Proceedings of the 17th IEEE International Symposium on Robot and Human Interactive Communication, Technische Universität München, Munich, Germany, August 1-3, 2008

A Methodological Variation for Acceptance Evaluation of Human-Robot Interaction in Public Places

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Abstract - **Several variations of methodological approaches are used to study the social acceptance in Human-Robot Interaction. Due to the introduction of robots in the home, working practice and usage typically informing the design of new forms of technology are missing. Studying social acceptance in Human-Robot Interaction thus needs new methodological concepts. We propose a so called breaching experiment with additional ethnographic observation to close this gap. To investigate the methodological concept we have been conducting a field trial on a public place. We gathered feedback using questionnaires, in order to estimate whether this method can be beneficially to evaluate social acceptance. We could show that breaching experiments can be a useful method to investigate social acceptance in the field.**

I. Introduction

WOULDN'T it be weird if you are walking through a pedestrian area noticing a robot working as a tourist guide?

An increasing number of studies focuses on the assessment of the sociality and interactive functionality of robots and to what extent humans accept robots as co-workers, care-givers or as daily companions in everyday life. Most studies have addressed social acceptance of robots or interface design (e.g. [2]) in laboratory settings. Using experiments various influencing factors were evaluated, adding to the steadily growing body of knowledge on how to develop social robots. Experiments in laboratory or other controlled settings, simulations and modeling techniques are the most common methods in Human-Robot Interaction, with a trend to more studies in the field in recent years [14]. The introduction of robots in our everyday life has already taken place, raising at the same time human-robot interaction questions on how robots will change our social structures and patterns. When investigating the social acceptance of robots in everyday life, we have to face several methodological limitations. Methods like experiments or observation in the lab include (real and fully functional) robots to enable the study of manipulated variables. But how will people react when they are facing a robot as a tourist guide during their daily walk in the downtown pedestrian area? Research questions like these need new forms of (possibly adopted) methods, to address issues like peoples first time reactions, social influences or other phenomena, which might only be studied in a real setting.

Following we will describe such a methodological variation to study peoples first time reactions in public settings and a first trial to validate this methodological set-up. This methodological variation can be seen as a kind of breaching experiment including a specially designed questionnaire to validate the methodological usage in the context of social acceptance.

Manuscript received February 15, 2008 This work was supported in part by the ROBOT@CWE project (funded by FP6-2005- IST-5)

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II. Evaluating Social Acceptance

A. Evaluating Social Acceptance

The conditions when humans will accept (humanoid) robots have been investigated thoroughly during several past decades. Already 25 years ago Apostolos [1] assessed the user acceptance of a robotic arm in a clinic setting with an exploratory methodology.

Dillion defines user acceptance as "the demonstrable willingness within a user group to employ technology for the tasks it is designed to support" [5]. The most interesting aspect of user acceptance evaluation is to survey the reasons why people accept a robot as partner e.g. as working-partner, guide or assisting-partner. When addressing acceptance various explanatory models exist. Research in information society studied for a long time how and why individuals adopt new technologies. Several theoretical models exist, describing individual acceptance of technology using intention or usage as the key dependent variable [20]. A basic concept underlying user acceptance models can be described as follows: Step one is the individual's reaction to the usage of information technology. This reaction influences (step two) the intentions to use information technology, which influences at last (step three) the actual usage of information technology. Of course individual reactions on using information technology and actual use are interdependent. Venkatesh et al. [20] provide an excellent overview of eight of the most commonly used acceptance models, all focusing on usage or intention as dependent

978-1-4244-2213-5/08/$25.00 ©2008 IEEE

variable of acceptance. Based on this extensive analysis the UTAUT (Unified Theory of Acceptance and Use of Technology) model was developed. Summarizing all factors available in the eight most commonly used acceptance models four determinants were identified: performance expectancy, effort expectancy, social influence, and facilitating conditions.

UTAUT has already been used in previous studies to evaluate the acceptance of robots ([10], [15]). Heerink et al. [15] used the UTAUT model for examining the influence of the social abilities of the robotic agent iCat for elderly participants in eldercare institutions. They used two experimental conditions: one more socially communicative and a less socially communicative interface. Their results showed that the more communicative condition caused a higher feeling of comfort and higher communication rate among the participants. For evaluating the user social acceptance they extended the UTAUT model by questions regarding computer experience, conversational acceptance and social abilities.

B. Methods for Social Acceptance Evaluation

From the methodological viewpoint the evaluation of human-robot interaction in terms of social acceptance has to deal with several challenges. The differing types of robots (robots in the working context, social robots), with their different shapes, design, and various forms of interaction and feedback will evoke different reactions (e.g. [2], [10]).

Additional to the typically used more strict experimental set-ups new forms of evaluation have been developed. For example the introduction of new forms of measurements, enable the user to report the level of comfort by using a so called distance comfort measure [17]. Others have varied the methodological setting to enable early evaluation within the development using more human-computer interaction oriented methods (see [18] for a listing). Another methodological variation is the usage of games to evaluate HRI concepts [19]. However, most of the methodological variations addressing new aspects of HRI have been developed for the lab.

The environment the robot is used in adds another level of complexity. But as especially social robots are meant to function as part of everyday life we have to find methodological set-ups enabling us to study first time reactions of users in real life. "It is therefore necessary to evaluate human-robot interactions as socio-culturally constituted activities outside the laboratory" [18], p.576.

Evaluations "in the wild" have been performed in various areas of human-computer interaction, especially for investigating the usage of new forms of mobile technologies [16]. For evaluation of human-robot interaction field settings typically include observational behavioral analysis [18] or more strict experimental set-ups [14].

Hayashi et al. [14] for example introduced robots into a public space. They conducted an experiment in a train station. They used robots as a communication medium, presenting information about the travel duration to Osaka, the institute responsible for the experiment, where the passengers may go on this train line, the facilities near the station and they also provided information about east Osaka. During the evaluation of the video material various people's reactions have been found: ignoring, noticing, stopping to watch, staying, touching, changing course to investigate, talking about robots, watching with child and taking pictures. The results showed, that the limited-realistic interactivity of the robot - with the usage of a sensor indicating the position of the human and the adoption of the scenario - achieves the best feeling of being addressed. The disadvantage is that this limited-realistic interactivity makes people lose interest in the information presented by the robot.

However, when dealing with acceptance of robots we argue that observation and behavioral analysis of social interaction in the real environment are necessary to fully understand how to inform the design of socially accepted robots.

III. Methodological Set-Up

A. The Breaching Experiment

Developments of new forms of robots to support user tasks are typically informed by the working practice they are embedded in. While today robots become used in everyday life, these practices and routines used to inform design are often missing. To evaluate typical reactions of people when a robot is appearing in their daily life, we propose a variation of a breaching experiment. The main idea is to confront people with a robot during their daily routines. The breaching experiment as research instrument disrupts ordinary action in order to enable a sociological analyst to detect some unusual behaviors and reactions. Variations of breaching experiments are used to investigate new aspects of technology [11]. Treating the new forms of technology as breaching experiment allows us to study the new forms of robot usage beyond the typical laboratory setting. Crabtree [3] gives an excellent overview of the benefits of these breaching experiments to investigate new forms of usage related to a mobile game. He states that "in absence of practice with which to inform design, novel technological innovations might be deployed in the wild in order to confront them with novel situations …"p.2.

B. The Evaluation Set-up

To investigate if such a beaching experiment is reasonable to address social acceptance, and even beyond to investigate possible societal impacts for human-robot interaction we developed a questionnaire. The questionnaire is based on the UTAUT model, investigating the four factors *performance expectancy, effort expectancy, social influence, and facilitating conditions*.

To investigate what kind of social interaction people perceive today, we follow the theory of "Sociality with objects" of Knorr-Cetina [21]. She argues that the extent of sociality is not decreasing. Instead people start to alienate and colonisate with objects (for example robots). She calls this 'postsocial relationships' and refers to "new kinds of bonds such as those constructed between humans and objects" [21]. Examples in the literature include scientific and technological things ([22], [23], [24]). Sociality here consists in the phenomenon that the subject takes over the object's wants — as a structure of wanting, the subject becomes defined by the object. In this movement, the self is endorsed and extended by the object. Based on this conception of an object the core elements of sociality are a feeling of reciprocity (mutuality) and attachment to the object. We thus also address reciprocity and attachment within the questionnaire. The whole questionnaire is given in Table I.

TABLE I
QUESTIONS REPRESENTING THE SOCIAL ACCEPTANCE FACTORS

Factor [a]	Questions [b]
A_1	I would trust the robot, if it gave me an advice1.
A_2	I would follow the advice of the robot.
AT_1	I think it is a good idea to use the robot.
AT_2	I am afraid to make mistakes or break something while using the robot.
C_1	Many people would be impressed, if I had such a robot.
C_2	Robots are nice working colleagues.
C_3	I feel afraid, that I could loose my job, because of a robot.
EE_1	I could control the robot with speech.
EE_2	I think the robot is easy to use.
G_1	I like the presence of the robot.
G_2	I could solve tasks together with this robot.
G_3	I felt threatened by the robot.
PE_1	This robot would be useful for me.
PE_2	This robot could help me solving tasks.
PE_3	Robots can support me in my work.
R_1	I consider the robot as social actor.
R_2	I feel understood by the robot.
SE_1	I feel comfortable while interacting with the robot.
SE_2	I could work with the robot, if someone helped me.
SE_3	I could your with the robot without any help.
SE_4	I could work with the robot, if I had a good initial training.

[a] PE: Performance Expectancy; EE: Effort expectancy; AT: Attitude toward using technology; SE: Self efficacy (UTAUT Model Factors) G: Forms of grouping; A: Attachment; R: Reciprocity; C: Cultural Context (Object Centered Sociality Factors)
[b] As the whole experiment was conducted in German, the statements used in this paper are translated to English.

IV. FIELD TRIAL

The methodological variation of the breaching experiment was conducted on a public place (Karlsplatz/Stachus) in Munich, Germany on July 30th, 2007. We used the ACE Robot simulating an autonomously moving robot in the pedestrian area. For security reasons we controlled the robot from a distant location (hidden for the normal pedestrians passing by). The several hundreds of by-passers perceived the ACE robot as autonomously moving. The questionnaire based survey started with a short introduction based on the Thomas theorem [28] saying: "If people define situations as real, they are real in their consequences" The introduction text sounded as follows: "*The robot you have just seen, is already used in the tourism sector. He informs tourists when visiting historical sights and allows them to use the touch screen to ask for further information like event notes or recent news*. *We would like to know what you think about the assignment of the robot and therefore ask you some questions"* This social construction of reality should support our breaching experiment, therefore participants answer the questionnaires under the assumption that the robot is an active part of the social order. The duration of the first validation of the method lasted 2 hours. Researchers observed the behavior of the people interacting with the robot and conducted a survey with pedestrians selected by chance.

A. The ACE Robot

The ACE robot is depicted in Figure 1 measures 67 cm in length, 56 cm in width, and 35 cm in height. It has a maximum payload of 150 kg. The platform is moved by two wheelchair drive wheels (30 cm diameter) with differential drive and treads. It has two castor wheels (12 cm diameter) in the rear and two castor wheels on springs in the front (10.5 cm diameter).

The upper body, as shown in Figure 1, is constructed of strut profiles and measures 68 cm in length, 52.4 cm in width and 110 cm in height. The framework supports the camera head and the arms of the robot, as well as the speakers and microphones. Four PCs with ATX main boards with dual core processor's, are mounted on racks between the profiles. Two PCs are needed for vision data processing and one for navigation and interaction, respectively. Power is supplied by four gel batteries, in the base of the framework, with 12 V and 30 Ah each.

Fig. 1: ACE Robot

To communicate with humans the robot possesses an audio communication system. This system consists of a speech synthesizer (female voice, German language), active stereo speakers, a speech recognition system that is trained with noisy templates to be able to face real outdoor conditions. To localize and focus on a speaker, a microphone array attached to the body of the robot will be used together with beamforming techniques. In addition to the audio communication system the robot comprises a monitor with a touch screen. The monitor can be used to display an animated face to make human-robot communication more natural to humans; also it enables the robot to display further information. The touch screen can be used as a complementary input device that supports the audio communication system. For further technical details we refer to [26].

The monitor displayed an animated face, which could look at the spot that was touched on the screen. Additionally there were buttons exhibited on the screen, which offered information about the robot, the Karlsplatz and surroundings, latest news, and a weather forecast. Information was synthesized beforehand with Boss – Bonn Open Synthesis System and replayed on the stereo speakers when the according button on the monitor was touched. Also some statements such as “Hello, my name is ACE,” and “Do not touch me!” could be replayed by remote control.

The stereo camera head was looking around focusing on humans in its vicinity by visual attention control based on color, orientation, and motion features. The movement of the camera head combined with the remote controlled speech gave the robot a lively and conscious appearance.

B. Participants

All people passing by in the area (the Stachus is a crowded shopping area with access to several sub-way lines) were considered as possible participants. 48 participants were selected by chance (on a voluntarily basis) to answer a set of questions related to their current interaction with the robot (simply observation or direct interaction). 18 (from the 48 participants) had a direct interaction with the robot and thus answered the extended questionnaire. The age of the 48 participants ranged from 18 to 75 years. 33 were male, 15 were female. Interestingly one third of the participants indicated having a university degree.

C. Observations

During the breaching experiment one researcher conducted an unstructured observation. Notes were taken on interesting and unexpected behavior as well as the setting in general. The experiment was also documented by two “SenseCams” [25] carried by the two interviewers. The “SenseCam” is a wearable digital camera that is designed to take photographs passively, without user intervention, while it is being worn. The advantage for the experiment was that the experimental set-up and the interviewing situation could be documented unobservable for the participant.

C. Interviews

The 48 participants that were interviewed either with a simple questionnaire (in the case of only observing the robot) related to the acceptance of robots in general, or an extended questionnaire with additional question on the ACE robot in specific (for people having direct contact interaction with the robot). The simple questionnaire consisted of 12 questions: an introduction – warming-up question, three questions on embodiment of the robot, three demographic questions, and five statements which had to be assessed on a Likert scale. In case of direct contact interaction with the robot people we additionally asked 16 statements, which had to be assessed on a Likert Scale. The 5 point Likert scale ranged from “ I totally agree” to “I do not agree at all”. The questions are all given in Table I.

Additionally we integrated three questions regarding the perception of embodiment of robots. Embodiment describes the relationship between the robot and its environment. A robot must match its intended function and the social context. It has to preserve some “human-like” and some “robot-like” aspects to avoid wrong user expectations (“uncanny valley”) [27]. We used the following two pictures as examples for an anthropomorphic look and a functional designed robot.

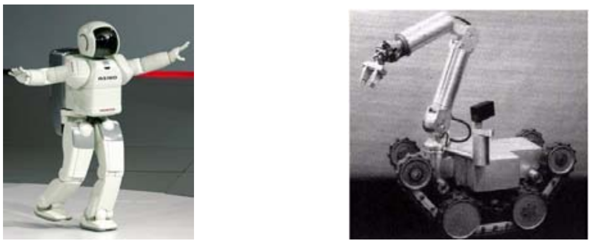

Fig.2. Anthropomorphic vs. Functional Design

As a follow-up question we asked the participants how close they would allow the selected robot to approach them and therefore presented the following graphic, based on the theoretical framework of Hall [29] to choose the distance:

The circles describe individual interaction levels of behavioral distances in public spaces. The first cycle describes the intimate space, which is the area that immediately surrounds the individual’s body. This area is the most private and involves both physical and emotional interactions. The second cycle covers the personal space, which is the area a person allows only select friends to enter, or fellow workers with whom personal conversation is mandatory. The third cycle is the social space in which the individual expects to make purely social contacts on a temporary basis. The external cycle contains the public space where the individual does not expect to have direct contact with others.

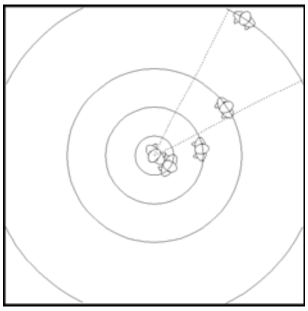

Fig. 3. Distance Diagram

V. Results

Main goal of this field trial was to validate if a breaching experiment can help to understand people's social acceptance of robots in daily life. We conducted the field trial, and used questionnaires to assess if typical factors of social acceptance were addressed. The following section shows the statistical analysis of these factors, and if they were addressed by the items within the experiment.

A. Validation of the Social Acceptance Factors

To test which items can retain for the final scale for each defined factor the correlations between all pairs of items, based on the ratings of the participants was conducted. As correlation measure Spearman's ρ was chosen assuming the data is on an ordinal level, but the subsequent ranks indicate equidistant positions. Table II shows the correlations between an item and the factor variable, which was created by summing up the individual factor items for each respondent. Items with a correlation score lower than 0.5 were not taken into account for the final scale for a factor. The scale for each factor was computed by summing up the means for the selected items and dividing them by their number.

TABLE II
CORRELATIONS BETWEEN ITEMS AND REPRESANTATIVE FACTOR

Factor	Spearman's ρ	Factor	Spearman's ρ
A_1	0,937(**)	G_1	0,436
A_2	0,950(**)	G_2	0,864 (**)
AT_1	0,390	G_3	,000
AT_2	0,748(**)	PE_1	0,981(**)
C_1	0,435	PE_2	0,936(**)
C_2	0,774(**)	R_2	0,599(*)
C_3	0,544(*)	SE_1	0,535(**)
EE_1	0,636(**)	SE_2	0,739(**)
EE_2	0,559(**)	SE_3	0,832(**)
		SE_4	0,676(**)

** Correlation is significant at the 0.01 level (2-tailed);
* Correlation is significant at the 0.05 level (2-tailed).

In general people were quite positive about the robot in terms of social acceptance, as the mean of the overall scale on social acceptance is 3,6 (S.D. 0,706). The results for the mean values show that except for the reciprocity scale all factors equaled a mean value higher than 3. This indicates that the breaching experiment is really evoking typical reactions in by-passers that contribute to a social acceptance.

If reciprocity in a field setting like this can be reasonably addressed is questionable. Only 54 % (26 participants) perceived the robot as interactive, thus the limited interaction possibilities in the not controllable environment might heavily influence the perception of reciprocity.

To descriptively analyze the gathered data material collected during the experiment minimum, maximum and mean were computed for each scale. Table III gives an overview, showing that the chosen factors can be reasonably addressed in a breaching experiment.

TABLE III
DESCRIPTIVE STATISTICS FOR THE SCALES

Symbol	Minimum	Maximum	Mean	S.D.
Scale PE	1,00	5,00	3,8472	1,40071
Scale EE	2,50	5,00	3,9722	,69604
Scale SE	3,00	5,00	4,4167	,68061
Scale AT	1,00	5,00	3,8889	1,36722
Scale G	1,00	5,00	3,5417	1,54312
Scale A	2,00	5,00	3,6389	,88792
Scale R	1,00	3,50	2,2500	,80896
Scale C	1,00	5,00	3,5000	,96205
Overall Scale	2,00	5,00	3,5987	,70609

Minimum, Maximum, Mean and SD for each scale from the questionnaire, indicating that the breaching experiment can be reasonable address social acceptance.

The combination of a questionnaire with additional observation supports the findings on social acceptance. It is worth noting that the observational data showed an interesting interaction pattern. Although the questionnaire data shows, that forms of grouping was not highly assessed, a group building moment was observed. Participants formed a group with others when interacted with the robot. So each time one person was keen enough to use the touch screen a group of people gathered around this person (at least 10 people).

Fig. 4. Group based Interaction

One by one pure observers also tried to interact with the robot. So although people did not build a group with the robot they did build a group with other people (although they were complete strangers) to gain a more secure feeling in interacting with the robot. This aspect might be one of the research questions that this kind of methodological variation might help to answer.

VI. Conclusion and Future Work

Breaching experiments can close a methodological gap in evaluating acceptance. We could show that the method is reasonable to address social acceptance in the field, and can help to investigate the first time reaction of people confronted with a robot in their everyday life. We could show that the factors of social acceptance can be addressed in a breaching experiment and that the investigation of reciprocity might not be reasonable evaluated in such a setting, but should be addressed with other methods.

The approach presented shall lay the basis for further evaluations of social acceptance and can be seen as a first step to take a closer look on societal impacts of new forms of human-robot interaction and the introduction of robots into everyday life. However, in this special experimental setting the research framework was limited according to the robotic agent and the time and space context. Thus, the next steps will be experiments in the same general condition, but on different days and day times to examine if the time factor has an impact on the behavioral patterns. Furthermore, the experiment will be conducted with different robots in different prototypical stages to investigate the influence of embodiment and anthropomorphic appearance on the social acceptance. To get a higher variability across differences in gender and age longer experimental duration is planned (this was not possible in this case according to battery limitations).

ACKNOWLEDGMENT

We would like to thank all partners from the ROBOT@CWE project (funded by FP6-2005- IST-5).

REFERENCES

[1] M. K. Apostolos, “Exploring user acceptance of a robotic arm: a multidisciplinary case study (choreography, aesthetics, disabled),” 1985.

[2] C. L. Breazeal, Designing sociable robots, Cambridge, Mass.: MIT Press, 2002.

[3] A. Crabtree, “Design in the Absence of Practice: Breaching Experiments”. Proceedings of DIS04: Designing Interactive Systems: Processes, Practices, Methods, & Techniques, 2004, pp.59-68.

[4] B. De Ruyter, P. Saini,, P. Markopoulos.,, A.J.N. Van Breemen, “Assessing the Effects of Building Social Intelligence in a Robotic Interface for the Home” in Interacting with Computers, 17(5), 2005, pp. 522-541.

[5] A. Dillon, “User acceptance of information technology,”in Karwowski, W. (ed.). Encyclopedia of Human Factors and Ergonomics. London: Taylor and Francis, 2001.

[6] A. J. Dix, Human-computer interaction, 3rd ed., Harlow: Prentice Hall, 2003.

[7] R. M., Fretz, R. I. and Shaw, L. Writing Ethnographic Fieldnotes, University of Chicago Press, Chicago, USA, 1995.

[8] E., Eriksson, T. R., Hansen, A., Lykke-Olesen, “Reclaiming public space: designing for public interaction with private devices”. Procceedings TEI 2007, ACM Press, 2007, pp. 31-38.

[9] D. M. Fetterman, Ethnography : step by step, 2nd ed., Thousand Oaks, Calif.: Sage, 1998.

[10] T. Fong, I. Nourbakhsh, and K. Dautenhahn, "A survey of socially interactive robots,"in: Robotics and Autonomous Systems, 42 (3), 31 March 2003, pp. 143-166.

[11] H. Garfinkel, Studies in ethnomethodology, Englewood Cliffs, N.J.,: Prentice-Hall, 1967..

[12] J. Goetz, J. Goetz, S. Kiesler, and A. Powers, "Matching robot appearance and behavior to tasks to improve human-robot cooperation," in Robot and Human Interactive Communication, 2003. Proceedings. ROMAN 2003. The 12th IEEE International Workshop on, 2003, pp. 55-60.

[13] E. Goffman, Behavior in public places; notes on the social organization of gatherings, [New York]: Free Press of Glencoe, 1963.

[14] H. Kotaro, S. Daisuke, K. Takayuki, S. Masahiro, K. Satoshi, I. Hiroshi, O. Tsukasa, and H. Norihiro, "Humanoid robots as a passive-social medium: a field experiment at a train station," in Proceedings of the ACM/IEEE international conference on Human-robot interaction Arlington, Virginia, USA: ACM, 2007.

[15] M., Heerink, B.J.A., Kröse, B.J., Wielinga, V. Evers, “Studying the acceptance of a robotic agent by elderly users,”in International Journal of Assistive Robotics and Mechatronics 7, (3), 2006, pp. 33-43.

[16] E. Hutchins, Cognition in the wild, Cambridge, Mass.: MIT Press, 1995.

[17] K. Kheng Lee, M. L. Walters, and K. Dautenhahn, "Methodological issues using a comfort level device in human-robot interactions," in Robot and Human Interactive Communication, 2005. ROMAN 2005. IEEE International Workshop on, 2005, pp. 359-364.

[18] S. Sabanovic, M. P. Michalowski, R. Simmons “Robots in the Wild: Observing Human-Robot Social Interaction Outside the Lab” Proc. of AMC’o6 Istanbul..

[19] M. Xin and E. Sharlin “Playing Games with Robots – A Method for Evaluating Human-Robot Interaction” In: Human-Robot Interaction, Eds.: N. Sarkar, pp. 522, 2007.

[20] V., Venkatesh, M. G., Morris, G. B., Davis, F. D.,Davis, “User Acceptance of Information Technology for Unified View”. in: MIS Quarterly, 27(3), 2003, pp. 425-478.

[21] K. D. Knorr-Cetina, Sociality with objects: social relations in postsocial knowledge societies. Theory, Culture and Society 14(4), 1997, 1-30.

[22] M. Callon, Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. In Law, J. (ed), Power, Action and Belief: A New Sociology of Knowledge?, 1986, London: Routledge and Kegan Paul, pp. 196-233.

[23] K.D. Knorr Cetina, The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science. Oxford: Pergamon, 1981.

[24] S. Turkle, Life on the screen : identity in the age of the Internet, New York: Simon & Schuster, 1995.

[25] S., Hodges, L., Williams, E., Berry, S., Izadi, J., Srinivasan, A., Butler, G., Smyth, N., Kapur, K.,Wood, “SenseCam: A retrospective memory aid.”in Procceedings. Ubicomp 2006, ACM Press, 2006, pp. 13-17.

[26] G. Lidoris, K. Klasing, A. Bauer, T. Xu, K. Kühnlenz, D. Wollherr, M. Buss, "The Autonomous City Explorer Project: Aims and System Overview," Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Oct 29 - Nov 2, San Diego, CA, USA, 2007.

[27] K. F., MacDorman, H., Ishiguro, “The uncanny advantage of using androids in social and cognitive science research,” Interaction Studies, 7, (3), 2006, pp. 297-337.

[28] W. I. Thomas, and D. S. T. Thomas, The child in America; behavior problems and programs, New York,: A. A. Knopf, 1928.

[29] E. T. Hall, The hidden dimension, Garden City, N.Y.: Anchor Books, 1982.