Engaging with artificial pets

Marti P.* **Pollini A.*** **Rullo A.***
*Communication Science Dpt., University of Siena
Via dei Termini 6, 53100 Siena, Italy
marti@unisi.it, {pollini,rullo}@media.unisi.it

Shibata T.†
† Intelligent Systems Institute, AIST, PRESTO,JST
1-1-1 Umezono, Tsukuba, Ibaraki, 305-8568 Japan
shibata-takanori@aist.go.jp

ABSTRACT
This paper is a reflection about the compelling yet difficult nature of interaction dynamics among humans and robots, and a special category among them: robots capable of mediating social interaction. Such systems are not designed to help the human being performing work tasks or saving time in routine activities, but to engage them in personal experiences stimulated by the physical, emotional and behavioural affordances of the robot. The argument is illustrated by a case study in which an artificial pet was used as a support to therapeutic treatment of children with severe cognitive impairment.

Keywords
Interaction design, human-robot interaction, social robots, cognitive rehabilitation.

INTRODUCTION
Robotics has mainly been the object of industrial applications that have produced programmable machines, capable of carrying out physical tasks, very far from the interests of cognitive ergonomics, psychology and interaction design. However, recent developments of the discipline have produced technologies that have made interdisciplinary studies possible. We refer to the design of machines capable of engaging in social relationships with other machines and with human beings. These are robots capable of taking initiatives and having certain autonomous decision-making abilities, capable of negotiating their presence with the environment in which they operate and that are mediators of communication in social contexts. These robots mainly take the form of artificial pets, robotic toys with pet-like behaviour. Unlike traditional robots, which are made to be intelligent tools that serve their users, artificial pets are autonomous creatures that stimulate interaction and elicit personal meaning attribution and attachment from their owner. This type of machines provides psychologists and interaction designers with new research issues that need further consideration. One first important issue is that human beings tend to perceive these robots as being different from other machines. Obviously, one of the reasons behind this is the physical nature and the tangibility of these robots that act as catalysers of interaction and generate a particular phenomenon for which humans tend to consider them as anthropomorphic or zoomorphic creatures (Fiedman, Kahn, & Hagman, 2003) even when their physical aspect is obviously different from that of an animal or a human being.
A second important aspect is their ability to take decisions and act autonomously. This capability becomes particularly interesting if combined with the ability to create a relationship with the environment, to negotiate the use of resources available in a dynamic way, to be equipped with physical components which are closely integrated with the functional ones.
Therefore artificial pets provide a fascinating arena for studying and designing the morphological and behavioural characteristics that stimulate interaction and elicit meaning attribution and attachment from the human beings.
In the paper we will analyse the distinctive features of robot mediated social interaction through the presentation of a case study in which the seal robot Paro was used with children with a severe cognitive impairment. The case study is illuminating to show how even in presence of seriously compromised cognitive and sensorial conditions, the artificial pet may act as a mediator of social interaction.

ROBOT MEDIATED INTERACTION
The concept of sociality in robots has taken on a wide variety of nuances and meanings that basically depend on two elements: the ability these machines have to support the social model they refer to, and the complexity of the interaction scenarios they are capable of facing (Breazeal, 2003). In line with these two elements there are various kinds of social robots, from those which *evoke* sociality *(socially evocative robot)* by placing the accent on anthropomorphic or zoomorphic characteristics; to those known as *social interface robots*, which adopt social and behavioural rules to provide their human interlocutors with a "natural interface"; from *socially receptive robots* with learning abilities by means of imitation; to *sociable robots* capable to pro-actively engage in interaction with human beings in order to satisfy an internal need (desires, emotions).

The perspective on social robots that we discuss in this paper is not specifically connected to one of the above categories apart from the others but to the quality of interaction and to the personal significance that every human being creates by getting involved and involving its own life experience in the interaction with artificial pets. We will analyse the interaction dynamics that develop when a social robot mediates and catalyses human beings' creative ability to construct personal meanings when engaging in the interaction with an artificial pet (Marti, 2005).

Artificial pets have been developed in a variety of forms, from the simple "key-chain" pets (Tamagotchi) to complex robots such as Aibo, Tama or NeCoRo inspired by cats and dogs.

Even with profound differences, these artificial pets share several key behaviors: they act autonomously, they require frequent interaction and they develop in response to their owner's actions.

However it is not always easy to predict when their behavioural and physical qualities foster successfully interaction and attachment. For example, in the case of Tamagotchi, the poorness of its physical qualities does not seem to negatively affect the engagement of the owner. Indeed even if it is just a small plastic key-chain egg with simple animations on a low-resolution screen, however people become extremely attached to them, giving high priority to caring for them and mourning them when they "pass away".

For Aibo, Tama and Necoro the situation is quite different. Although similar in their physical aspect to cats and dogs and very sophisticated in their behaviour, they have received alternating or lukewarm acceptance. For example, Aibo had to be "dressed" and look like a toy in order to be accepted by elderly patients (Yonemitsu et al., 2002), and this is not a unique anecdote for social robots. Different attempts to develop cat-robot and dog-robot (Shibata et al., 1999) revealed the inadequacy of these models in supporting interaction with humans. Their physical appearance turned out to be unsuccessful in meeting human beings' expectations during the interaction. The unlikeness from real cats and dogs was so evident to compromise any possibility of attributing meaningful contents to such robots and therefore to engage a meaningful interaction.

THE SEAL ROBOT PARO

In what follows we examine the case of the artificial pet Paro, a baby seal robot whose morphological, perceptual and behavioural characteristics have been exploited to stimulate interaction and attachment in children with serious sensorial and cognitive impairments. The study provides preliminary results on the design of artificial pets able to engage the owner in the interaction but most of all to mediate communication and support the human ability to give significance to its experience of the world.

The seal robot Paro was designed by Shibata (Shibata et al., 2001) using a baby harp seal as a model (see Figure 1). Looking at the robot one can think it is a simple artificial pet developed to establish and maintain a relationship with its owner.

However even if it has been designed as a robot companion for personal entertainment, it has been successfully introduced as a support for therapeutic treatment of young and elderly patients affected by cognitive, sensorial and motor deficiencies (Marti et al., 2005), (Saito et al., 2002).

Robot's appearance is from a baby of harp seal and its surface is covered with pure white and soft fur. Also, a ubiquitous tactile sensor is inserted between the hard inner skeleton and the fur to create a natural feel and to permit the measurement of human contact with Paro. Its fur hides a complex network of sensors that allows it to react to environmental stimuli. Paro is equipped with the four primary senses: sight (light sensor), audition (determination of sound source direction and speech recognition), balance and the above-stated tactile sense. Its moving parts include vertical and horizontal neck movements, front and rear paddle movements and independent movement of each eyelid, which is important for creating facial expressions.

Figure 1: The seal robot PARO

The robot is able to exhibit three kinds of behaviours: proactive, reactive, and physiological. Pro-active behaviours are generated considering internal states, stimuli, desires, and a rhythm of the day. The basic behavioural patterns include some poses and some motions. The seal robot reacts to sudden stimulation like turning the head towards a source of sound and behaves following the rhythm of the day with some spontaneous desires such as

sleep and tiredness. Indeed, Paro has its own "physiological life". When its batteries are high it acts more lively, but if it "works" for a long time, it looks tired and its movements slow down. Paro generates its behaviour depending on its internal states, rhythm of the day, and stimulations. There are several candidates of behaviours in a situation and each behaviour has a weight that is used as probability of behaviour selection.
Furthermore when Paro is stroked gently, it feels good, and adds some weight on a candidate of its behaviour that was chosen in the situation. Paro responds to pats and to external stimuli by moving the body and the head in a coordinated way, by fluttering the eyelids, making sounds, purring if cuddled.

AN EXPLORATORY STUDY

In this study we experimented the seal robot Paro in a group therapy with three patients (Paolo, Chiara and Emanuele), two of them affected by Down syndrome (Chiara and Emanuele) and the third, Paolo, affected by Hanhart and Moebius syndromes. The study was conducted at the "Le Scotte" Hospital in Siena, Italy, where these patients regularly followed a therapeutic treatment.
The Down syndrome is a genetic disease in which many different cognitive and physical problems collapse. From a clinical perspective Down syndrome represents a quite uniform, even if not stereotyped, whole of morphological body traits, especially in the face; malformations of internal organs and various level of cognitive delay.
Usually a patient affected by Down syndrome shows:

- a cognitive development that doesn't arrive at the formal operation stage, i.e.: the capability of discriminating, generalizing and memorization;
- a slower elaboration of auditory information;
- a delay in organizing the motor answers;
- a not immediate use of the auditory memory;
- a distorted and deficient representation of the self.

The severity of these symptoms vary person by person, but all these disturbs are present in each subject at a certain percentage, and thus for the patient involved in our study.
Chiara is a 27 years old girl with a severe behavioral and relational delay. She often shows aggressiveness and poor collaboration in social exchanges. It is very hard to involve her in group activities even those implying only talking. She usually selectively directs her talk towards very few people and doesn't come into physical contact with the others.
One of the main therapeutic goals of the treatment conducted at the "Le Scotte" Hospital, was to improve her production of context-relevant meaningful talk. In order to support her in appropriate interactions, the therapist also aimed at enhancing her visual and physical contact with the others. Eventually, the group therapy had the scope of developing a collaborative attitude with peers.
Emanuele is 23 years old with a poor and disarticulate expressive language and a very reduced initiative in social relationships. He usually tends to be isolated without trying any approach towards other people. Whereas, when involved, he behaves appropriately, despite of a certain delay in following the flow of the interaction.
One of the aims of the therapeutic treatment was to improve his relational skills and to support his communication capabilities.

Paolo is 14 years old with combined Hanhart and Moebius syndromes. These are two very rare syndromes whose precise cause remains unknown. The signs are dramatically evident for both the diseases. In fact Hanhart syndrome is characterized by signs as short, incompletely developed tongue (hypoglossia); absent or partially missing fingers and/or toes (hypodactylia); malformed arms and/or legs (peromelia); and an extremely small jaw (micrognathia). Moebius Syndrome is a disorder characterized by lifetime facial paralysis. People with Moebius Syndrome can't smile or frown, and they often can't blink or move their eyes from side to side. In some instances, the syndrome is also associated with physical problems in other parts of the body. As for cognitive skills, Paolo has great difficulties in keeping his attention focused even for short periods of time. He always tends to start talking about current or historical event, without any relevance to the context. For this reason, one of the therapeutic objective of the treatment followed at the hospital was to reduce his logorrhea related to fanciful contents and support him to produce appropriate contents during the conversation.

An intensive observation period of the patients under treatment was carried out in order to share problems and practices with the therapists. As a result of the observation and interviews with the therapists a clear difficulty in the social relationships emerged: the three patients did not relate to each other and any attempt to involve them in collaborative tasks failed. Basic social skills seemed to be compromised.
On this basis, we decided to conduct an exploratory study with Paro with he purpose of studying the potential of the robot in mediating social relations, catalysing the attention and stimulating the sensorial exploration.

Method

The study was conducted following a qualitative approach. It was organized in sessions lasting one hour with weekly occurrence over a period of three months.

The observation was carried out on two levels: 1) a micro-level inspired to Interaction Analysis principles (Heath, 2002); and 2) a macro-level taking into consideration a broad unit of analysis including dyadic and triadic exchanges, the use of tools, the environment, the context of interaction and the therapeutic protocol. In this way we could focus both on meaningful interaction events like gaze direction, touch, speech etc.. and on complex activities like storytelling and pretend play with more general objectives. Interaction events were analysed in relation to the activity in which they occurred. To facilitate the process, an observation grid was defined containing meaningful events to focus during the video analysis, strictly related to the main objectives of our study: sensorial exploration, social exchanges and emotional intelligence.

For each main objective a set of meaningful interaction events was defined as follows:

General objective: SENSORIAL EXPLORATION

to stimulate the exploration of the physical and functional characteristics of the robot during individual and collaborative activities.

Examples of interaction events:

- *Touching the robot*
- *Stroking the robot*
- *Holding the robot*
- ....

General objective: SOCIAL EXCHANGE

to analyse social exchangse between the subjects in the group, by encouraging physical contact, communication and collaborative behaviour.

Examples of interaction events:

- *speech*
- *touching other people*
- *gaze coordination*
- *control of turn taking during verbal communication...*
- ....

General objective: EMOTIONAL INTELLIGENCE

to study the presence of emotional intelligence, that is the "ability to monitor one's own and other's feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions" (Salovey, Mayer 1990). This ability may be considered as the result of a transactional process (Bruner, 1986) in which beliefs and orientations are negotiated. One of the outcomes of this process is the creation of representations and expectations on our own as well as on others emotions.

Examples of interaction events:

- *Naming own emotional states*
- *Naming emotional states referred to others*
- *Describing the strength of feelings*
- *Explaining own internal states*
- ...

Setting, objectives and activities

Nowadays, the therapy conducted at the "Le Scotte" Hospital is inspired to the occupational therapy, a kind of treatment focused on the acquisition of autonomy in daily activities. The therapy usually takes place in a dedicated structure, called ECONART, a home-like environment fully equipped with facilities for people with different abilities. Our study was hosted in the same environment to get continuity with the therapeutic program and perform the activity in a familiar context.

Each experimental sessions consisted of three main phases:

1. a warming up phase, basically concentrated on the exploration of the robot;
2. the introduction of specific tasks such as storytelling and pretend play, both individual and collaborative;
3. occupational therapy tasks to maintain consistence with the activities usually undertaken.

The warming up started with an invitation of the therapist to hold and caress the robot and to verbalize sensations. She stimulated the exploration of the physical and functional characteristics of the robot asking questions like: 'What do you feel? Does it smell? Is it soft? What is inside? Which parts are soft?'. She aimed to build and share a background knowledge for the following phase of storytelling.

In the storytelling the therapist mainly suggested simple stories having the seal as the main character, asking the subjects to enrich the story by adding elements like fantasy objects or properties (colours, materials, uses) which could play a role in the pretended situation.

Different tasks were proposed for the storytelling:

- "*Tell a story to the robot*"
- "*Tell a story about Paro to other people*"
- "*Engender an emotion in Paro*"
- "*Paro is going to…*"
- "*I would like to…*"
- "*Write a letter*"

Also collaborative storytelling was tried out like continuing a story started by someone else. This was a quite demanding task implying focused attention on the story sequence, and the full understanding of the narration milestones in order to proceed in a consistent way.
Another collaborative storytelling task was based on playing sounds. In this task the therapist told a story very slowly while the patients had to play sounds and generate noises mimicking the contents of the narration.
In the pretend play task the subjects were asked to send pictures of Paro to its mother in Japan, to give her an impression of her son's life in Italy. Before taking the pictures the subjects built scenes like staying on the beach, or sleeping with Paro or having a picnic together. After the scene setting, the subjects assigned roles and assumed the pose for the picture.

RESULTS AND DISCUSSION

As anticipated, the study lasted three months and all sessions were video-recorded. The video analysis was performed adopting a qualitative approach both at level of micro interaction events defined beforehand (touching, gaze, speech analysis) and at the level of more complex activities (storytelling and pretend play). In the following we provide exemplars of outcomes.

Sensorial exploration

The warming up phases were mainly dedicated to the exploration of the physical and functional properties of the robot. As said before, indicators were defined in order to collect evidences of explorative behaviours like:

- *Touching the robot*
- *Stroking the robot*
- *Holding the robot*
- *Looking at the robot*
- *Paying attention to its calls*
- *Following robot's gaze*

…

Occurrences of these behavioral events were annotated together with the correspondent speech and a description of the context of the interaction (use of other objects, expression of joy or frustration, interruptions etc..). Finally, the data were put in relation with the therapeutic objectives, discussing differences and commonalities between the currents session and the previous ones with occupational therapy.

Figure 2. Sensorial exploration

One of the most successful activities was washing the seal and then compare the different sensations engendered by the dry and the wet fur. The therapist damped the robot and then invited the subjects to stroke its fur. "*What do you feel*?" (therapist): "*It is as if it was under water*", "*You know it was really under water*" (Paolo and Emanuele). Afterwards she asked them to wash their hands and to dry them using the robot's fur as a towel, by touching and exploring all parts of its body. They were invited to put attention on the sensation of becoming dry. An example of the conversation was: (therapist): "*We put it in the sun to make it dry, don't we??*", "*It is getting warmer and warmer*" (Emanuele).
It is important to notice that the exploration of the robot was done individually and each subject waited for his/her turn without moving the attention from the robot (Paolo and Emanuele answered together to the therapist even if only one of them was touching the robot). This respectful behaviour was observed in all sessions and was quite unusual considering the extremely aggressive behaviour of Chiara, Paolo's difficulties in maintaining the attention and Emanuele's tendency to isolation.
Furthermore, in the previous treatment based on occupational therapy these patients used to move around the room without coming into contact with each other. They had to be continuously stimulated by the therapist to remain focused on the activity and to pay attention to the others' activity. On the contrary, in the sensorial exploration tasks with Paro, the subjects sit at a table focusing on the robot all together and respecting the turns for the exploration. Furthermore, the exploration was not confined to the physical manipulation but it was extended to fondle the robot with the nose or the face and to take care of it (protecting it by cold or feeding it). This means that even if the subjects were perfectly aware that Paro was not a real seal, however it was considered an "agent" rather than a mere object. This facilitated a continuous process of intention attribution and recognition.

Social exchanges

Quite articulated social exchanges established among the subjects all along the experimental sessions.

Figure 3. Social exchanges

The following is an extract from the "I would like to…" task. The subjects had to randomly pick up a sheet of paper from a basket containing few of them, each one carrying on a written verb completing the phrase "I would like to ..."

1	Therapist	Chiara, pick up the verb, pick up a sheet of paper so that we can complete the sentence "I would like…"
2	Emanuele	I would like to go to the Canary Isles
3	Therapist	*(smiling)* I would like to go to Canary Isles. *(referred to Emanuele.)* Please listen to what Chiara would like to do. *((pause))*
4	Therapist	(*looking at Chiara*) I would like to… *((pause))*
5	Chiara	(*Chiara takes a sheet*) Care… *((whispering)) ((pause))*
6	Therapist	Care?… *((asking)) ((pause))*
7		To care… *((waiting))*
8	Chiara	To caress.
9	Therapist	I would like to caress… *((pause))*
10	Chiara	I would like to caress… *((pause))*
11		I would like to caress Paro
12	Paro	*(it emits its call interpreted by the subjects as a response to 11)*
13	Therapist	Oh, what a beautiful
14		Would you like to caress Paro? And then? *((pause))*
15		Would you like to caress anyone else? *((pause))*
16		Tell me, tell me *((pause))*
17		I would like to caress… *((pause))*
18	Chiara	I would like to caress you (to the robot)
19	Therapist	And then?
20		Paro really would really like to know *((short pause))*
21		Who would you like to caress?
22		Any one else?
23	Chiara	I would like to caress… *((short pause))* …the hand ((*touching Emanuele*))
24	Therapist	She said she wants to caress your hand *(referred to Emanuele) ((pause))*
25		Nice! *((pause))*
26		What a beautiful story we told to Paro.

The therapist interpreted this interaction event as extremely positive considering Chiara's difficulties in relating to other people. Indeed she had never voluntarily touched another person during the occupational therapy.

In the "*Taking a picture*" task interesting examples of collaboration among the subjects emerged from a simple, basic commitment. The therapist introduced the activity talking about Paro and its mother: "*Paro really misses its mother and it would like to visit her and bring her some pictures about its vacations in Italy. That's why today we brought our camera*".

The three subjects were then involved in deciding and setting up the stage for scene, pretending to take pictures. Each picture was later accompanied by a brief discussion about the tools to be used, the most meaningful pose and background.

In this way, the subjects had the opportunity to remain focused on the same activity being involved in understanding the actual context and the pretend situation. They were engaged in negotiating the meanings of the pictures and sharing different opinions and suggestions.

Figure 4. Taking a picture

Most of the pictures were proposed autonomously by the subjects who demonstrated to recognize and feel involved in the relation of Paro with its mother. They projected their own experience in the situation selecting elements from past events (home situations with parents) or imagined events (holidays, games, fairy tales) and combined them for representing a likely context for the picture.

Emotional intelligence

The "Write a letter" task was especially devoted to investigate traits of emotional intelligence. The task consisted in writing a letter to Paro's Japanese father asking for letting Paro prolong its visit to Italy. During the activity Paro was put on the table. The subjects did not touch it being they busy with writing but they continuously looked at it making any effort to produce a convincing text. Each subject wrote part of the letter and the different contributions were edited in a very simple way, as it is in the following:

"Dear Prof,

I would like to play longer with Paro, because it is beautiful, good, nice and gentle and it is so tender. Therefore we would appreciate to spend more time with it and to caress it for long more.

DATE - SIGNATURE"

During the video analysis of the activity it was possible to recognize numerous events showing traits of emotional intelligence like the capability to recognize and control emotions.

Chiara, in particular, showed unusual behaviours. During the occupational therapy, she was not used to pronounce words related to emotions and in general she spoke rarely even when explicitly encouraged. During the interaction with Paro she started to speak about Paro's emotional states. "*Paro is sad*", "*...it is very angry*" she often said, and in some situations she expressed opinions like "*Paro is happy*" just interpreting Paro's reactions to external stimuli (strokes, calls etc..). In the later sessions she started to speak about emotional states related to Paolo and Emanuele ("*He likes Paro...*") and, more rarely and only when encouraged by the therapist, she spoke about her own emotional states "*I'm tired, I want to leave*". This is again an interesting behaviour considering that during the occupational therapy she was used to leave suddenly without saying anything.

In the last session, Chiara and Paolo clearly declared their appreciation of Paro explaining how positive it was for them. Chiara said: "*It is true we don't want it to leave, we want it to stay here with us*".

CONCLUSIONS

The study we presented can be considered an early attempt to investigate interaction dynamics with artificial pets, in particular in therapeutic contexts. The initial outcomes demonstrate a clear role of the robot in mediating social exchange and stimulating attachment and engagement. However it is not obvious which are the behavioural and physical qualities of the robot that successfully foster interaction and attachment. In other words, would a real pet or a peluche induce the same effects we observed in our study?

The efficacy of pet therapy is widely recognised and in general, it can be said that keeping a pet is good for health. For example, 10 month prospective study (Serpell, 1991) examined changes in behaviour and health status in 71 adult subjects following the acquisition of a new pet (either dogs or cats). Both pet owning groups reported a highly significant reduction in minor health problems during the first month, and this effect was sustained in dog owners through to 10 months. In addition, they also showed improvement in their scores on the GHQ (General Health Questionnaire) over the first 6 months and, in dog owners, this improvement was maintained until 10 months.

However, the pet therapy has its disadvantages related to the management of animals and their introduction into the hospital.

Paro's qualities as a therapeutic robot have been tested in non-pharmacological therapies on children with cognitive, sensorial and motor deficiencies (Marti, Palma, Pollini, Rullo & Shibata, 2005) and other studies have been conducted on elderly patients (Saito, Shibata, Wada & Tanie, 2002). These studies demonstrated that its morphological characteristics, together with the tactile impression it yields, favour interaction and exploration of its body and behavioural characteristics. This effect seems even more surprising when observed in child patients with serious deficiencies in interpersonal relationships like the ones observed in this study.

With the aim to detect any difference in interaction dynamics between a situation in which just the morphological characteristics and the tactile impressions of the robot were present, and one in which the robot's behavioral characteristics were also displayed (movement of paws and fins, rotation of head and eyes, emission of sounds), we replicated two testing sessions with Chiara, Emanuele and Paolo using the robot turned off, like a regular peluche (soft toy).

From these two sessions we noticed that the effects we detected on the three dimensions of social exchange, sensorial exploration and emotional intelligence were not present with the same efficacy and occurrence observed during the sessions in which Paro was turned on. Anyhow some positive

effect though less intense and durable, was also observed in condition when Paro was used as a simple peluche. This effect had not been previously noticed in any case that involved the use of dolls, for example.

This suggests that the physical perceptive characteristics of the robot (appearance, shape, colour, weight) may play a role in catalysing the human attention, and when combined with behavioural characteristics (reactive and pro-active behaviours) they may engage the human interlocutor offering the possibility of filling the interaction experience with private and personal significance. As an entity to be explored and discovered, the robot mediates the relationship between what is inside and outside the individual, both in the direct relationship between the human and the machine, and in the human-human exchange mediated by the machine.

ACKNOWLEDGEMENTS

We would like to thank the Director Maria Grazia Burroni and the therapists of the Functional Rehabilitation Unit of the "Le Scotte" hospital in Siena, in particular Daniela Pinassi, who supported the study with enthusiasm and professionalism. We would thank also the PhD students Filippo Fanò and Valentina Palma who collaborated in carrying out the testing. A special thanks goes to the patients and their families to have shared with us their experience of life, their concerns and hopes.

REFERENCES

Breazeal, C. (2003) Toward sociable robots. *Robotics and Autonomous Systems*, 42 (2003), 167-175.

Bruner, J. (1986) *Actual minds, possible worlds.* Cambridge, MA: Harvard University Press. xi, 201 pages.

Friedman, B., Kahn, P. H., Jr., & Hagman, J. (2003). Hardware Companions? - What Online AIBO Discussion Forums Reveal about the Human-Robotic Relationship. CHI 2003 Proceedings, pp. 273-280. New York: Association for Computing Machinery.

Heath, C. Hindmarsh J. (2002) "Analyzing Interaction: Video, ethnography and situated conduct". To appear in May, T. (ed.) Qualitative Research in Action. London: Sage. pp. 99-121.

Marti, P. The contagion of emotions. In Bagnara, S. Crampton Smith, G. (eds.) *Foundations of Interactive Design*, New Jersey: Lawrence Erlbaum Associates Inc., 2005.

Marti, P. Palma, V., Pollini, A. Rullo, A. Shibata, T. (2005) My Gym Robot, Proceedings of AISB05 International Symposium on robot companions: hard problems and open challenges in human-robot interaction, UK, April 2005.

Saito, T., Shibata, T., Wada, K., Tanie, K. (2002). Examination of Change of Stress Reaction by Urinary Tests of Elderly before and after Introduction of Mental Commit Robot to an Elderly Institution. In Proceedings of the 7th International Symposium on Artificial Life and Robotics, Vol.1, pp.316-319.

Salovey, P. & Mayer, J.D. (1990). Emotional intelligence. *Imagination, Cognition, and Personality*, 9, 185-211.

Serpell J.A. (1991) Beneficial effect of pet ownership on some aspects of human health. *Journal of the Royal Society of Medicine*, 84:717-720,.

Shibata, T., Tashima, T., Tanie, K. (1999) Emergence of Emotional Behavior Through Physical Interaction Between Human and Robot. In Proceddings of ICRA 1999, pp. 2868-2873.

Shibata, T. Mitsui, T. Wada, K. Kumasaka, T. Kazu Tagami Tanie, K. (2001) Therapy of children assisted by mental commit robot. Advanced Intelligent Mechatronics, 2001. Proceedings. 2001 IEEE/ASME Volume: 1, On page(s): 4-4

Yonemitsu, S., Higashi, Y., Fujimoto, T., Tamura, T. (2002). Research for practical use of rehabilitation support equipment for severe dementia. In *Gerontechnology* 2002; 2(1): 91.