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# Role and value of character design of social robots

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**Abstract.** This paper presents on the meaning and value of the “character” of a robot. Through reflection and analysis of the robot development process and demonstration experiments with a robot designed by the authors, it was found that the completeness of the design of each element of the robot—such as its shape, color, sound, and so on—is not important; on the contrary, maintaining overall balance of those elements should take precedence. We considered that the goal of designing the robot was to avoid giving the user “discomfort.” Accordingly, to reach that goal, we confirmed the relationship through which the character of the robot is perceived by humans.

**Keywords:** social robot, character design, communication robot, information design

## 1 Introduction

In recent years, the technological progress of artificial intelligence (AI) has been remarkable, and opportunities to directly interact with artificial objects such as speakers equipped with AI we have been increasing. Such “AI devices” refer to a variety of information and provide us with something we want to know or happen. At that time, we experience an intellectual interaction with such AI devices that differs from that we get from conventional devices. In this paper, an object that provides such an intellectual interaction experience is called an “intelligent symbiotic artificial devices” (ISAD). As for ISADs, character designs such as “agents” on a screen and social robots are sometimes used to personify or add character to robots. Hereinafter, “character” refers to an anthropomorphic character or persona assigned to an intellectual symbiotic artificial device. In this study, we focus on social robots, which are especially physically present in our living environment as kind of intelligent symbiotic artificial devices.

## **2 Background**

We experience interaction with intelligent symbiotic artificial devices in various scenarios of everyday life. That interaction ranges from searching for a convenient train transfer or searching for a restaurant of choice on your smartphone to being provided with the conditions that you like at home, such the air-conditioning and lighting settings. The next time you start up your computer, you will see ads that reflect the content you just assessed on your smartphone. It is becoming a new social issue that personal information is acquired through these experiences, and that acquisition of our personal information gives us the feeling that someone is always watching our behavior, giving us a negative impression that makes us uneasy. Such experiences have created a negative image of AI and increased our anxiety that we will lose our work to AI in the future. In other words, the design of an intellectual symbiotic artificial device must allow the device to coexist with humans.

An effective way to communicate with an ISAD is to give it a “character.” Some robots that communicate directly with humans often wear clothes and speak in a strangely familiar manner. It is likely that the developers of such robots have found such features necessary from demonstration experiments in social environments; however, cases in which clear intentions and effects are explained accurately and scientifically are few and far between. Moreover, the design method and acceptance criteria for the character to be assigned to an ISAD are personal.

If we focus on the character of ISADs, we find that many AI speakers and other AI devices have voices that are spoken politely by adult men or women. Although these ISADs may be presented as representatives of “no character,” isn’t it right that the characters “adult women and men” and “no character” fully exist? It is thus urgent to design ISADs to allow them to interact with us in a manner that enables them to evolve with technology and become deeply involved in our daily lives. Incorporating “character” can be regarded as one effective method to satisfy that requirement; however, it is necessary to clarify meaning and effects scientifically and clarify the design method.

## **3 Peculiarities in character design concerning intelligent symbiotic artificial devices**

Regarding methods for designing characters, many examples—such as designing fantasy worlds like animations and roll-playing games (RPGs) as well as regional, company, and product mascots—and we can use that knowledge for robot design. However, ISADs differ from these characters in the way they exist and interact directly with the “real” world. Moreover, even if you have a method for designing a character, you still need to determine what characters are suitable for the ISAD that you want to design. In the world of fantasy, such as anime and RPGs, a “world view” is designed first. Then, characters are created on the basis of their affinity with the world, their significance, and their role. As for ISADs, this world view is everyday life itself, and it is necessary to design the interacting users themselves as people in the world. That requires “user experience (UX) design,” namely, designing the

experience of the user. UX design represents the value of user experience, and it is one of the most important themes in the design field today [1]. In other words, when designing a character for an ISAD, it is necessary to have knowledge of both the fantasy field (such as animation and RPGs) and “metadesign” theory—integrated from the perspective of UX design.

## 4 Research methods

The ultimate goals of this research are twofold: (i) clarify the necessity of a “character” in an ISAD and (ii) demonstrate design methods and present design guidelines. To achieve those goals, this research focuses on the design process. In particular, we investigate what role the character of an ISAD plays in its interaction with humans, and we attempt to clarify how to design the ISAD and identify what matters are important in that design process.

As for the development of social robots, a sociological approach called “technomethodology” has been attracting attention, and actual interactions of robots with humans in society have been observed, and the observations fed back to the development [2]. As for that development, one idea of designers is to solve the problems observed in society. That idea seems to have been reflected from the “ethnography,” and by analyzing those interactions, we can expect to discover design processes and methodologies. For that purpose, it is effective to analyze previous cases; however, designing the character of social robots is problematic because such cases are very scarce, and the design process and design are personal and not externalized.

In light of the above-described circumstances, in this study, we attempt to clarify a “personalized character design” by using a technique of art design.

According to Sunaga, art is “a world woven as the integration of perception and conception”; namely, it lies between a world filled with perceived events—called “life”—and the “science” that has been proven as a conceptual structure. Art design includes “expression, creation, and synthesis (construction)” as creation and “explanation, criticism, and analysis” as reflection. By contrasting and coordinating these worlds of perception and conception, it creates a code of practice [3].

In other words, the process of developing a social robot is the “creative” part, and analyzing and considering the developed robot is the “reflection” part.

Accordingly, in this study, which targets robots designed by the authors from 1997 to 2018, each design development is taken as “creation,” and the research activities to analyze and consider those designs are regarded as “reflection.” In this way, by contrasting and coordinating the former and latter, the meaning and effects of “characters” are clarified. Regarding the examples of the robots developed by the authors, each robot

- can engage in intellectual communication,
- can interact directly with people (i.e., it is designed to interact with people),
- has a strong character,
- and has demonstrated its high degree of completeness at various experimental demonstrations (such as Expo 2005 Aichi).

We therefore considered the specifications to be appropriate for this study.

## 5 Characteristics of the robots to be studied

Next, the robots targeted in this study are described. The personal robot “PaPeRo”—developed between 2001 and 2008—is shown in Figure 1.

It is fitted with speech-recognition technology to enable verbal communication, and it has CCD cameras built in both eyes so it can identify people from the images it captures and confirm the identity of each person. With these communication functions as basic functions, PaPeRo has been applied in the field in places such as kindergartens and nursing-care facilities implemented [4].



**Fig. 1.** Personal Robot PaPeRo(2001, 2003, 2005 and 2008 model)

The robotic agent called PIVO2, fitted in a concept car of Nissan Motors, is shown in Fig. 2. It supports driving while interacting with the driver through voice dialog [5].



**Fig. 2.** Robotic Agent PIVO2

A robot developed for research on interaction between humans and robots from aspects such as psychology and sociology is shown in Figure 3. Up until that development, we have used PaPeRo in humanities research; however, we could not deny that the character and size of PaPeRo influenced the experimental results. We therefore made its height variable and developed its character to be neutral. Based on PaPeRo and renamed “PaPe-Long” because of its increased height, PaPe-Long was demonstrated in tests carried out at local railways and rehabilitation hospitals, and it received the same high evaluations as PaPeRo [6, 7, 8].







**Fig. 3.** PaPe-Long.

## 6 Characteristics of the robots to be studied

The design of the robot (PaPeRo) was categorized in terms of each element, and a design specification was structured for each element. First, the design elements are broadly classified into ones that the user directly contacts (e.g., shape, color, voice, and dialogue) and contents such as utterances and the functions to be executed. Hereinafter, the former elements are called “surface” ones, and the latter elements are called “behavior” ones. The surface elements are further classified into more target elements, namely, shape, color, motion, timbre, sound, and dialogue (tone of voice) (see Table 1).

Behaviors are classed as functions such as utterance contents, “messages,” “reading out information on the Internet,” and “singing songs,” etc. Rather than being handled by elemental technologies such as voice recognition and face recognition, the functions are handled in units that are meaningful to the user.

**Table. 1.** Structured design elements

				
	Personal Robot PaPeRo	Personal Robot PaPeRo 2003	Personal Robot PaPeRo	PaPeRo R500
Surface				
Shape	Basically the same□ a new existing functional from rather than simulating something□			
Color	Colorful in a pop	Metallic silver		Pearl & colorful
Voice	Recording sound (cute voice)	Text to Speech(childlike machine voice)		
Sound	American comics (pop)	Synth system (electronic sound)	Mixed (separation of UI SE and production ME)	
Dialogue	“...da yo”(casual)	“...desu”(polite)	non personality	



**PIVO2**



**PaPe-Long**

Shape	Inherit vehicle modeling concept	Functional design of torso expansion and contraction
Color	Same color as vehicle body	Paste white satin cloth
Voice	Symbolic motion that indicates the state of the motion robot linked to speech and movement	Text to Speech(childlike machine voice)
Sound	Synth system (electronic sound)	Mixed (separation of UI-system SE and production-system ME)
Dialogue	“...desu”(polite)	non personality

## **6.1 Shape**

The element “shape” refers to the shape and size of the robot. As for PaPeRo, instead of simulating something already existing, we aimed to create a something new in a functional form that simply realizes basic functions. This styling concept was inherited by robots developed after PaPeRo, and although minor changes have been made to the details of each new robot, the subsequent robots are largely the same. The head and face were not changed. As for PIVO2, the concepts used in modeling vehicles were basically inherited. For research purposes, PaPe-Long has a function allowing it to reduce its height. Since our development purpose was “neutral design,” the torso of PaPe-Long is a duct hose pipe shaped as the minimum-required simple line covering the internal mechanisms in consideration of keeping the basic function of the design as is, and the rest of PaPe-Long is the same as PaPeRo.

## **6.2 Color**

The “color” element refers to the color of the robot, but in this study, the material and finish (matte, gloss, etc.) are also treated as color. Regarding color, in 2001, PaPeRo was colored vividly, while in 2003, its targeted color was silver. The exhibited model (“ExpoPaPeRo”, hereafter) and 2008 model were based on pearl white and used slightly different, brighter colors than the 2001 model; even so, their overall image is that inherited from the 2001 model. PIVO2 inherits the color of the car, and PaPe-Long has a simple white but satin-like cloth on the surface. This is because painting PaPe-Long in the same color as PaPeRo must be avoided because gloss and reflection of light create the image of an industrial robot. A matte paint was also a candidate, but a cloth was used in consideration of its durability in subsequent experiments.

## **6.3 Motion**

The element “motion” refers to the movement of the robot. As for PaPeRo, the neck can move, the LEDs forming the mouth can move, and the body can turn and move. As for motion, it is mainly directives such as the moving the neck when speaking and emitting the LEDs of the mouth. In the case of the expo version, the LEDs of the mouth were designed to correspond to the contents and application status of the robot so that the person demonstrating PaPeRo at the expo venue could check the robot status. In 2008, LEDs were added to the chest so that information could be presented via the chest LEDs. Regarding the motion of social robots, various previous studies have been reported, and they are expected to be significantly reflected in the present development; however, we would like to report them in detail as one study on another occasion.

#### **6.4 Tone of voice**

The element “tone of voice” refers to the voice of the robot. Excluding the content of utterances, it purely means the sound of the voice. PaPeRo2001 has a voice recorded by a voice actor; the rest have synthesized voices. PaPeRo2003 and expo model had the same synthesized voice, while the synthesized voice of the PaPeRo2008 was a more child-like. PIVO2, PaPe-Long, and the PaPeRo2003 had the same voice as ExpoPaPeRo.

#### **6.5 Sound**

The element “sound” is the sound, as well as its voice, emitted by the robot. As feedback to interactions, it the sound of a directed fanfare, BGM when the robot dancing, etc. As for PaPeRo2001, its voice was designed with a focus on comical American comics in combination with colors. PaPeRo2003 and ExpoPaPeRo extensively used electronic sounds like machines and synthesizers according to the color and speech-synthesized voice. As for ExpoPaPeRo and PaPeRo2008, the sound used as the user interface was mainly synthesizer-based, and they used common sound effects for scenarios with strong directive elements such as fanfares when the user answered quizzes correctly. PIVO2 adopts a sound based on that of PaPeRo2003, and PaPe-Long’s sound is designed on the basis of the same concept as PaPeRo2008.

#### **6.6 Dialogue (tone of voice)**

The element “Dialogue” is the tone (b) of the robot’s speech. As for PaPeRo2001, the tone of voice was “—da yoo” (“That’s right!”) and “nee-nee” (“Guess/You know what!”). As for speech synthesis, it was difficult to produce unique expressions like the manner of voice recordings by voice actors, and the unnaturalness of utterances such as “—da yoo” (“That’s right!”) and “nee nee” (“Guess/You know what!”) was extreme. Since PaPeRo2003, which adopted speech synthesis, the utterances simply ended in “desu” or “masu” (standard verb ending and polite verb ending, respectively, used at the end of a Japanese) sentence.

#### **6.7 Behavior**

Next, the element “behavior” is described. PaPeRo has a typical “cute” image, speaks in a friendly manner with phrases such as “Let’s play!”, gives quizzes, imitates things, makes jokes, and dances. On top of that, it has functions that match the work done in the field of each experimental demonstration. For example, in a kindergarten, it reads a picture book or says “Good morning” alongside the head teacher at the school entrance in the morning. ExpoPaPeRo is basically intended for caring for



children at daycare centers in the future, so it will give intellectual quizzes and sing songs. In addition to providing route guidance and driving navigation, PIVO2 also utters phrases like “Your driving has gotten better recently.” Like PaPeRo, PaPe-Long imitates things by using jokes and sounds as well as handling matters related to the field of the experimental demonstration. For example, in an experimental demonstration at a local railway, PaPe-Long imitated sounds of a train such a carriage door closing, a horn blowing, and the motor running.

## 7 Considerations

As for what matters were reflected through structuring, focusing on the design process, we consider (i) how the character is designed and (ii) how a person perceives that character.

### 1) How is the character designed?

According to a study by Ito, et al., PaPeRo is an image representing “cute,” and that cuteness stayed almost the same from PaPeRo2001 to PaPeRo2008 [9]. Hereafter, we consider this “cute” to be a state that can be understood and accepted as a communication target. If the following two conditions,

- being perceived as one character
- being recognized as an object of interaction,

are satisfied, characters are designed by maintaining a certain balance between all the surface elements and behavior elements; that is, it was considered that they are designed from both the viewpoint of character-design methods in fields such as RPG and animation and user-interface design in the field of UX design. A “certain balance” means that “discomfort” does not occur.

For example, PaPeRo2001 has a recorded voice by a voice actor, but the other PaPeRos have a synthesized voice. The synthesized voices of PaPeRo2003 and ExpoPaPeRo are the same, but PaPeRo2008 has the synthesized voice that was a little child-like. When the voice was changed from a voice of an actor to a synthesized voice for the development of PaPeRO2003, we prototyped a robot that spoke in a voice synthesized from that of PaPeRo2001. The voice synthesized at that time was the general speech of an adult woman (e.g., a voice like that of a TV presenter). The tone of the voice was the same as that of PaPeRo2001. As a result, developers and users who cooperated in evaluations was “not cute”. This evaluation meant that the two conditions above were not satisfied and the voice needed to be improved. Accordingly, when the recorded voice and synthesized voice were used together, we got comments that the voice gave the impression of being “transformed” or “possessed” at the moment it changed. Moreover, the voice actor’s speech (tone) was uttered as it was by the speech synthesis, so it was evaluated as “not cute.” Accordingly, with the tone as “desu” and “-mas,” the speech-synthesized voice was designed to have a higher pitch than that of an adult woman to make it sound like a child’s voice.

When the sound was designed in this way, the bright colors did not mismatch the sound, so the color was changed to silver. And the sound effects were changed from that of the previous American comic tone to the sound of a mechanical synthesizer. As a result of these designs, although PaPeRo2003 was also perceived as the image of “cute,” its character clearly differed from that of PaPeRo2001. While PaPeRo2001 had a bright and zany character, PaPeRo2003 (with synthesized speech) gave a serious and clever impression.

Focusing on the behavior element, after developing PaPeRo2003, we applied the various kinds of humor found in the comic genius robot “PaPe-Jiro” as the robot’s behavior [10]. With a serious and clever image, PaPe-Jiro worked with human comics (Fig. 4). A variety of “humor” was created using the characteristics of the PaPeRo concept and functions while performing a live show at an actual standup-comic venue. For example, by taking advantage of the characteristics of speech synthesis, it was possible to make PaPe-Jiro utter tongue twisters that were too fast to be audible, so that humor was updated to something like “robotic humor.” We consider that by making humorous utterances in this manner, PaPe-Jiro achieves a balance between the behavior elements and cuteness.



**Fig. 4.** Zenjiro and Pape-Jiro on the M-1 Live show

From the considerations described above, regarding how the character is designed, it is assumed that all the surface and behavior elements must be designed, not specific ones such as shape and voice, and that all of them are designed by maintaining a certain balance. It is considered that having no sense of discomfort at that time is a major criterion of design. This is close to the viewpoint of design called “tone manner” and the previously mentioned “world view” in the field of games and RPG.

## **2) Human perception of the character**

Next, human perception of character is considered. In this paper, human perception is a reflection on the cognitive activity of users and developers in the development of robots themselves and social experiments using the robots. It was

therefore considered that humans tried to find meaning and character through active cognitive activities to understand social robots as objects of communication.

In a psychological study with Kashiwabuchi, et al. conducted at an exposition, we conducted experiments to identify factors that strongly influence the image of the robot (Fig. 5) [11]. In addition to the normal PaPeRos, we prepared a PaPeRo limited to movement only, a PaPeRo with utterances only removed, and a PaPeRo subjected to multiple experimental conditions that restricted the surface and behavior elements (such as one with the communication function removed), and had them interact with each other to evaluate their individual images. In the experiment, in addition to identifying influences, we hypothesized that as the surface elements, behavior elements, and communication functions became more abundant, the evaluation would be better. However, experiments revealed that there were no significant differences between the surface elements, etc., and that it was not necessarily better to have more surface elements, behavior elements, and communication functions. Under for all the experimental conditions, even under the condition that PaPeRo's voice-recognition function was restricted (cannot-communicate specification) and its movement was restricted (chat but not move), PaPeRo was still highly evaluated with comments like "Talking with PaPeRo was fun." And even when PaPeRo did not respond to the user's question, many of its cognitive behaviors were attempts to understand its inability to communicate with user who said, "Oh, I don't like this sort of chat!" The comment "Oh, I don't like this sort of chat!" is presumed to arise from PaPeRo's interests and preferences, and it can be considered that cognitive activities aiming to understand the state of communication were conducted among users.



**Fig. 5.** Psychological observations

As for the development of PIVO2, the challenge was, unlike PaPeRo, its design, in which the robotic agent had a "state of doing nothing". A "state of doing nothing" means that the robotic agent has no need to work for the user while the vehicle is running normally. During development, we designed each element for each interaction, so PIVO2 did nothing if the user did nothing. However, the user is always driving and the car is always running. It was observed that in that situation, if the agent did nothing for a certain period of time, the user became anxious and said, "Is it broken?" Therefore, even when the user did nothing for a certain period of time, PIVO2 added certain "living" feelings such as moving its neck a little [5]. This can be

regarded as a positive cognitive activity by which the user tries to understand the state of the robot.

During development, PaPe-Long was designed with the goal of not expressing a specific “character” for that purpose. The design concept was “neutral design.” Based on this concept, the body was designed from the torso with a contraction function first; however, no matter what we did, the design created a “girl-like” or “penguin-like” image (see Fig. 6). So, ultimately, we minimized the design of the body as a “contraction/elongation” function.



**Fig. 6.** Designing the body

As a result of that design, a sense of uncomfortableness between the design of the head (designed for PaPeRo) and the body (with minimized design and functions), so we redesigned the head (Figure 7). When the head and body designs were balanced, arms were added because having “no arms” was obvious. As a result of proceeding with such a design, the “character” was called “ponkotsu” (“retro robot images”) — which are the exact opposites of our original goal, namely “neutral.” Ironically, in a later demonstration experiment, PaPe-Long was evaluated as “cute” as PaPeRo, so it turned out that we had perfected its character [6].



**Fig. 7.** Designing the head

Looking back on this design development revealed that the design task was to eliminate the “uncomfortable feeling,” and as a result of eliminating the

uncomfortable feeling, the “retro robot images” characters were designed. Given this, it might be possible for a developer think of something unconscious as a criterion for “discomfort.” At first the criterion was “neutral,” but in the first place, “neutral” is vague itself. We suppose that the contraction/elongation function was designed in a vaguely minimal manner, and the “duct hose pipe” adopted as the robot’s appearance seemed to give a sense of uncomfortableness based on that minimum design. In addition, as for part of the movement itself, the balance of the center of gravity was unstable, and that unbalance gave a kind of “unpredictable” movement. It is conceivable that as a result of proceeding with the design so as not to feel uncomfortable with this “duct hose pipe” and “unpredictable” movement, the design would finish up with the image of “retro robot images”. At this stage, the developers themselves unconsciously found the characters “retro robot images” from “duct hose pipe” and “unpredictable.” So we might also be able to think of a criterion for “discomfort” from those characters. If so, it is conceivable that the developer was also performing cognitive activities to find characters as guidelines for designing the target element.

From the above, it is considered that humans are actively engaged in cognitive activities aimed at robots. That means trying to understand the state of the robot and the robot itself. And it can be considered that there is some prerequisite for that understanding, that is, the character of the robot. That character is perceived from the “surface” and “behavior” elements.

## **8 Concluding remarks**

In this study, what is the role of the character of a social robot (that is, an intelligent symbiotic artificial device) was investigated by using an art-design technique? In particular, we tried to clarify how the robot was designed and what was important in designing it. As a result of this investigation, it is concluded that the character of social robots are important information in understanding the robot as a conversation partner in interaction with humans. It was also considered that the character “always exists” regardless of the developer’s intentions. This is because people actively and cognitively interact with social robots in an effort to understand them and try to perceive their character. If a robot does not show a character, people will look for information in more detail. So developers probably need to treat “character” as essential in development of robots. The clues to that character are all the surface and behavior elements mentioned in this paper, and it is important to consider the overall balance between those elements rather than the completeness of each element. At that time, an important viewpoint of design is “discomfort,” which can be handled from the viewpoints of “world view” and the user interface.

Two main issues face the final purpose of this research. One is to confirm, through further development, whether or not the matters reflected in this study are true. The other is “character”; in particular; we must clarify relationships in the social environment where the social robot is placed.

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