performed matches the movement sample (Figure 8). The on-site staff needs to set up cameras to record each movement and create sample sign boards to facilitate the film analyzing process.

(8) Movement review: after all votes are counted, the selected 12 movement designs are announced and recorded videos played to gather feedbacks.

(9) Scenario-based performance: participants are assigned to perform the voted movement in the scenario-based performance to further verify if the movement is appropriate for the scenario. A typical scenario adopted is shown below --

"*After the master comes home, the happy and resting rabbit Nabaztag greets the master in a delightful mood. The master asks if the rabbit received any email today. Nabaztag gently acknowledges the question and plays the Email title with sound.* "

(10) Workshop completion: all participants are rewarded with payments to show appreciation for their attendance.

(11) Participant interview: three committed participants are selected from the eight participants for the 20-minute interview. Participants are encouraged to describe the challenges they encountered, surprises they experienced and other interesting discoveries in the workshop. The interview is about the process design of the workshop and movement designs. Typical interview questions are shown below:

(a) Do you agree that emotions can be conveyed through the hand movements (ear simulation)? If yes, why? / If not, why not?

(b) Do you agree that the 12 movements voted can reflect the emotions that they represent?

(c) Do you think that it is effective to perform the voted movements in the scenario-based performance? Why?

(12) Interview completion: interviewees are provided with payments to thank them for their interview contributions.

Figure 7. Participant, movement performance and filming process

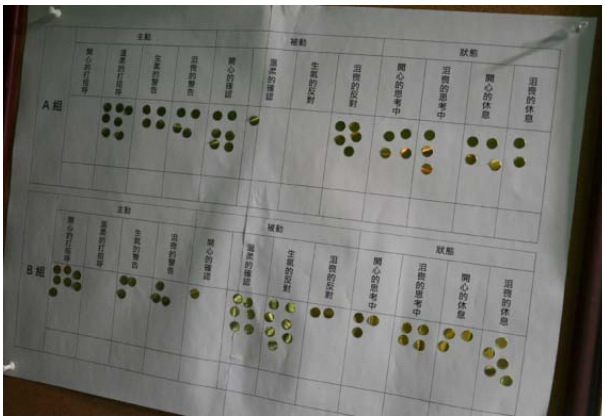

Figure 8. Voting table

6. Workshop Results

Movements are brainstormed for the 12 specific Kansei vocabularies utilizing the bodystorming technique. All participants then vote for the proposed vocabularies and select movements for each of the 12 Kansei vocabularies, as shown in Figures 9 ~ 20.

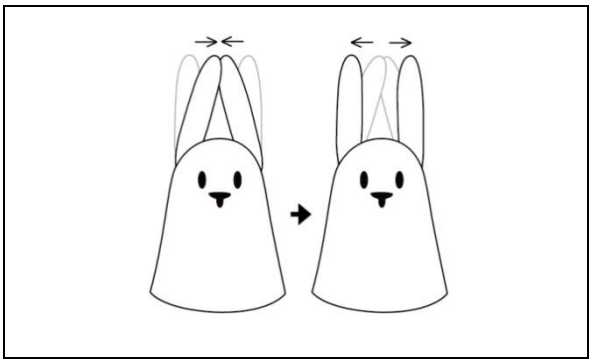

Figure 9. Happily greeting: both ears wiggle symmetrically and consecutively.

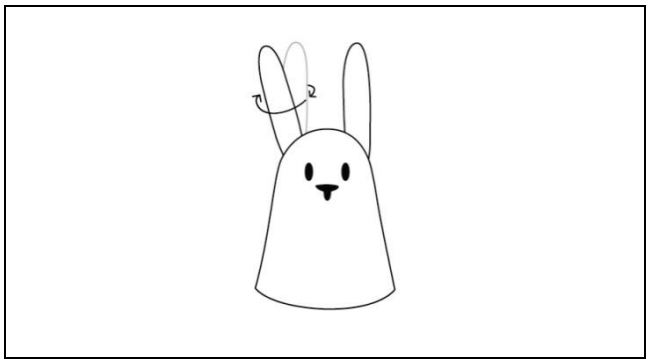

Figure 10. Gently greeting: the left ear rotates consecutively at a fixed speed

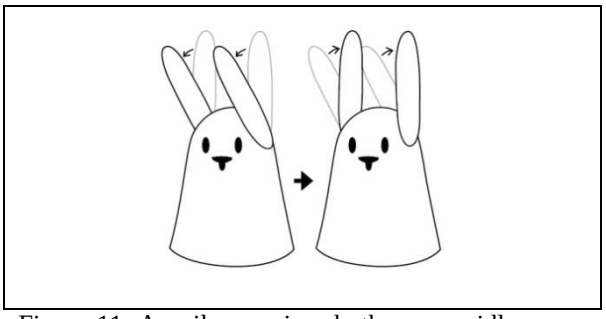

Figure 11. Angrily warning: both ears rapidly move downwards toward the front and then return back to their initial position at a normal speed.

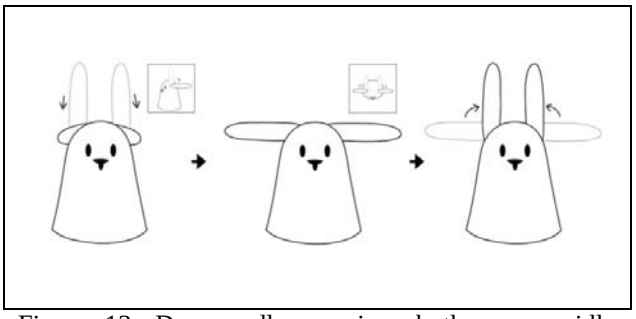

Figure 12. Depressedly warning: both ears rapidly move downwards toward the back, open toward the sides and slowly return back to their initial positions.

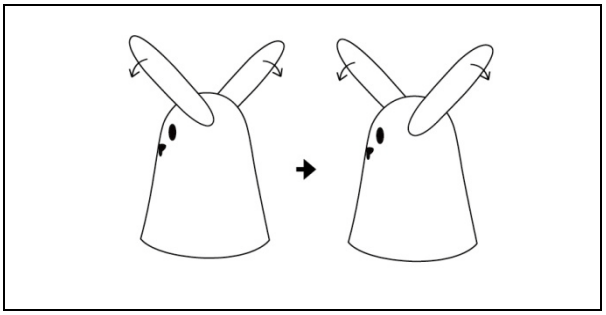

Figure 13. Happily acknowledging: both ears rapidly wiggle back and forth alternately.

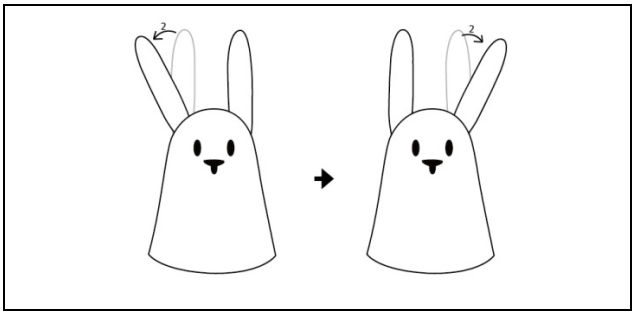

Figure 14. Gently acknowledging: both ears wiggle toward the front twice at a constant speed.

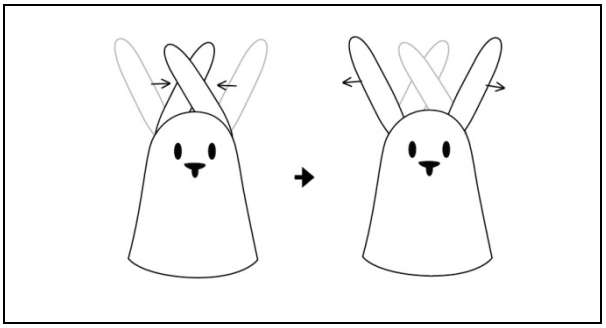

Figure 15. Angrily disagreeing: both ears rapidly cross at the same time and return back to their initial positions at a normal speed.

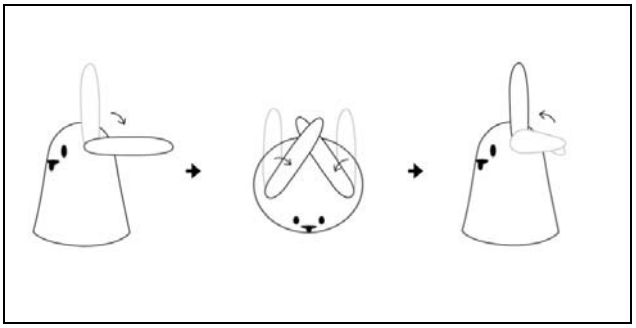

Figure 16. Depressedly disagreeing: both ears move downwards and cross like “X” and finally return back to their initial position at the normal speed.

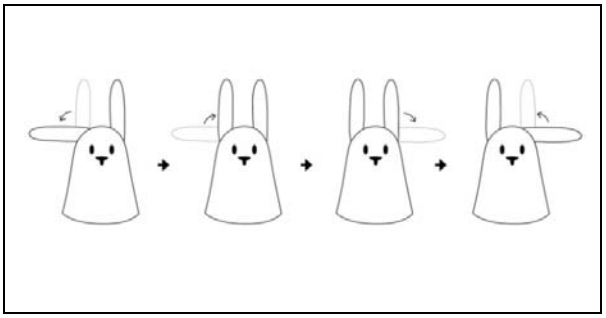

Figure 17. Happily thinking: both ears take turns to move toward both sides at a normal speed.

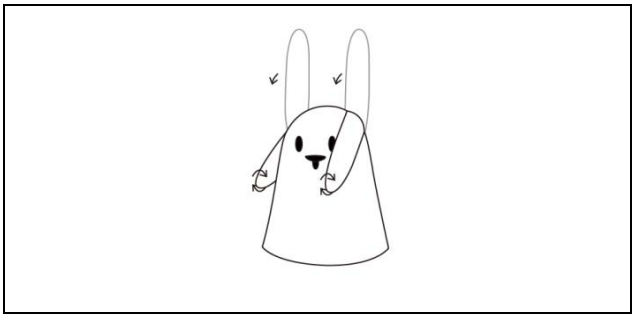

Figure 18. Depressedly thinking: both ears slowly move downwards toward the front and rotate consecutively

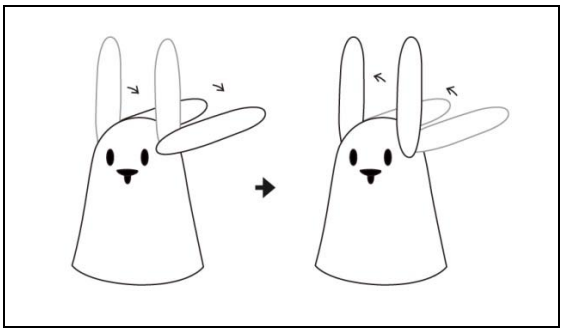

Figure 19. Happily resting: both ears move toward the back at a normal speed, pause for two seconds and rapidly return back to their initial positions.

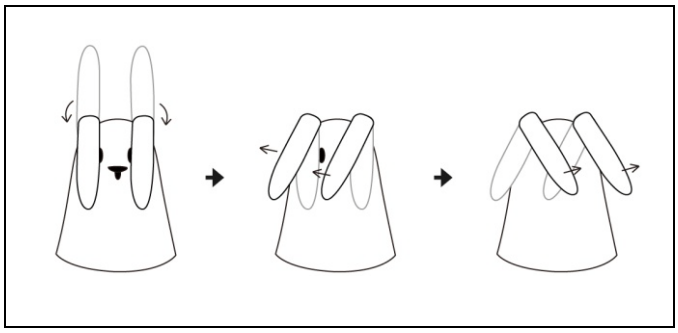

Figure 20. Depressedly resting: both ears slowly move toward the front and sway from left to right and then from right to left consecutively.

7. Conclusion and Discussion

There are two purposes for this study. The first is to discover the possibility and effects of user participation in the design process of robot pet movements. In the bodystorming workshop, a number of movements are generated and 12 movements most representative of the Kansei vocabularies are voted after participant performance. Thus, we believe that bodystorming and co-design workshops can indeed facilitate the design and development of innovative interactive styles. Finally, through the interviews conducted during and after the workshop, participants are mostly positive about the workshop. Some participant feedbacks are excerpted below:

(1) The descriptions about the previous study described at the beginning of the workshop are effective for us to establish a basic understanding of emotional movements.
(2) The icebreaker game is very helpful to ease the jitters of the participants who are meeting for the first time, and they can quickly fit into the group and better bond with one another.
(3) The rabbit ears and face masks can help them with their performance, and the participants indicated that with those tools, they are willing to pose for all movements. They do not feel shy during the scenario-based performance as their faces are hidden behind the face mask and the judgments of the remaining participants observing the performance are not affected.
(4) The interviewees pointed out that in the brainstorming process, it is rather difficult to generate 12 unique movements and express emotions with movements.

The second purpose of this study is to compare the movement designs generated in the bodystorming workshop with those derived from the traditional Kansei Engineering approach [7] and identify their differences. It has been confirmed in the study that some of the rabbit ear movement designs generated utilizing the bodystorming technique match those identified in the previous study. Particularly, the influences that the speed and initial position dimensions, as defined for the rabbit ear movements, have for the participants corresponded to the perceptions that they have for the Kansei vocabularies. The details are explained below:

(1) In this study, although “happily acknowledge” and “angrily disagree” are opposite in their emotional implications (one positive emotion and anther a negative emotion,) participants mostly choose to convey both of them utilizing rapid movements. Therefore, this verifies the conclusion in the previous study – movement speed correlates more to the magnitude of the emotions inducted rather than to the perceptions toward

positive or negative emotions.

(2) For movement design, the positions for the “happily” and “gently” (both positive emotions) movements are both front and rear up, whereas the positions for “angrily” and “depressedly” (both negative emotions) are both front down and down. This also verifies the results of the previous study.

(3) Although the Nabaztag’s ear movement ranges defined in the previous study are slightly different than the ranges chosen by the workshop participants, in the bodystorming workshop, most ear movements for positive emotions are still concentrated on the upper half circle while ear movements for negative emotions are mostly concentrated on the lower and front half circle. This proves most of the results in the previous study.

Unlike the traditional design industry in which a lot of design knowledge is already available to facilitate the design and development processes, designers in the fields of Kinesthetic sense-based Kansei designs (especially the HRI or other emerging IT service and product applications) do not have extensive examples and knowledge to refer to. From the attempt in this study to design robot pet movements through the bodystorming workshop, it is verified that this innovative design approach is indeed feasible and effective. We expect that this study can arouse the interest of scholars from the field of Human-Robot-Interaction in favor of co-design workshops and inspire them to explore forms and possibilities of diverse and innovative movement designs to enhance the sociability and pleasantness for users of robots in their daily life.

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