Emotion in robot cultures

Cultural models of affect in social robot design

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Abstract: This paper shows how cultural models relating to the display, perception, and experience of emotion are reflected in social robot design through a comparative analysis of social robotics in Japan and the US. A more implicit approach to emotional expression in Japanese robotics is related to community-oriented social practices and existing cultural forms such as Noh theatre, which encourages situational interpretation of neutral facial expressions, and interdependent notions of self. Western robot designs, in contrast, display more explicit expressions of emotion that may be related to an independent definition of the self. I review the literature on cultural models of affect to identify relevant themes, which I use to analyze historical and contemporary uses of cultural models in technology design. I conclude by suggesting possible research directions and design implications for cross-cultural robotics. By tracing particular cultural models of affect as they are embodied in technological artifacts, we gain a new perspective on the repeated assembly of culture through technology.

Key words: Cultural models, social robotics, affective design, comparative analysis.

1. Introduction

Social robotics is a growing field of study focusing on robots that can interact with people in everyday environments outside the factory and lab and take on social roles as guides, receptionists, assistants, teachers, and even caretakers and companions. These "emotional machines" can incite affective reactions from people as well as display and even "feel" emotions in turn [1]. Sherry Turkle suggests that the development of robots that are no longer mere tools but can do things "with" and "to" people [2] is producing a "nascent robotics culture" and redefining our notions of self and how we relate to technology [3]. Social robot design "repeatedly assembles"[1] [4] culturally defined and situated patterns of social interaction and construction of meaning.

As the commercial application of social robots becomes a foreseeable possibility, the influence of cultural factors on robot design and on users' responses to robots has become a salient theme of inquiry.[2] Numerous studies indicate that cultural models and practices are important factors in social robot design, influencing both the attitudes that users bring to the interaction and the notions of sociality that robot designers embody in their work. Lucy Suchman suggests that our expectations from social robots are "shaped not only by individual experience, but also by the specific cultural and historical resources that the world makes available to us" (p.8)[5].

[1] Repeated assembly connects the cultural past, present and future through social imaginaries, material artifacts, cultural practices, and institutional structures. These assemblies are often cyclical in nature, repeating certain themes across individual lives, generations, societies, and global webs of technology [4]. The assemblies are not identical, but mutative, so that repeated assemblies do not produce exact copies of existing cultural forms, but reinterpret and adapt them to different times and contexts.

[2] Social robotics research is a transnational practice, involving researchers in the US, Europe, and Asia.

Kaplan's [6] analysis of popular and traditional narratives in Japanese culture seeks to identify cultural factors that affect our perceptions of robots. Kitano [7] suggests that differences in the social, historical and cultural development of Japan have led to a unique conceptualization of the ethical significance of robots. Shaw-Garlock [8] contrasts the design visions of two social robotics projects, Repliee in Japan and Kismet in the US, to show how historical, theological, and popular aspects of culture surrounding robots play a role in robot design. Focusing on users' perceptions of robots, Bartneck et al [9] find significant cultural variation in people's negative attitudes towards robots among Dutch, Chinese, German, American, Japanese, and Mexican participants. Evers et al [10] study how users from China and the US respond differently to robots; further research done by Wang et al [11] suggests that robots are more effective in influencing the opinions of human team-members when they use explicit communication in the US and implicit communication techniques in China.

In this paper, I use Shore's notion of "cultural models" [12] to show that social robot design in the US and Japan embodies and repeatedly assembles [4] culturally situated conceptions of the affective and interactive self. I identify independent and interdependent definitions of self, explicit and implicit expressions of affective cues, and individual and relational perceptions of affect as salient cultural models of sociality in the US and Japan, respectively. I then present examples from historical and contemporary constructions of social robots to show how these cultural models are expressed in technological design. My results suggest the need for further cultural study of social cognition and affect that can be implemented through human-robot interaction research.

2. Cultural models of affect

Sociological and psychological theories suggest that our notions of self are a product of socio-cultural factors, constructed through interaction with other social actors and cultural artifacts in our environment [13, 14, 15]. While certain aspects of emotional and cognitive development may be universal, the specific ways in which people experience and perform selfhood and respond affectively to the others can vary according to culturally situated norms and practices. Cultural cognitive styles also define aspects of the environment that are worthy of attention and acceptable communication patterns (p. 294) [16]. Extensions of Ekman's work [17] on the universality of facial expressions suggest that cultural variation in display and decoding rules governs the frequency, appropriateness of use, and interpretation of emotional expression [18, 19].

Nisbett [16] claims that different cultural and social structures correlate with varying cognitive styles, which are the foundation for the tacit epistemology and folk psychology that we understand as common sense: "people use the cognitive tools that seem to make sense—given the sense they make of the world" (p. xviii). Shore's notion of "cultural models" refers to external materializations in society of these "models of experience… from which individuals construct more of less conventional mental models" (p. 51)[12]. "Social orientational models" index "fundamental qualities of relationships," "provide a degree of standardization in emotional response within a community," and designate appropriate roles and behaviors within interaction as well as in displaying, perceiving, and experiencing affect (pp. 62-63) [12]. The frameworks of the independent and the interdependent self [20] and related models of implicit and explicit modes of communication, field dependent and independent attention, and analytical or dialectical notions of agency and causation are particularly relevant for the study of social robots (summarized in Table 1).

Table 1. Dominant cultural models of sociality and affect in the US and Japan.

CULTURAL MODEL	INDEPENDENT SELF	INTERDEPENDENT SELF
Individual	Defined by internal thoughts, feelings and actions	Contingent on perceived thoughts, feelings and actions of others
Emotional display	Explicit cues	Implicit cues
Role in communication	Transmitter	Receiver
Attentional focus	Goal-relevant objects	Social environment
Presentation of self	Leader, agent of change	Achieving social harmony, fitting in
Explanatory logic	Formal, causal, rule-based	Dialectical, relational, contextual
Source of social agency	Attributes of object	Attributes of the social context
Unit of analysis	Individual	Agent in context

2.1. Independent and interdependent selves

According to Kitayama and Markus' [20] framework, the independent notion of self, widespread in the US, encourages a focus on individual characteristics, "one's own internal repertoire of thoughts, feelings, and actions," as definitive of the self. The interdependent notion of self, prevalent in Asian societies, emphasizes the individual's relational identity and the contingency of one's behavior on "the thoughts, feelings, and actions of *others* in the relationship" (p. 227) [20]. Besides describing an ideal-typical individual, the two frameworks also suggest different ways of acting within the environment—interdependence focuses on fitting in with others, while independence calls for expressing the separateness of the self and its ability to change the environment. Kitayama and Imada [21] suggest that American cultural practices include more tasks that encourage independence, such as "being a leader" or "taking initiative," while Japanese practices include more tasks that encourage interdependence, such as "achieving social harmony" or "fitting in" (p.176-178).

2.2. Field dependence and attention

Nisbett's research on field dependence suggests that the emphasis on community in the practices and structure of Asian societies leads to an analytical focus on relationships among things and with their context; the resulting cognitive style is more holistic, "attending to the entire field and assigning causality to it, making relatively little use of categories and formal logic, and relying on 'dialectical' reasoning" (p. 291) [22]. The dominant cognitive style in Western societies, on the other hand, is found to be more analytic, "paying attention primarily to the object and the categories to which it belongs and using rules, including formal logic, to understand its behavior'" (p. 291) [22]. In one of Nisbett et al's [16] experiments, American and Japanese students viewed a recording of an aquarium full of fish and were asked to describe what they saw. American students tended to focus on individual fish, describing fish in a tank. Japanese students, on the other hand, tended to focus on the tank, describing a tank with fish. Field dependence also affects how people interpret the intentions and feelings of agents. When Chinese and American students were shown videos of a group of fish, the Chinese students readily explained how the fish were feeling, including the mood of the group as a whole; American students seemed somewhat perplexed by the exercise. Nisbett suggests that this variation can stem from two different cognitive styles: one emphasizing contextualized relationships among things and events, and the other privileging rule-based causal explanations that emphasize the inherent characteristics of objects and persons.

2.3. Implicit and explicit communication

Independent and interdependent notions of self, coupled with field dependent and independent cognition, have also been related to differences in communication styles, particularly in the use of nonverbal behavior [23]. Nisbett suggests that cultures differ according to their expectation that the individual will be "transmitter" or a "receiver" of information (p. 60) [16]; in interdependent cultures it is assumed that you will be able to infer the affective meaning of behavior even if it is not made explicit and strive to maintain the relationship. In societies that foster an independent view of the self, individuals are expected to explicitly communicate their desires and feelings to others. Furthermore, individuals with interdependent conceptions of the self, which is common in community-oriented Asian cultures, tend to attenuate their emotional expressions in front of other people. This would suggest that, in the US, people look more at the individual's expressions of emotion, whereas in Japan the context gives a lot of clues about the response and emotion being expressed.

The psychological concepts described above are based on studies of human-human interaction; below I show how they relate to the design of robots as socially interactive artifacts. I start with a historical example and follow with contemporary case studies to show how culturally defined understandings of self and others are repeatedly assembled in the design of interactive technologies.

3. Robots as cultural models of sociality

Technology is instrumental in the transmission and reproduction of culture, understood as a "shared system of socially transmitted behavior that describes, defines, and guides people's ways of life, communicated from one generation to the next" [23]. Designers make explicit and implicit use of "cultural models" of behavior and experience to create interactive artifacts; in this sense cultural models are akin to "design patterns" as defined by Christopher Alexander [24] and applied to human-robot interaction by Kahn et al [25].[3] As "cultural models," technologies provide affordances that enable and encourage people to act in culturally appropriate ways.[4] At the same time, people's ability to use technology is contingent on their tacit familiarity with the cultural models that they reflect.[5] Analysis of the notions of sociality and affect in automata and social robots traces the "repeated assembly" [4] of cultural models of the independent and interdependent self through their materializations in "design patterns" for social robotics [24, 25]. Cultural models are mutable and hybrid, so I provide the examples below as salient trends in culturally situated robot design, without assuming that robots from a given region always follow the same cultural logic.

3.1 A historical look at cultural models in technology

A comparative look at automata, mechanical representations of humans and animals, in Europe and Japan shows technologies "imbedded in a network of meanings and symbols" (p.6) [27]. In the West, automata inspired and

[3] Like cultural models, "design patterns" [24] exist both in mind and in the world, as materialized constructions of "space and activity" that scaffold people interactions with the physical and social world (p. 98)[25]. In line with repeated assembly, design patterns are regularly repeated but never quite the same twice.

[4] Compare the foods and behavioral norms that accompany dining with chopsticks and with a knife and fork.

[5] Hutchins [26] describes navigation as a system of distributed cognition, which includes people, artifacts, computational and embodied practices, and concepts. He then compares Western maritime exploration, using maps and navigational instruments, with Micronesian navigation, relying on the navigator's cultural understanding of the movement of land in relation to the boat and environmental cues (stars, animals, waves).

embodied a mechanistic cosmology that sought to depict the inner workings of human and animal bodies and of society. Japanese *karakuri ningyo* interpreted clockwork through a different cultural lens, valuing the mechanisms for their emotional effect on people and their craftsmanship [28, 29].

3.1.1 Representations of the independent self

European designers of automata paid particular attention to the realism and precision with which their mechanisms simulated the natural actions of animals and humans (p.17) [30]. These explicit depictions of emotion and intent reflect an independent model of self. Many automata had explicitly animated eyes, eyelashes, lips, and even tongues. Jaquet Droz's automata are still appreciated for the attention to detail that went into the exact direction of their gaze, the rise and fall of the Musician's breast as she completed her tune, the Writer's flick of the pen to remove excess ink, and the Artist's conscientious removal of stray pencil dust with a few breaths. Von Kempelen's speaking machine explicitly professed its purported feelings towards its audience: "Vous etes mon ami" and "Je vous aime de tout mon coeur." (p.84) [31].[6]

Through their biomorphic features and life-like functions, automata also played a significant role in changing "the mental habits of their viewers" (p. 86) [32]; they inspired a mechanistic philosophy that emphasized causal explanations of phenomena in the natural world. Vaucanson's duck splashed, quacked, ate, and defecated. Unlike a regular duck, however, the automaton had the additional ability to exhibit the internal process by which these actions came about through its open abdomen, which exposed the workings of the mechanism. Its success inspired the construction of a similar representation of the human circulatory system, a "man-machine" (p.46) [30]. The mechanistic logic of European automata represented life through the internal functioning of the mechanism, rather than its relations to the environment.

3.1.2. Mechanisms of interdependence

The design logic of Japanese *karakuri ningyo* emphasizes the relationship between the audience and the artifact, rather than seeking to represent life. According to Takashina Shoji, the sole maker of *karakuri* in Japan today, "the performances of most mechanical dolls depend on input from the viewer, at least to some extent" [33]. The mechanisms by which *karakuri* operated were kept hidden from the public so as to evoke a more emotional response. Furthermore, the faces of *karakuri ningyo* were characterized by a neutral expression resembling the masks used by actors in Noh theatre performances, which are sculpted so that the audience can perceive a variety of expressions depending on the orientation of the head [33] (see Figure 1). This implicit pattern language used to communicate with the audience fits the emphasis on nonverbal communication in Japanese culture (p.3) [19].

The experience of emotions in *karakuri ningyo* also relied on the audience's interpretation of contextual information. In the case of the archer automaton *yumihiki doji*, for example, viewers interpret the doll's movements (which are always the same) and the play of shadows across its face as joy or embarrassment depending on whether it hits its target or not (p.27) [29]. In fact, the archer is purposely constructed to occasionally miss its target and thereby keep the audience engaged: "If the doll succeeds in hitting the target, we applaud him. If he misses, we will him to hit it next time. We become involved in the action" [33]. These

[6] Translation: "You are my friend" and "I love you with all my heart."

design choices suggest that *karakuri* are conceived as relational objects, whose significance becomes apparent in relation to the social context and through the active participation of the audience.

Figure 1: The "Noh effect" as depicted by Lyons et al [34]. (Photo from http://www.kasrl.org/noh_mask.html)

3.2. Cultural patterns in contemporary social robot design

Cultural models of the independent and interdependent self, seen in automata, can also be identified in social robot design. Design choices about embodiment and interactive behaviors, the defining traits of social robots, are indicative of different cultural notions of sociality and affect. In investigating how cultural models of independence and interdependence are displayed in the design of social robots, I attend to the use of implicit or explicit social cues, inherent or relational definitions of sociality, and individual or contextual notions of affect.

4.1. Robots as second selves

Social robot designs premised on an independent notion of self focus more on the inherent aesthetic and behavioral qualities of robots and less on the context in which they will be used. Bit, a prototype for the robotic toy called My Real Baby designed by Rodney Brooks' team at MIT, relies on a collection of human-like behaviors to simulate infancy:

> "We had tried to model the behavior of a real baby as much as possible. If the baby was upset, it would stay upset until someone soothed it or it finally fell asleep after minutes and minutes of heartrending crying and fussing. If Bit was abused in any way—for instance, by being swung upside down—it got very upset. If it was upset and someone bounced it on their knee it got more upset, but if the same thing happened when it was happy, it got more and more excited, giggling and laughing, until eventually it got overtired and started to get upset. If it was hungry, it would stay hungry until it was fed. It acted a lot like a real baby." (p.109) [35]

Bit's design suggests that the self is defined by certain traits and behaviors appropriate to its role; it can be described as a set of "components that interact according to well-defined (though not all known to us humans) rules" (p.173)[35]. Brooks' perspective on human nature is aptly portrayed on the cover to his book *Flesh and Machines*, which has a white outline of a person filled in with bits of machinery: a photo-camera, an extension cord, a propeller, spring, calculator, bicycle gear, screw, etc. (see Figure 2a). This mechanistic and analytical

understanding of human cognition was instantiated in the robot Cog.[7] Robots, as well as people, are envisioned as goal-based mechanisms acting according to a set of discrete rules, which define their roles and identity. In fact, robots can be our "second selves," representing human cognition and behavior in a mechanized form.

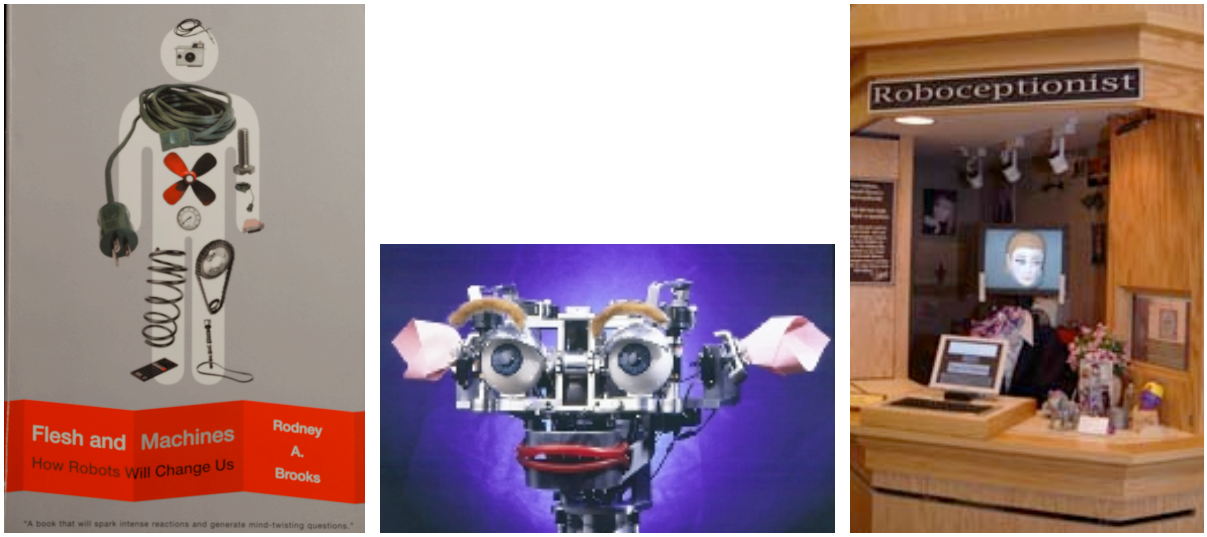

Figure 2. (a) The cover of Brooks' *Flesh and Machines;* (b) Kismet displaying "interest" (Photo: P. Menzel); and (c) the Roboceptionist in its booth at Carnegie Mellon University's Robotics Institute.

The sociable robot Kismet, another MIT creation, is particularly relevant to our focus on affective machines. Kismet is an infant-like robot designed to engage people in care-taking behavior that supports the robot's learning. The robot resembles an abstract Gerber baby: it has big blue eyes, a rubber red mouth that can be stretched and twisted to produce different expressions, and animated eyebrows and ears. Kismet perceives the world through audio, visual, and proprioceptive sensory inputs and gives off a number of important social cues, such as gaze, facial expression, and vocalization. The robot's affective displays reproduce Ekman's universal expressions: anger, happiness, surprise, sadness, disgust, interest and calm/neutral (see Figure 2b); it also externalizes its emotions by modulating the pitch and rhythm of its vocalizations. Although it is one of the first robots to use nurturing as a goal of the design, its design relies on an individualistic understanding of social interaction as transmission of information and goal regulation between actors.

Kismet's behavior is governed by an internal "emotion system" (p.110-110) [36], which allows the robot to experience different states of affective arousal (e.g. contentment, boredom, distress, etc.) and behave accordingly. Kismet's emotional displays are goal-directed and meant to modulate the actions of its interaction partners as well as its own activities. The robot's behaviors display its feelings to the person interacting with it and thereby modulate the interaction. For example, if a person is rapidly shaking a toy in front of Kismet's face, the robot may become distressed and move away from the stimulus, which would signal to the person to stop what they are doing. The emotional drive of the robot can also help it learn by reacting to people's scolding and praise as positive and negative reinforcement. The robot's sociality is predicated on a long list of conditions, which combine individual and relational characteristics such as the need for a social environment, to appeal to humans visually, explicit social cues, and contingent responses to the human's actions. Kismet's

[7] For more information, see the project website at http://www.ai.mit.edu/projects/humanoid-robotics-group/cog/

architecture, however, relies on the explicit expression of emotions and intentions by both the people and the robot to drive the interaction and on a complex set of rules that relate its sensory input to its behavioral output.

While Kismet uses explicit emotional cues to modulate interaction, the Roboceptionist engages people using soap opera style narrative. The resulting human-robot interaction follows the model of self as transmitter of information. In addition to answering questions about the weather and office locations, the Roboceptionist presents its personal story in a serialized format, so that people can hear about new events every few weeks. Its scripted behavior and advancing storyline are meant to involve people in long-term interaction. The robot's social identity is also supported through props in its environment, such as flowers, clothing, and photos (see Figure 2c). These hint at the robot's personality and aim to encourage people to ask particular questions that will help them discover new aspects of the story that the robot is telling. The linear storyline and personality-related props betray a focus on the robot's inherent characteristics and explicitly performed sociality. While the robot and its story are emotionally charged, interaction possibilities are delimited by the pre-programmed succession of narrative events and information the robot seeks to transmit to the user.

3.2.2. Machines with heart

Social robotics projects in Japan often emphasize the robots' emotional effect on users. Tatsuya Matsui describes his robot Posy, modeled after a flower girl, as a machine "that speaks directly to the soul" and can "make us happy" [37]. In *Wabotto no Hon*, Waseda University robotics researchers describe the humanoid robot Wabot as "a director of hearts" and "a bridge of the heart and the heart" [38]. Shibata calls the seal-like robot Paro a "robot that touches the heart" and emphasizes the relational aspects of its design:

> "Paro has a limited number of functions as a machine. But through the interaction with human beings I designed Paro to evoke associations in the human's mind. Humans have a lot of experiences and memories so when people interact with Paro they remember something, or associate with something. When some people interact with Paro, they remember a previous pet. When I was with Paro at nursing home a lady cried and said that it reminded it of her husband who had passed away… So in that case it's not necessary for Paro to have all the functions. The interaction can enlarge the number of functions."[8]

Some roboticists refer to robots as machines with *kokoro*, a term that refers to heart as well as mind and designates "the integration of emotion, intelligence and intention… It is the origin of all the behavior of the human."[9] *Kokoro* is defined in a relational manner. According to Shigeki Sugano, the "*kokoro* function" suggests that the robot will be able to attribute value to its sensory input by relying on its ongoing experiences of the environment; this presents the agent in context as a unit of analysis.[10]

The contextual interpretation of robots like Posy, Paro, and Keepon is made possible by their minimal design, which relies on underdetermined and implicit social cues that are given meaning through interaction. Nobuyoshi et al [39] call this the "subtractive method"—removing all but the most necessary communicative features to engage "the human drive to relate to others" (p. 1). Keepon is designed to project minimal

[8] Panel discussion at Japan Society in New York City, June 2006.
[9] Interview with roboticist in Tokyo, May 2005. Anonymized by request.
[10] Interview with roboticist in Tokyo, May 2005. Anonymized by request.

attentional and emotional cues that can be the foundation for interpretation within interaction [40]. Okada et al [41] applied the principle of relational subjectivity in designing the robot Muu. Inspired by Lorentz's "baby schema," Muu has one large eye, round cheeks, a soft rounded body, and staggering movements that imply infant-likeness. Muu's communication with people is based on "exchanging incomplete information with others" (p.1) [22] through relational sounds and movements; it "relies on an inherent incompleteness in the organism that needs to be filled in and repaired through interaction."[11] Muu's design is inspired by the Noh effect [34], in which a neutral facial expression is given meaning by the context and responses of other actors and the audience. Muu can also participate in triadic interaction (see Figure 3a), in which it collaborates with people in building up a tower of colored blocks using verbal prompts (e.g. "The yellow one is good" and "Blue!"). This activity scaffolds the building of a relationship between Muu and its human interaction partner through shared attention to a mediating object—the building blocks. The ambiguity of Muu's movements and sounds gains meaning within the context of interaction and through its relationship with the other social actors in its environment.

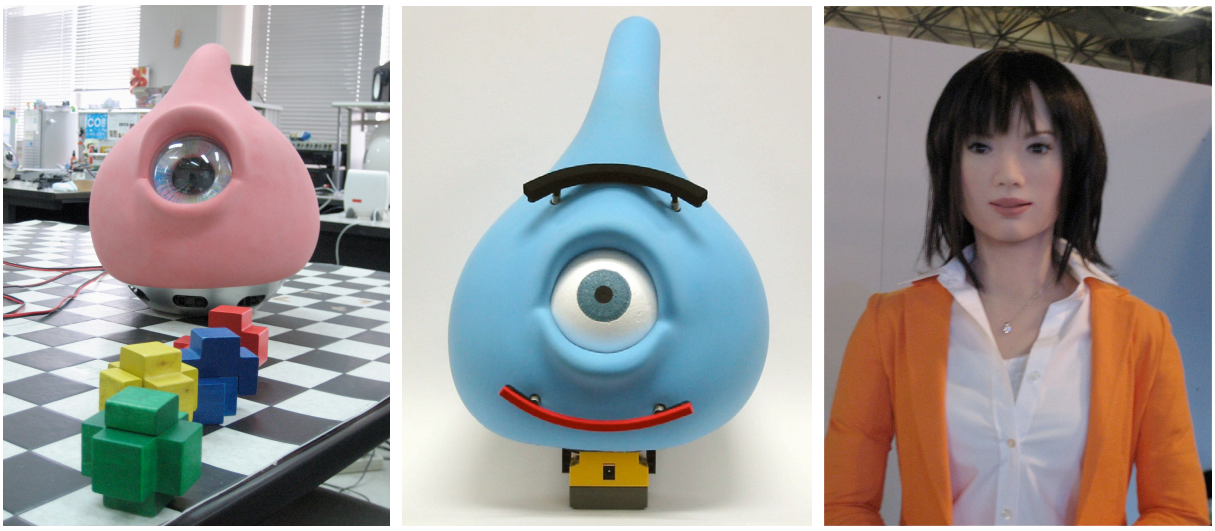

Figure.3 (a) The social robot Muu at Toyohashi University of Technology; (b) its "emotional" counterpart e-Muu at the Eindhoven University of Technology (photo: C. Bartneck); and (c) the Kokoro android at NextFest 2006.

Japan is also known for developing humanoid and android robots (see Figure 3c), which seem to be the opposite of the underdetermined minimalist design philosophy described above. However, roboticists suggest that such robots can provide a feeling of "human presence" and social contact in the future.[12] Even in the case such robots, the focus is on their relational effect, rather than their inherent characteristics.

6. Conclusions

In this paper, I described how different cultural models of the display and perception of affect influence the design of socially interactive robots. As robotics projects start circulating more freely in our daily lives and around the globe, it's timely to ask how design practices developed in one culture can carry over to another and follow the hybrid practices and cultural models that are created. The Noh mask effect as a design rationale may have different effects when used in different cultural settings; Lyons et al [34] have shown that the effect is

[11] Michio Okada speaking at the Minds and Machines Seminar, Rensselaer Polytechnic Institute, 9/21/2006.
[12] Interview with roboticist in Osaka, May 2005. Anonymized by request.

culturally variable and users who do not have experience with Noh theater and implicit affective cues may have trouble "reading" the robot's intentions. It's interesting to note that Cristoph Bartneck, from Eindhoven University of Technology, modified Muu by adding an eyebrow and a mouth that would allow it to display more explicit emotions (see Figure 3b). This change seems to make the robot more akin to the cultural model of the independent self, whereas the initial form is interdependent. Kaspar, a robot developed at the University of Hertfordshire, provides an intermediate case, where minimal design is mixed with more explicit cues. Kaspar is envisioned as a minimally expressive robot and is influenced specifically by the idea of the Noh effect, particularly in the design of the robot head [42]. Unlike the Noh mask, however, Kaspar does have some minimal movement in its face. These design choices beg the question of whether explicit information is necessary for Western users, or whether this is just a cultural assumption reproduced by designers.

The results of my analysis suggest cultural models of affect in design as a salient field of study. Further studies can focus on human-robot interaction with people from different cultures responding to explicit and implicit displays of emotion and interacting with minimal and more richly designed robots. We need to consider whether certain cultural models, such as the contextual understanding of affect in Noh theater, make the same sense when transported from one culture to another (e.g. Japan to England) and one genre to another (e.g. theatre to human-robot interaction), or whether we need to scaffold human-robot interactions differently. Robots can be used as platforms for validating and testing various theories of cultural cognition and social interaction. We may also want to consider what kinds of social models and schemas robots may be reproducing in their travels around the world. While robots as socially intelligent agents are a mirror that reflects our own views of social interaction, interacting with these new technologies also changes how we experience and practice sociality.

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