Morphing Agency: Deconstruction of an Agent with Transformative Agential Triggers

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Abstract
This paper presents our vision of Human Computer Interaction (HCI) called the "Morphing Agency." The Morphing Agency redefines the notion of an agent in HCI, and proposes separated use of all agential triggers that evoke a user as an agent. This paper describes three key levels of agential triggers that are humanlike, behavioral, and internal. We illustrate these concepts with three prototype systems – the morphExplainer, transExplainer and parasiticBelt – to identify underlying research issues.

Author Keywords
Human-agent interaction; anthropomorphization; human interface;

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors

Introduction: Extending Agent
Human-agent interaction (HAI) has become an important field in the field of human-computer

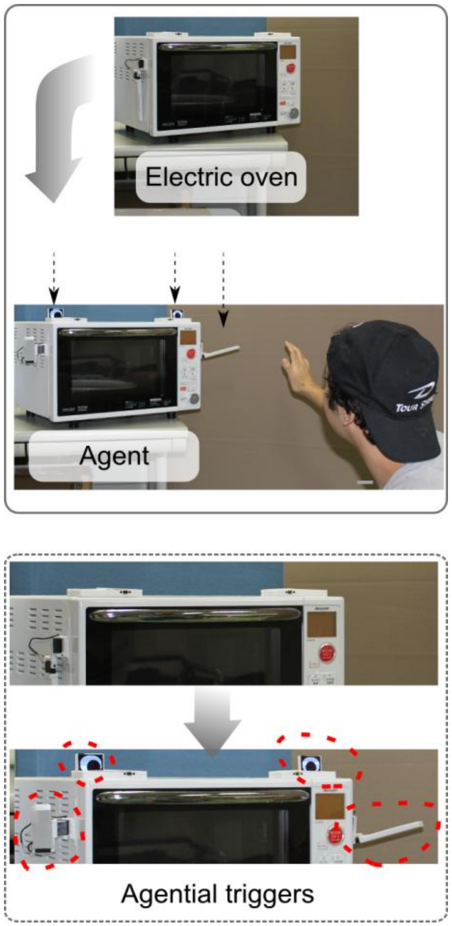

Figure 1: Concept of Morphing Agency

interaction (HCI) [1], [2]. The agent in HAI behaves with users as if it has its own intentions. It triggers users' social responses, and instructs users through social channels. The use of HAI is widespread from the field of entertainment to medical purposes. The robots Aibo and Pleo are commercialized pioneers in HAI that entertain users with their behaviors by changing user's internal states [3], [4]. The seal-like robot Paro, AuRoRA projects, and other agents have tried to solve dementia and autism through their behaviors [5], [6]. Virtual agents have established intimate relationships with users through their behaviors, and they have even accelerated sightseeing in the real world [7].

The tremendous success of these HAI agents has been supported by the intentional behaviors of agents. These agents are sometimes very simple, but if their behaviors are sufficient to trigger users' social acceptance, they are regarded as being agents. Several studies have found that humans interpret (or misinterpret) tools as agents just by slight nuances of intentional behavior. A study on media equations found that even though tools are merely implemented as media, humans behave socially with the tools [8]. A field study on the robotic vacuum cleaner Roomba conducted by Sung et al. categorized how users established social attitudes toward the robot and regarded it to be an agent [9]. This paper defines the agent in HAI as a tool that evokes human social behaviors with its expressions in order to trigger the cognitive channels of the human brain.

The key factor in agent design through HAI is whether it has necessary and sufficient triggering expressions to evoke users' social behaviors. If we mistake the selection of appropriate expressions for users and tasks, we could create exaggerated agents that would impose greater cognitive loads on users. Agents are not panacea for all problems if they are not well designed. Lieberman was slightly anxious about the future of agents in that not all users accept agential solutions [10]. Fussel et al. found that the acceptance of anthropomorphic agents is dependent on each user's personal experiences about agents [11]. Epley et al. found that the tendency of each user to be lonely influenced anthropomorphic attitudes toward objects [12]. Users' acceptance toward agents is not only dependent on their design and expressions, but also dependent on gender, culture, and personal traits [13], [14]. When we use HAI as a solution, we need to carefully select agents' expressions to trigger users' social attitudes that are appropriate and not overwhelming.

This study proposes a new concept in the field of HCI called the Morphing Agency in this paper, where all expressions that evoke a user as an agent (like shape, motion, behavior, and auditory and visual changes) are called agential triggers. The system turns each agential feature on or off, creates an appropriate presence for the agent, and select better cognitive acceptance of the agent by each user. There is an example of our concept in Fig. 1. The agent in the figure at left instructs an adult user about its functions with a voice without behaving like a human. The agent in the figure at right instructs a child user about its functions. The agent reveals different agential triggers and tries to evoke the social attitudes of individual users differently. Figure 2 explains the differences between a conventional agent in HAI and that with our concept. Conventional HAI is shown in the upper figure, where an agent is covering the interface of the system, interacting with a user through social channels by evoking a cognitive model of

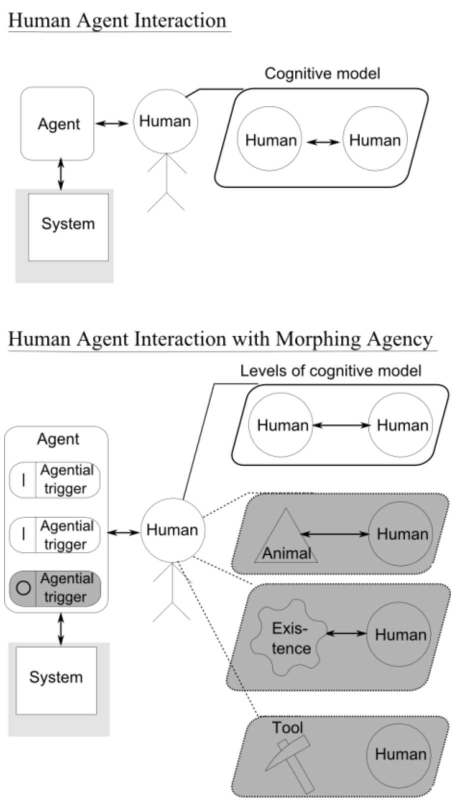

Figure 2: Difference between conventional HAI and our approach

human-human interaction from the user, and creating a solution through human-computer interaction (HCI). However, the agent in Morphing Agency is constructed with agential triggers. The system selects appropriate agential triggers according to individual user states and tasks. As a result, the system can select the most appropriate cognitive model for a particular user.
First, we define the agent and agential features we used in this study. Second, we examine how agential triggers improve interfaces referring to several successful ventures in the HCI/HAI field. Third, we categorize three key levels of agential triggers, which are humanlike, behavioral, and internal, for selecting worthy agential triggers for implementation. Lastly, we illustrate our concept with three examples of morphExplainer, transExplainer, and parasiticBelt using agential triggers in humanlike level and discuss the future of the Morphing Agency.

Definition of Agents and Agential triggers

Prior work in human–computer interaction (HCI) has used many kinds of meaning for the term *agent*. Before starting a discussion on the possibility of the Morphing Agency, we will define the notions of agent and agency in reference to several HCI/HAI studies.

The term *agent* means an acting mediator. The use of the term has been extended in several areas in human-computer interactions, and there are many definitions for agents. We defined an agent in this study as an artificial social actor that is accepted by users through her/his intentional stance, based on Dennett's Intentional Stance, whether users are conscious or unconscious of the fact [15]. The definition can include the unconscious social behaviors of users presented in media equation studies [8], [16]. The definition also includes a suspension of disbelief in human-agent interactions as explained by Duffy et al. where people accept the system as an intentional agent consciously to reduce cognitive load, even if they know that this is really not like watching drama on a stage [17]. Based on the definition of agents, we defined agential triggers as elements where someone feels artificial existence as an agent.

Because the definitions of agent and agential triggers just depend on the cognitive model of users, the behaviors of the agents themselves are not crucial unless and until they are accepted by users as constituents of the agency, and whether a user accepts them as such depends on what channel in the user's brain has been activated by the behaviors of the agent [18]. We can find "intentional subjects" from slight clues in the environment like when stains on a wall sometimes look like facial expressions [19]. This cognitive ability has been applied in the HCI field. Komatsu et al. proposed giving slight agent-like expressions to artificial machinery to make appropriate explanations to users called Artificial Subtle Expressions [20]. People felt intentions and behaved with better manners just by using a facial photograph on a wall [21]. The human social attitude for Roomba is accelerated simply by their two-wheeled behavior [9].

The above definition of an agent and agential triggers, and related studies on the ability of our brain to find intentions from slight clues supports the notion of Morphing Agency. These agential triggers are used in several HCI fields that are related to HAI, like cognitive science, intelligent virtual agents, and human robot interactions. Affective computing and the media equation are pioneers in the use of agential features [22], [23]. Similar features have been studied as animacy or biological behavior [24], [25] in the robotics, cognitive science, and HCI fields. Yamada et al.'s early work proposed agential features [26]. The Morphing Agency has been inspired by these seminal studies.

Designing Concept of Morphing Agency

Humanlike components evokes the intentional stance of a user. Gestures have been widely studied in anthropology, psychology, and cognitive science [27] [28]. Eyes, neck, arms, and hands are frequently used in virtual agent and robot studies. Several commercial products use anthropomorphic appearances for making things familiar, keeping things the same, reflecting product attributes, and projecting human values [29]. For these reasons, we have chosen to attempt an implementation of humanlike eyes and arms as a first step toward illustrating the Morphing Agency.

We created the three concepts shown in Fig. 3. The morphExplainer achieved appropriate expressions according to each user's attributes. Agential triggers in morphExplainer were attached to an appliance. The appliance transformed its appearance according to the attributes of an arriving user (for adult and children, shown at left of Fig. 3). The transExplainer, inspired by ITACO [30], is an instructor that explains sequential task using multiple appliances. Agential triggers are activated by a sequential scenario that explains the functions of multiple home appliances. The parasiticBelt is an HAI application inspired by Pygmy [31]. This belt has two eyes in it. It is attached to the human body and turns on/off the agent. It makes the human body an agent and helps in communication.

We designed non-intrusive agential trigger devices with several requirement (easy to use, thin and light, no damage to attached objects, easily attachable and removable without requiring special tools, scalability, sage, and robust) requirement by referring to a study on Pinoky [32]. We implemented movable eyes and arms as agential triggers. All devices were designed to be light and thin. The covers of the devices were made from white polycarbonate plastic. All parts were fabricated with a 3D printer.

Fig. 4 has a photograph of the implementation of the arm devices. An OLED display, a microcontroller, a DC servomotor, a Bluetooth module and a battery were arranged in 105 x 48 x 11.5 mm sized box. The eye device had an OLED display with a servo motor. It could automatically open and close (activate and deactivate) the OLED display. The OLED display could show movements of the pupil and several emotions. The battery was polymer lithium ion rated at 400 mAh. Each eye device weighed 45 g. The eye devices were directly placed on the target, or attached to the object with double-sided tape. The eye devices worked for more than two hours without charging the battery.

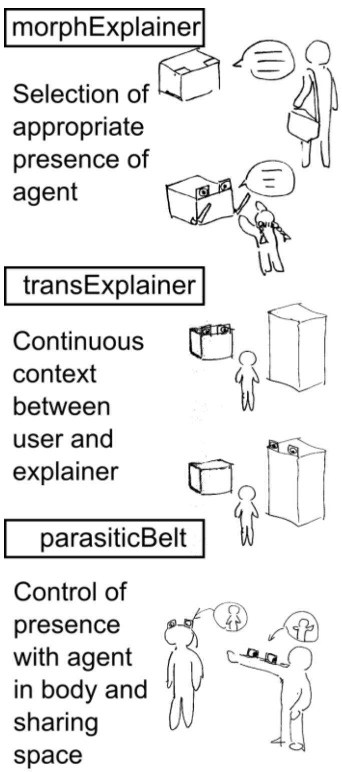

Figure 3: Research prototype for Morphing Agency and several concepts

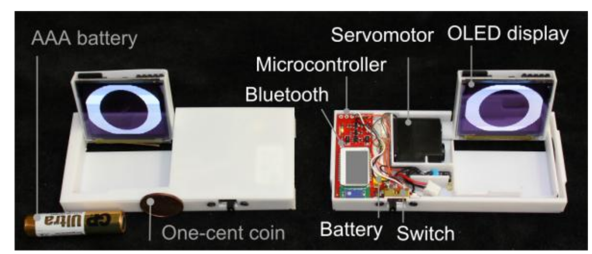

Figure 4: Movable eye device (left eye is covered and right eye is open). US cent and AAA battery have been shown for comparison.

There is a photograph of the arm devices in Fig. 5. Each arm devices had two DC servomotors and it could be directed to any location in the real world. The battery was polymer lithium ion rated at 400 mAh. All

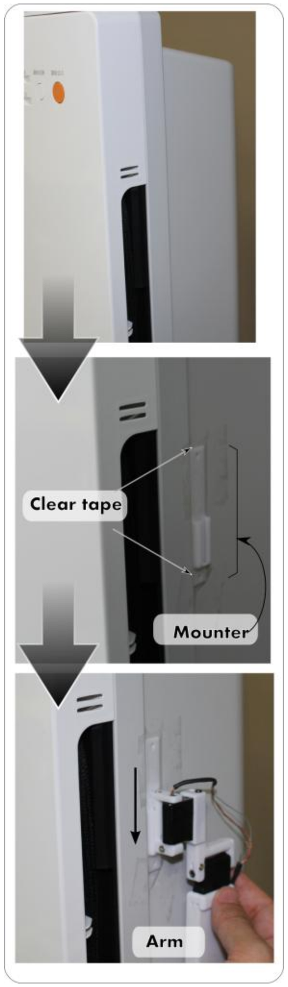

Figure 7: How to attach arm parts with an object.

circuits and the battery were implemented on the limbs of the arms. The total dimensions of the arms were 175 x 60 x 12 mm and the limb size (without the servomotor) was 115 x 28 x 10 mm. The thickest part of the arm was 12 mm. The thickness of the limb was 10mm (this is less than the radius of the AAA battery). Each arm weighed 55 g. The arm device worked for more than three hours without charging the battery.

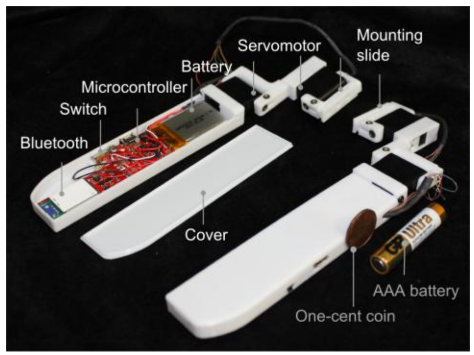

Figure 5: Movable arm devices (left arm is uncovered and right arm is covered). US cent and AAA battery have been shown for comparison.

We also designed various mounting parts for the arm devices to fix them to an object because they frequently moved (shown in Fig. 6). These mounting tools were also made from polycarbonate and fabricated with a 3D printer. The backside of the wide mounting base (bottom left of Fig. 6) was created with Velcro hooks. It easily attached to the Velcro loops. Two slender two mounting bases (bottom right of Fig. 6) were attached by tape or screws. Each arm device was slide onto the mounting base and meshed. When the mounting basement was firmly attached to the target device, each arm could be attached anywhere on the object. There are examples of the process to attach the arms in Fig. 7. The base was taped on the hidden side of the object (air conditioner). When the base was fixed with tape, the arm was fixed and it retained accurate pointing motion

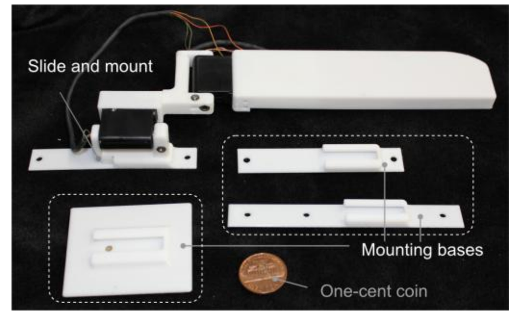

Figure 6: Various mounting bases and right arm device.

Implemented Concepts

morphExplainer

The morphExplainer is an instruction application that extends standard HAI in the Morphing Agency. The home appliance in morphExplainer becomes the agent, and it instructs how it is to be used with dialogue based interaction. The shape of the agent transforms according to individual user attributes.

We implemented both automatic and manual applications of morphExplainer in the first step. Based on previous research on anthropomorphic tendencies between age and gender [33], we hypothesized that young children under 10 years old would mostly favor anthropomorphic representations, adults more than 30 years old would accept partially anthropomorphic appearances, and teenagers would not want any anthropomorphic representations. Due to this hypothesis, the shape of the agent transformed according to each user's age. The age of users was

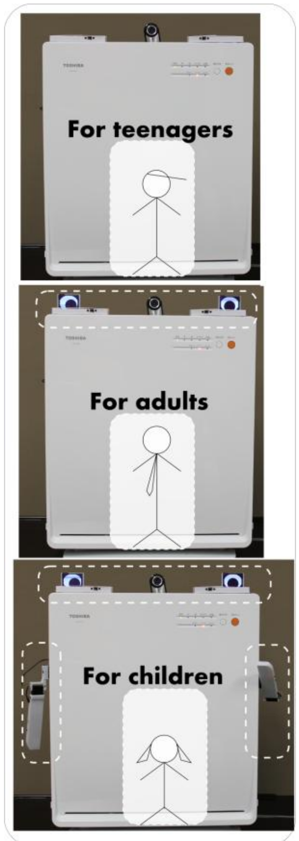

Figure 8: Automatic transformation in morphExplainer according to user height (Top device is for teenagers, all devices are deactivated. Middle device is for adults. eye devices are activated. Bottom device is for young children, all devices are activated).

measured from their heights, and this was measured from the position of the face. We categorized people in the prototype into three groups (young children: 0–130 cm for the eyes and arms, teenagers: 130–160 cm for just the voice, and adults: 160 cm for the eyes) and presented three different shapes according to each category. Although each boundary was empirically defined, the program could behave as if it was detecting each user (Fig. 8). However, it was possible to separately activate and deactivate the eyes and arms in manual application.

We demonstrated morphExplainer at a technical meeting for embedded computing at Gero hot springs in Gifu prefecture (the venue was mainly attended by adults who participated) and a robotic presentation at Ogura mansion in Fukushima prefecture (the venue was mainly attended by children, mothers, and university students who participated). Participants enjoyed both automatic and manual applications. We did not conduct a laboratory experiments to obtain free responses to our concept (especially for children). We just asked participants to evaluate each mode's "presence" while including an explanation "how strongly do you feel that the agent is in here" (nothing, arm, eye, eye+arm) on a questionnaire with a 10 point scale. The participants answered on a Likert scale on a tablet screen with 10 being the highest presence and 1 the lowest. Even children understood the representation. There is a photograph of morphExplainer and a subject in Fig. 9.

The demonstration was attended by more than 30 people. We administered a questionnaire for the presence of the agent to 15 participants who agreed to respond. There were 11 males (from 10 to 49 years old) and five females (from 20 to 49 years old). The average was 8.4 (SD. 1.3) for the eye+arm, 7.3 (SD. 1.2) for the eye, 3.8 (SD. 1.1) for the arm, and 1.6 (SD 0.9) for no sense of presence. We found significant differences in ANOVA ($p<.05$). We conducted a Bonferroni test and found significant differences ($p<.05$) under all conditions. The results suggest that morphExplainer could change its presence according to the change in agential triggers. Unfortunately, we could not find any gender or age differences because of the limited number of participants. Although our demonstration could not confirm the differences of acceptance between gender and age, our result support the general difference on presence by agential triggers.

Figure 9: Demonstration of morphExplainer (at Ogura mansion in Fukushima city. The participants are sitting on a tatami-mat and are interacting with the agent)

We also observed that a child under 10 years old said good-by (sayonara) by waving his hand when morphExplainer's eyes were physically closed. Even though he could not respond to the questionnaire, we think that he could feel a different presence to the agent according to the transformation of agential triggers.

transExplainer

The transExplainer is an instructor that explains sequential tasks by using multiple appliances. It was inspired by the ITACO study [30] and we extended it to

Figure 10: transExplainer: Explanation of Cooking sequence. The system behaves as an explaining agent transit from the refrigerator to the electric oven, with explanation process.

Figure 11: parasiticBelt:

the Morphing Agency. ITACO used the transitional direction of the agent to maintain the relationship between the user and object. However, transExplainer used the transitional direction of agential features to continue its explanations.

We implemented an instruction task on cooking food. The details are presented in Fig. 10. We only used eye devices in this concept. The user opened a refrigerator and removed food according to instructions from the agent in this task. The agential triggers - eye devices - on the refrigerator were activated during the interaction. When the user finished removing food and nodded to the agent, the agential triggers activated and deactivated the eye devices as if the agent had moved from the refrigerator to the electric oven. The delay between the movements of both eyes was about 2 sec.

The system detected the user's facial movements with a frontal camera (using faceAPI). When the user looked at the refrigerator for more than 5 sec, the system started its explanation. Members of the laboratory joined in on the experiment. They understood the instructions from the agent, removed food from the refrigerator to the electric oven, and then heated it by pushing appropriate buttons. All users changed their gaze when the agent moved from the refrigerator to the electric oven. Continuous instruction was achieved through observation even though the task was simple.

parasiticBelt

The parasiticBelt was inspired by the idea in Pygmy of sharing a body with the agent [31] and we extended it to the Morphing Agency. Users could easily activate and deactivate attached agential triggers different from the case for Pygmy. We implemented the concept as a helping agent for 24 h by using this feature where the agent was attached to the user's body and was usually sleeping. When the user wanted to ask the agent a question, the agent replied.

The implementation of parasiticBelt is shown in Fig. 11. We used only eye devices in this concept. Eye devices were attached to the belt with Velcro tape. The belt had a speaker and a microphone underneath it. A user could select anywhere on his/her body to share with the agent. The belt was attached to a body part with a rubber band. We implemented the Wizard of Oz style [34] to evaluate the effect of parasiticBelt. All devices were connected to a handheld PC. The manipulator stayed in another room, and replied to questions for the agent. The manipulator's voice was translated to the agent’s voice and produced from the belt.

We tried both arm-mounted and head-mounted implementations on members of our laboratory. If the question could be answered by the wearer, he/she thought it unusual if the question was asked by another person; the user felt that his/her body was alienated. One user noted that he suddenly felt that his body was not his own. He noted that this feeling was more intense in arm-mounted situations than head-mounted situations, because participants could watch the responses of entire reactions to robot parts. In the future, we plan to implement a simple navigator as a pilot application. The user will ask the location for the agent in this application. Then, the agent will reply to the closest area according to GPS information. All devices will be controllers implemented with handheld computers or smart phones.

DISCUSSION

Our concepts achieves the control of presence on agent, the transformation of the agent from one place to another, and sharing the presence of agent's body with the user. These concepts succeed to expand agent forms, and makes findings from HAI field more applicable. For example, in minimal design policy, home appliances are mostly designed as useful tools. Humanlike friendliness is avoided as exaggerated expressions. In Morphology Agency, however, it is possible to reinject advantages of agent to the appliances dependent on context. These various agent styles expand applicability of HAI's findings toward UI field, and make both fields richer.

We realized that our study was at the watershed of a new frontier between designed interfaces and intentional interfaces. There are two policies in the HCI field. The first is described as "every tool must be an extension of our hand." The computer interface under this policy needs to be more "intuitive" to avoid imposing cognitive loads on users. Autonomous solutions have sometimes been estimated to be irritating. Ergonomics, virtual reality studies, and haptics have focused on this goal. The second policy is described as "every tool needs to be our secretary." Autonomy and intelligence are appreciated under this policy. The main tide of robotics (except tele-presence) and artificial intelligence has been oriented in this direction. HAI researchers have also focused on the latter policy in my long experience with HAI studies. However, they are more conscious of their policy than other studies because HAI researchers know how to accept objects as tools or agents, i.e., "extended hands" or "helpful secretaries", is just as dependent on the workings of our brains.

Our concept triggers applications in HAI while combining conventional methods and our concept, and expands targets for using HAI findings and technologies. We can show several possibilities. For example, guiding agents become more personal for users by merging the attributes of personal agents in smart phones and transforming them to environmental objects as transExplainer does, which is different from the previous "museum guide agent" model. Parasitic agents can support the rehabilitation of user behavior by sharing his/her arms or legs as its body and "to have conversational and anthropomorphize" conditions in the body (as visualization method). Like several avatar studies (e.g., Telenoid[35] and TEROOS[36]), these flexible agents are also able to be used as avatars (by teachers and care workers).

The most acceptable design for humans in HCI is ultimately judged by our brains. Policies must follow the requirements generated from human cognitive abilities. We think that the Morphing Agency portends its vision of helping HCI design in cognitive aspects along these lines. It would be a good mediator to cultivate a common field between these two policies.

Conclusion and Future work

We proposed a new concept called the Morphing Agency in this study, where all expressions that evoke a user as an agent (like shapes, motions, behaviors, and auditory and visual changes) are called agential triggers. They system turns each agential feature on/off, identifies the appropriate presence of an agent, and selects better cognitive acceptance of the agent by each user. We defined the agent as an artificial social actor that accepted users through her/his intentional stance, based on Dennett's Intentional Stance [4]. We also defined agential triggers as elements where someone felt artificial existence as an agent.

We described three key factors of agential triggers on humanlike, behavioral, and internal levels by referring to related studies in the HCI field. We illustrated these concepts with three prototype systems – the morphExplainer, transExplainer, and parasiticBelt – to identify underlying research issues. In the future, we will try to add another two levels of agential triggers and expanding the vision of Morphology Agency.

References

[1] D. A. Norman, "How might people interact with agents," *Communications of the ACM*, vol. 37, no. 7, pp. 68–71, Jul. 1994.

[2] J. S. Edited by Justine Cassell, *Embodied Conversational Agents*. MIT Press, 2000.

[3] N. Suzuki and Y. Yamamoto, *Pursuing entertainment aspects of SONY AIBO quadruped robots*. IEEE, 2011, pp. 1–5.

[4] J. Dimas, I. Leite, A. Pereira, P. Cuba, R. Prada, and A. Paiva, "Pervasive Pleo: Long-term Attachment with Artificial Pets," in *Workshop on playful experiences in Mobile HCI*, 2010.

[5] K. Matsukuma, H. Handa, and K. Yokoyama, "Subjective Evaluation of Seal Robot: Paro - Tabulation and Analysis of Questionnaire Results -," *Journal of Robotics and Mechatronics*, vol. 14, no. 1, pp. 13–19, 2002.

[6] I. Werry, K. Dautenhahn, B. Ogden, and W. Harwin, "Can Social Interaction Skills Be Taught by a Social Agent? The Role of a Robotic Mediator in Autism Therapy," in *4th international conference on cognitive technology: instruments of mind*, 2001, pp. 57 – 74.

[7] D. Wakabayashi, "Only in Japan, Real Men Go to a Hotel With Virtual Girlfriends," *The Wall Street Journal*, 2010.

[8] B. Reeves and C. Nass, *The Media Equation: How people treat computers, television, and new media like real people and places*. Stanford, 1996.

[9] J.-Y. Sung, R. E. Grinter, H. I. Christensen, and L. Guo, "Housewives or technophiles?," in *Proceedings of the 3rd international conference on Human robot interaction - HRI '08*, 2008, p. 129.

[10] H. Lieberman, "Autonomous Interface Agents," in *Proceedings of the ACM Conference on Human Factors in Computing Systems*, 1997, vol. 11, no. 1, pp. 67–74.

[11] S. R. Fussell, S. Kiesler, L. D. Setlock, and V. Yew, "How people anthropomorphize robots," in *Proceedings of the 3rd international conference on Human robot interaction - HRI '08*, 2008, pp. 145–152.

[12] N. Epley, A. Waytz, S. Akalis, and J. T. Cacioppo, "When we need a human: Motivational determinants of anthropomorphism.," *Social Cognition*, vol. 26, no. 2, pp. 143–155, 2008.

[13] C. F. DiSalvo, F. Gemperle, J. Forlizzi, and S. Kiesler, "All robots are not created equal," in *Proceedings of the conference on Designing interactive systems processes, practices, methods, and techniques - DIS '02*, 2002, pp. 321–326.

[14] T. Nomura and T. Kanda, "Influences of Evaluative Contexts in Human-Robot Interaction and Relationships with Personal Traits," in *International Symposium on Robot and Human Interactive Communication*, 2012, pp. 61–66.

[15] D. C. Dennett, *The Intentional Stance*. A Bradford Book, 1989.

[16] C. Nass, J. Steuer, and E. R. Tauber, "Computers are social actors," in *Proceedings of the SIGCHI conference on Human factors in computing systems celebrating interdependence - CHI '94*, 1994, pp. 72–78.

[17] B. R. Duffy and K. Zawieska, "Suspension of Disbelief in Social Robotics," in *International*

Symposium on Robot and Human Interactive Communication, 2012, pp. 484–489.

[18] L. Suchman, *Human-Machine Reconfigurations: Plans and Situated Actions*, vol. 58, no. 14. Cambridge University Press, 2007, p. 314.

[19] C. G. Gross, *Brain, Vision, Memory: Tales in the History of Neuroscience*. MIT Press, 1998.

[20] T. Komatsu, S. Yamada, K. Kobayashi, K. Funakoshi, and M. Nakano, "Artificial subtle expressions: Intuitive Notification Methodology of Artifacts," in *International conference on Human factors in computing systems*, 2010, pp. 1941–1944.

[21] P. Bourrat, N. Baumard, and R. Mckay, "Surveillance cues enhance moral condemnation," *Evolutionary Psychology*, vol. 9, no. 2, pp. 193–199, 2011.

[22] R. W. Picard, *Affective Computing*, vol. 136, no. 321. MIT Press, 1997, p. 292.

[23] C. Nass and Y. Moon, "Machines and Mindlessness: Social Responses to Computers," *Journal of Social Issues*, vol. 56, no. 1, pp. 81–103, Jan. 2000.

[24] B. Scholl and P. Tremoulet, "Perceptual causality and animacy.," *Trends in Cognitive Sciences*, vol. 4, no. 8, pp. 299–309, 2000.

[25] H. Fukuda and K. Ueda, "Interaction with a Moving Object Affects One's Perception of Its Animacy," *International Journal of Social Robotics*, vol. 2, no. 2, pp. 187–193, 2010.

[26] S. Yamada, *Designing "space" between human and robot (in Japanese)*. Tokyo Denki University Press, 2007.

[27] D. Morris, *Bodytalk: A World Guide to Gestures*. Jonathan Cape Ltd, 1994.

[28] D. McNeill, "Gesture and Thought," *Continuum*, no. 18, p. University of Chicago Press, 2005.

[29] C. DiSalvo and F. Gemperle, "From seduction to fulfillment," in *Proceedings of the 2003 international conference on Designing pleasurable products and interfaces - DPPI '03*, 2003, pp. 67–72.

[30] K. Ogawa and T. Ono, "ITACO: Effects to Interactions by Relationships between Humans and Artifacts," in *International Conference on Intelligent Virtual Agents*, 2008, vol. 5208, pp. 296–307.

[31] M. Ogata, Y. Sugiura, H. Osawa, and M. Imai, "Pygmy : A Ring-shaped Robotic Device that Promotes the Presence of an Agent on Human Hand," in *Asia Pacific Conference on Computer Human Interaction*, 2012, pp. 85–92.

[32] Y. Sugiura, C. Lee, M. Ogata, A. Withana, Y. Makino, D. Sakamoto, M. Inami, and T. Igarashi, "PINOKY : A Ring That Animates Your Plush Toys," in *Annual conference on Human Factors in Computing Systems*, 2012, pp. 725–734.

[33] H. Osawa, J. Mukai, and M. Imai, "'Display Robot' - Interaction between Humans and Anthropomorphized Objects," in *International Symposium on Robot and Human Interactive Communication*, 2007, pp. 451–456.

[34] J. F. Kelley, "An iterative design methodology for user-friendly natural language office information applications," *ACM Transactions on Office Information Systems*, vol. 2, no. 1, pp. 26–41, 1984.

[35] K. Kuwamura, T. Minato, S. Nishio, and H. Ishiguro, "Personality Distortion in Communication through Teleoperated Robots," 2012, pp. 49–54.

[36] T. Kashiwabara, H. Osawa, K. Shinozawa, and M. Imai, "TEROOS: a wearable avatar to enhance joint activities," in *Annual conference on Human Factors in Computing Systems*, 2012, pp. 2001–2004.