Robots As Social Mediators: A Study “In The Wild”

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***Abstract*— In this paper we present the results of an observational study on human-robot interaction conducted in a natural setting with the objective to focus the analysis not just on behavioral aspects of the interaction like usability and “being in control” of the object while using it. On the contrary we concentrated on the full experience which involves not only interaction with the robot, but also the human-human exchanges mediated or enhanced by a social robot, including dialogues, emotional exchanges, sharing of memories, meaning construction.**

I. Introduction

This paper discusses the compelling yet difficult nature of the design and evaluation of social interactive robots through the analysis of a case study.

Such systems are not designed to help users perform work tasks or save time. They should encourage users to spend time with the system and enjoy the interaction, and their ultimate mission is to engage the users in social exchanges [1]. Research in this sector has rapidly expanded from the design of robots inspired by the biological and behavioral characteristics of animal organisms, to the design of social robots inspired by the way human relationships and communication are carried out.

The concept of sociality in robots has taken on a wide variety of nuances and meanings and poses fundamental questions for the design and the evaluation of such systems. Indeed, social robots are most often evaluated within the same environments in which they are developed, using the analytical tools and assumptions about sociality that evolved in conjunction with its design [2].

In this paper we advocate the importance of analysing human-robot interactions in their natural context of occurrence, outside the laboratory. Indeed human actions are always situated in particular social and physical circumstances and the ways in which individuals try to get control of interaction and make sense of it are contingent upon and derive from the situated action that they represent [3]. Furthermore, the environment (physical, social, cultural) in which the interaction takes place is never neutral. It makes sense from the very moment we confront it. This is the reason why it is very important to perform an on-site study of the interaction [4], which is naturally situated within human constructed environments.

A thorough analysis of the situation is crucial to the action's interpretation [5]. In this paper we present field study carried out in the nursing home “Casa Protetta Albesani” with the purpose of investigating the role of Paro - a zoomorphic social interactive robot - in mediating social relations as they spontaneously occur within small groups of patients who are affected by different degrees of cognitive and behavioural diseases.

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II. The approach

Ethnographic observation is regarded as one of the most important methodologies for gaining a deep understanding of the users and the context of use. This methodology implies the description of human activities and culture and it is based on fieldwork. It involves the study of people performing activities and interacting in complex social settings in order to obtain a qualitative understanding of the interactions. The pioneer of this method is acknowledged in Bronislaw Malinowski’s work. In the early 20s he changed anthropology by entering into the lives of the people and learning what they actually did on a day-to-day basis. Rather than questioning them from the reports of travellers and colonial officials, he went to places, learned their language and recorded their activity (to the extent possible with a still camera and taking notes). His approach consisted in “going and getting one’s hands dirty” by conducting research through first hand observation.

Although ethnography was originally associated with an interest in the study of less familiar and perhaps more exotic cultures, over the past few decades it has been increasingly used to describe the ‘naturalistic’ organisation of activities in work settings. Ethnographic studies are currently used for a variety of purposes, such as developing new services, new organisational arrangements, and the design, evaluation, and deployment of new technologies.

In the research reported in this paper we performed a field study with the objective to observe human-robot interaction as it naturally occurs in natural settings. The reason for taking this approach is that we did not intend to focus the analysis on behavioral aspects of the interaction [6], like of usability and “being in control” of the object while using it. On the contrary we focused on the notion of robot-mediated experience which involves not only interaction with the robot, but also the human-human exchanges mediated or enhanced by a social robot, including dialogues, emotional exchanges, sharing of memories etc. .

III. Social robots

The concept of sociality in robots has taken on a wide variety of nuances and meanings that basically depend on two elements: the ability of machines to support the social model they refer to, and the complexity of the interaction scenarios they can face [7]. In line with these two elements there are several kinds of robots, from those which *evoke* sociality *(socially evocative robots)* by placing the accent on anthropomorphic characteristics, to those known as *social interface robots*, which adopt social and behavioral rules to provide their human interlocutors with a "natural interface," and from *socially receptive robots* which learn through imitation, to *sociable robots* able to interact proactively with humans to satisfy an internal need (desires and emotions).

In our study we concentrate on a particular category of social robots, the ones designed as mediators of social communication and therefore as artefacts capable of supporting people's ability to give significance to their experience of the world and to encourage them to share this meaning with others. Of course the environment (physical, social, cultural) in which such social exchanges take place is never neutral. For this reason we decided to perform an on-site study of the interaction with a social robot in the context of group activity among elderly people affected by dementia hosted in an Italian home care. The motivation for this study is that dementia is strongly characterised by social isolation and difficulties in communication. Speech becomes increasingly inefficient and progressive short-term memory difficulties and problems with new learning make conversations and other social interactions increasingly problematic. Dementia affected people experience a progressive social isolation that can result through the complete loss of social skills. Social robots can represent a new frontier for dementia care since they are designed with the purpose to sustain and encourage social exchanges and communication.

IV. Sociality and Communication Mediated by Robots

Attempts to create a robot capable of showing social behaviour and interacting with humans have been very popular in the recent history of robotics. Research in this sector has rapidly expanded to the design of social robots inspired by the way human relationships and communication are carried out. However human-robot interaction has been mostly studied in laboratory. For example, Breazeal and colleagues [8] carried out an observation of task-oriented interactions between the robot Leonardo and humans, in order to demonstrate the salience of nonverbal cues in cooperative task. Dautenhanhn and Werry [9] discuss the utility of behavioral observation performed in a controlled setting combined with statistical analysis for the assessment of a robot's effects on autistic children.

Sabanovic and colleagues [2] show the importance of conducting fine-grained observational analysis to analyze how human react to and interact with the robot in natural and unstructured context; how humans interact with each other while interacting with the robot; which aspects of the robot's, and human's, actions lead to breakdowns in the interaction; and how the robot succeeds and fails to engage humans in interaction.

Likewise we believe that the study of interaction with social robots in natural settings can greatly contribute in understanding human-robot and human-human robot mediated interactions.

V. The Case Study

A. Objectives

A key therapeutic objective in dementia care is the maintenance of social residual abilities. Dementia-affected patients acquire serious relation difficulties. At an early stage of dementia, progressive cognitive decay and behavioural disorders often cause patients' voluntary isolation since they feel to be inadequate to social relations. With the progressing of the disease, the isolation process is accentuated. This causes loneliness and an increasing loss of communication and social skills. At the same time different studies like that of Bassuk [10] and colleagues suggest that social *engagement can prevent cognitive decline* and that people must maintain social skills and the ability to communicate. A therapeutic intervention often becomes necessary in order to maintain the social residual abilities.

Social interactive robots could be an interesting therapeutic resource for the definition of intervention aimed to stimulate and maintain social abilities. The main objective of this study is to explore the potentialities of social interactive robots in favouring social communication exchanges among elderly subjects with cognitive and relational disorders. In particular, the focus of this work is on group dynamics and on the particular role that the robot plays in mediating the evolution of social relations among the participants.

Several studies have shown the role that such kind of robot could have in mediating social exchanges [7,9] among elderly people. Most of them focus on interaction dynamics between the subjects and the robot; the observation is generally carried out in a very limited temporal span and in a well structured and controlled setting. The acceptance of the robot, the recognition of the robot as an agent and the subjects' behavioural responses are the key issues considered in the observation and analysis of interactions.

In this study we studied human-robot interaction from a different perspective. The study is focussed on social exchanges among a group of people as they occur in a natural context, without the intervention of nurses or therapists. We observed over a month how social exchanges among participants spontaneously evolve with the objective to assess the effectiveness of the robot in promoting social exchanges, motivation and engagement and counteract social isolation.

We used for the study the seal robot Paro since its robot animal features stimulate feelings like "taking care," affection, tenderness and docility [11]. Paro was designed by Shibata [12] using a baby harp seal as a model. Its surface is covered with pure white fur and its weight is around 2.8 Kg. The robot is equipped with several sensors and actuators that determine its behaviour.

In designing PARO, a particular attention was devoted to create an impressive tactile experience, a fundamental perceptual source of stimuli and information during the interaction. Its surface is covered with pure white and soft fur. Also, a newly-developed ubiquitous tactile sensor is inserted between the hard inner skeleton and the fur to create a soft, natural feel and to permit the measurement of human contact with PARO. The robot is equipped with the four primary senses: sight (light sensor), hearing (determination of sound source direction and speech recognition), balance and the above-stated tactile sense. With respect to movement, PARO shows vertical and horizontal neck movements, front and rear paddle movements and independent movement of each eyelid, which is important for creating facial expressions. The combination of these technical features provides the robot with the possibility to react to sudden stimulation. For example, after a sudden loud sound, PARO pays attention to it and looks (turns the head) in the direction of the sound. Along with the reactive behaviour described above, PARO has also a proactive-behaviour that allows the robot to take initiative like producing the call or moving. The seal robot also behaves following the rhythm of a day with some spontaneous desires such as sleep and tiredness.

B. The context of the study

The study has been conducted in the nursing home "Casa Protetta Albesani", an institution that gives hospitality to 150 elderly people with different degrees of cognitive and behavioural diseases.

With therapists, physicians and nurses three people (see table 1) were selected from the population of the nursing home with a Mini Mental State Evaluation [13] score > 24 (mild or not cognitive impairments) and a diagnosis of depressive disorders. We made sure that the subjects involved in the study and selected according to the above mentioned criteria had no strong personal relationships.

Subjects	Age	MMSE
1	82	25
2	79	27
3	77	26

Table1. This table shows the age and the MMSE score of each subject.

Their cognitive capabilities are substantially intact even if initial problems of memory loss start to appear. Their autonomy is either intact or slightly compromised by physical impairments.. The main issues are depression and isolation; patients can understand their situation and once they are institutionalized they fall in depressive states. They become unmotivated to participate to social activities. Social interactions are very few and they pass most of their time alone.

These patients are hosted in an area of the nursing home, specifically dedicated to patient at an early stage of dementia. In this ward, the atmosphere is calmer with respect to others. Patients sit down alone or around a table, reading newspapers or watching television. The nursing stuff is reduced and their activity is less hectic than in other wards.

Social exchanges among the patients are limited to "institutionalized" situation such as the lunch or the dinner; in these circumstances each patient has her own sit around one of the tables in the ward. Spontaneous social interactions between patients are unusual; these are generally encouraged by nurses or care-givers without any good result. Most of the spontaneous social interactions of the patients are with nurses (mainly to satisfy certain needs) or with external visitors such as relatives or friends. When patients are hosted in the nursing home, the social network they belong to is inevitably broken. Furthermore, their diminished cognitive and relational abilities prevent them to create and maintain a new network of social relations within the nursing home.

C. Protocol of the study

The group was asked to take a seat around a table in a quiet room of the nursing home premises. The room is normally used for art therapy sessions and was not familiar to any of the experimental subjects. A video-camera was hidden, recording what was happening in the room, with the double aim to show it on a TV screen for the therapist to observe the session and for later the video analysis.

Observational sessions had a weekly schedule. Four sessions have been carried out. The protocol of the study for each session was structured according to the following schema:

Phase 1. Care givers lead the subjects to the setting, and ask them to take a seat around the table, the group is left alone for 5 minutes.

Phase IN. The therapist brings the robot to the table and says : "I am sorry but I have to go out for a minute. Could you please keep PARO with you until I am back? Thanks."

Phase 2. . The therapist leaves the room and goes in the adjacent space, where she observes what happens around the table thanks to the video-camera and a TV screen. The group is left alone with the robot for 20 minutes.

Phase OUT. The therapist is back, she gets the robot and has a few questions: "how are you? What have you being doing? Did you enjoy it?"

Phase END. The therapist concludes the activity and lead the subjects in the ward.

The observational analysis was focused on phase 1 and phase 2. Phase 1 (Pre-robot condition) has been designed to observe the amount of dyadic and group exchanges prior to the introduction of the robot in the setting. Phase 2 (Robot condition) the robot is introduced in the setting to observe the social dynamics within the group.

Each session was video-recorded and analysed by two independent experts according to the occurrence of a set of behavioural indicators (listed in Table 2), in line with the approach discussed by Dautenhahn and Werry [9] The coding schema has been focused on dyadic and group interactions. These data have been integrated with the annotations of a therapist, who observed each session in real time from a remote position filling in an observation grid designed on purpose.

Dyadic exchange (R2)	About PARO (R2P)
	About any other topic (R2T)
Group exchange (R3)	About PARO (R3P)
	About any other topic (R3T)
Touches PARO	

Table 2. This table reports the indicators we defined for our structured observation.

For phase 1 and phase 2 we scored the amount of time that each subject showed any of the identified behaviours.

D. *Results*

Social Exchanges. The analysis first concentrated on the total amount of social exchanges taking place across the four sessions. We defined the “social exchange” (SE) indicator as the sum of the time value members of the group spent in dyadic exchanges (R2 = R2P + R2T indicators) and in group exchanges (R3 = R3P + R3T indicators) over the total duration of each session.

Session	Social Exchanges (seconds)
1	531
2	1352
3	1360
4	1477

Table 3. This table shows the total amount of time (seconds) that members of the group spent in social exchange (SE) activities across the four session of the study.

These data show that a progressive increase of interpersonal relationships was observed. The most outstanding shift can be identified between the first and the second session, even if the trend is smoothly going up till session 4 (see fig. 1)

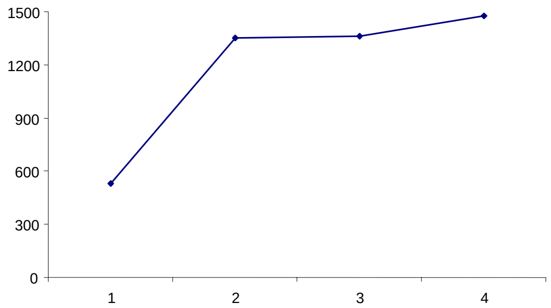

Figure 1. Seconds the group spent in Social Exchange activities (y-axis) during the 4 sessions of the study (x-axis).

Only in the second session, one of the patient leaves the group before the end of the activity. According to the therapist, this is a remarkable result; these subjects suffer of attentional disorders that prevent them to remain focussed on the same task for a long time. Furthermore, when the therapist organizes social activities in the ward, rarely patients engage in spontaneous social interactions with each other. Conversations are limited to very basic arguments: patients frequently ask the time, or how many hours they have to wait for before lunch or dinner. These questions are mostly directed to care-givers rather than to other patients sitting at the same table. The presence of PARO stimulated the discussion within the group. The subjects explored the robot and tried to make sense of the behaviour. At the beginning of the observation PARO was accepted as something interesting and unusual, a good argument of discussion. However, later in the observation, its role progressively changed across as time passed through as described in the following.

Dyadic and Group Interactions. After these preliminary observations we went through a deeper investigation of the evolution of the social exchanges among patients interacting with the robot. We analyzed the total amount of dyadic interactions (R2) versus group relations (R3) across the four sessions.

Figure 2 highlights the total amount of time (in seconds) the members of the group were involved in dyadic (R2) or in group (R3) relations over the four sessions.

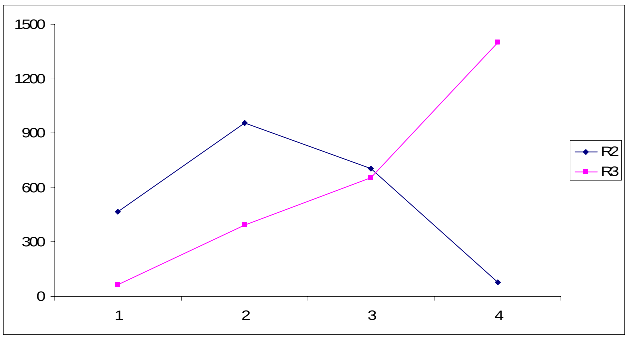

Figure 2. On the y-axis the total amount of time spent in face to face relational exchanges (R2) and on group exchanges (R3) is reported across the 4 sessions identified on the x-axis.

As we may observe the growths of both R2 and R3 indicators between session 1 and session 2 corresponds to the critical increase in social exchanges observed in the Figure 1 before.

Further, even if the total amount of time subjects were involved in social exchanges does not change from session 2 to session 4 (as it was observed in Figure 2), *the relationship between R2 and R3 dramatically inverts*: while face to face relations diminish from session 2 to session 4, group exchanges progressively augment. If we confront session 1 and session 4 we are in front of two totally different situations: while in session 1 the group was mainly involved in face to face social relations, in session 4, the group is mostly involved in a full-blooded group exchange.

The role of PARO. During the observation it emerged that the role of PARO as social mediator corresponds to its progressive fading as catalyst of group discussion and interpersonal exchange. Table 4 reports the rate of group social exchanges (R3P) mediated by PARO with respect to the total amount of group relations (R3) over the four sessions. These data refer to the phase 2 of each session.

Session	Rate (R3/R3P)
1	1,00
2	1,00
3	0,81
4	0,05

Table 4. The rate of group exchanges mediated by PARO with respect to the total amount of group exchanges in phase 2 of each session.

In the first two sessions the robot was the "subject matter" of the social exchange, people explicitly referred to Paro either in verbal or deictic exchanges. In session 3, PARO was the subject matter of the 81% of group exchanges. From the session 3 to 4 the rate of group exchanges decreases. PARO is no longer the "focus of attention" even if the subjects continue to talk.

This trend is represented in the following graph (see fig. 3), that shows the ratio between the group exchanges where PARO was still the centre of the discussion and where people talked about other topics. While the total amount of group exchanges progressively increases, the rate of social exchanges focused on PARO progressively decreases up until they disappear.

These data show that the robot seems to sustain an initial relation among the subjects but once the social group dynamics are consolidated, the robot fades into the background.

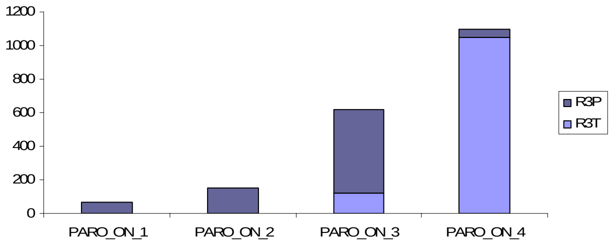

Figure 3. The ratio between group relations (R3) mediated by the robot (R3P) and not mediate by the robot (R3T). The y-axis reports time in seconds while on the x-axis the 4 sessions are reported.

If the trend is very clear concerning group relations the situation is more controversial when coming to dyadic relational exchanges.

Table 5 presents the rate of face to face (R2P) focused on PARO respect to the total amount of face to face (R2) over the four sessions, both for group ON and group OFF. Also in this case data come from phase 2 of each session. In the first session PARO was the subject of the totality of face to face communication. In session 3 and 4 PARO was the subject of the 64% and the 51% dyadic exchanges. The second session is apparently out of the trend. Indeed in this session one of the subject was particularly refractory to any kind of exchange, and ended up withdrawing from the group quite soon. The reason is not clear.

Session	Rate (R2/R2P)
	ON
1	0,95
2	0,08
3	0,64
4	0,51

Table 5. The rate of face to face exchanges mediated by PARO with respect to the total amount of group exchanges in phase B of the session for both conditions.

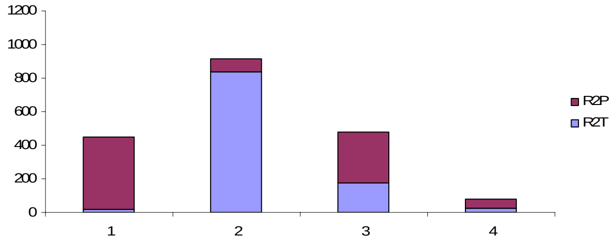

Figure 4. The ratio between group relations (R2) mediated by the robot (R2P) and not mediate by the robot (R2T). The y-axis reports time in seconds while on the x-axis the 4 sessions are reported.

These data describe the transformations of the role of PARO over the four phases: it seems plausible that in the initial interactions it actively mediated social relations among subjects reinforcing them session by session. When these relations are strong enough to be self-sustainable, the robot remains in the background. Actually, it continues to play a role in some face to face exchanges, but it is not anymore the central catalyst of the group exchanges. These data are confirmed by the analysis of graphs in figure 5 and in figure 6. Graph in figure 5 shows the difference between the total amount of time spent in social exchanges in phase 2 and the total amount of time spent in the same activity in phase 1, given the correct proportion. We observed with respect to the rate of social exchanges across session considering both the phase in which the robot was present and the previous phase. In session 1 the total time spent in interpersonal exchanges when the robot was present clearly exceeded the time spent in social exchange in the previous phase, when the group sat around the table together for the first time. This positive difference testifies the increase of social exchanges that the robot brought when firstly introduced.

In session 4 subjects spent the exact same amount of time engaging in social exchanges both when the robot was present than when it is not present (SE Phase B – Se Phase A = 0).

PARO progressively looses its catalyst function in time: Figure 6 shows the amount of time the subjects spent stroking the robot session by session. This value again illustrates that the subjects progressively loose interest in the robot.

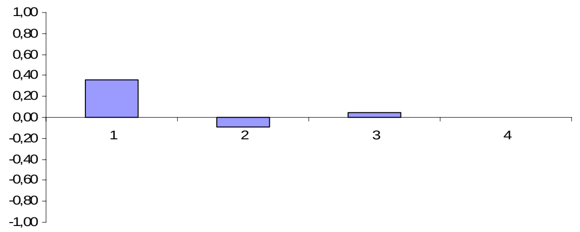

Figure 5. The trend observed in the difference between the amount of time spent in Social Exchanges in phase 2 and in phase 1 in each of the sessions.

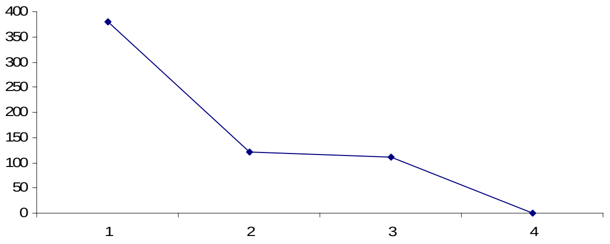

Figure 6. The total amount of time PARO was touched in each session. The y-axis reports time in seconds while on the x-axis the 4 sessions are reported

This attitude is confirmed by the annotations of the therapist related to the last session. She notes that PARO is well accepted when it is introduced in the setting, nevertheless the subjects do not change the topic of their conversation. They go on talking, but they pay also attention to the robot. Sometimes they comment that the robot is following their conversations. In conclusion, it seems that the role of PARO as an enabler of social exchanges changes over time, by shifting from being the focus of attention and the central object of the discussion to a peripheral element of the context once the communication dynamics in the group are consolidated.

VI. Discussion and conclusions

In this paper we presented the results of an observational study conducted in a natural setting to study the role of the social robot Paro in mediating human-robot and human-human interaction. The study shows that the physical, perceptive, and behavioral characteristics of the robot offer the human interlocutor the possibility of filling the interaction experience with private and personal significance that are elaborated and share with others. 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. In this respect, the context plays an important role in meaning construction and sharing. Human-robot interaction is the element that mediates the building of knowledge, a creation of significance that depends on not just the machine's physical and functional characteristics but also, and mostly, the specific context of interaction – on the personal history that every interlocutor calls into play and on the perception of mutual affordances, some of which come from the stimulus given by touching, hearing, seeing and moving, others from psychological processes that mediate empathic response in interaction with others. For this reason we believe that is very important to study human-robot interaction "in the wild" in order to favor the creation of natural ways for involvement in the activity, the perception of interactive experience at a level not only physical and functional but also aesthetic, perceptual and emotional in the same way this daily happens in familiar and natural settings.

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