Closing and Closure in Human-Companion Interactions: Analyzing Video Data from a Field Study

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Abstract— **A field study with a simple robotic companion is being undertaken in three iterations in the framework of a EU FP7 research project. The interest of this study lies in its design: the robotic interface setup is installed in the subjects' homes and video data are collected during ten days. This gives the rare opportunity to study the development of human-robot relationships over time, and the integration of companion technologies into everyday life. This paper outlines the qualitative inductive approach to data analysis, and discusses selected results. The focus here is on the interactional mechanisms of bringing conversations to an end. The paper distinguishes between "closing" as the conversational mechanism for doing this, and "closure" as the social norm that motivates it. We argue that this distinction is relevant for interaction designers insofar as they have to be aware of the compelling social norms that are invoked by a companion's conversational behaviour.**

I. Introduction

Much research and development is dedicated to virtual (agents) and embodied (robotic) devices that should serve as assistive technology especially to older or homebound people. One interesting field of application for agents and robots is their use as an interface to smart rooms and homes. Conversational interfaces would be the most natural and easy way to communicate with them, but they raise users' expectations in their scoial capabilities [1]. They should

- be aware of the user's world, both physical and social
- respect social norms and individual habits
- be useful and helpful where needed without indebilitating the user
- gain social status so that advice is accepted

and all that not just once, but day after day. Practical experiences with today's conversational interactive systems show the deep gap between the utopian companion and today's clumsy attempts, see for example [2, 3, 4]. We are still far away from what, taken together, we could call "sociability", the skill, tendency or property of being sociable or social, of interacting well with others, involving elements of culture, situation, status, identity, task, communication, emotion, personality, and body, all at once and as an integrated whole. New insights are being gained in nearly each of the domains relevant to sociability individually (cf. [5]), but they will not add up to sociability automatically. Nor do we know in what way sociability with robots is specific and distinct.

The project SERA (Social Engagement with Robots and Agents) has set out to study how systematic progress towards sociability of companions can be made. We realized that we need to know more about how users of companions actually interact with them in the real world, i.e. their homes, and over a period that is long enough to let novelty effects wear off. Apart from toys like Pleo or Aibo, most interactive robots and ECAs have not left the lab yet. The majority of tests and evaluation studies with them are done in short, task-oriented interactions. The studies of the FitTrack system [6, 7] are a notable exception, in that they comprised several weeks of continuous use of the system with its embodied agent Laura, and in that the system was intended to render real service to the user (as contrasted with toy robots or chatbots). However, the FitTrack system is PC-based, and its use is completely set apart from the user's everyday world and activities. Kidd's [21] study of the AUTOM robot is similar to ours in several respects, but is focussed more on the outcome (weight loss) than on the interaction with the robot.

II. The Field Study: Scenario, Setup and Data Collection

Like FitTrack and AUTOM, the SERA field study is being carried out in the context of potential companion applications in health and fitness assistance, especially for older people [8, 9]. In contrast to them, however, the primary goal of the study is to collect data on people's everyday life with such a robot, and not to evaluate the system.

So, while the application scenario of monitoring the subjects' physical activities is based on real application interests in rehabilitation, here it mainly served as a cover story for creating enough interaction situations for the study. Furthermore, the field study does not serve the purpose of directly informing the design of a "real" companion application. The robot was set up intentionally as a purely experimental system: the goal of the project is not to improve a specific system, but to gain new insights into the requirements for and designs of companions for long-term use.

The assumption underlying this approach consequently is that it is indeed possible to gain insights into human-companion relationships that can be, to a degree yet to be

established, generalized from one specific system to a broader range of future companion architectures. The way in which this is done in the project is to have results of the field study inform the definition of a reference architecture. This as well as the field study being work in progress at the time of writing this paper, it is not yet possible to assess the validity of the underlying assumption.

Given this approach, we decided to use a low-cost experimental system which largely depends on commercially available components. The hardware consists of a (hidden) desktop computer with broad-band mobile internet connection. The periphery consists of the Nabaztag, a rabbit-like WIFI device marketed as a slightly animated talking Internet interface, (see http://www.nabaztag.com/en/index.html), a passive infrared (PIR) motion detector, a micro-switch on a hook for the house keys, a webcam (for data collection) and the array micro-

Fig. 1 Field study setup

phone which will be used in later iterations for speech recognition (see Fig. 1). Speech recognition could not be implemented in the first iteration from which the data discussed here originate because the uncontrolled, noisy test environment and input led to intolerable latencies and recognition rates [22]. Instead, yes/no buttons had to be used as input device at this stage. This first iteration served mainly as a testbed for the experimental setup, so we did not plan for a wide range of different interactions or prolonged dialogs. Surprisingly, the study provided data that were more interesting than expected.

The participants were told that the goal of this study was to help users lead a healthy lifestyle. The background is provided by the goal to have companions assist patients recovering from a heart attack [8]. The dialogs therefore centered around the activity plan that the participants had established beforehand in the preparatory interviews with the researchers. The companion asked the participants about and reminded them of the activity plan, they were asked how they felt at the end of the day and to reflect whether they had had the right amount of activity. They were also asked whether they had weighed themselves that day as part of the fitness scenario. The Nabaztag could also provide participants with a weather report and could pass on messages from the researchers. The Nabaztag initiated interactions at five different occasions, namely (1) at the first appearance of participants in the morning, (2) when participants were going out of the house, (3) when participants were coming home (4) at a designated time after the last planned activity of the day and (5) when a message from the researchers had been received. Cases (2) and (3) were triggered by the participant removing/putting back the house keys on the key hook, (1), (4), and (5) were triggered by the motion sensor signal.

Video data were collected on a voluntary basis: subjects were invited to start the recording every time an interaction was initiated. The users were briefed about the companion and encouraged to interact with it, but were otherwise free in their choice of when, how, and how often to do so [10]. The first iteration involved three subjects who had the setup installed in their homes for about 10 days. 65 video recordings were collected, of which 45 could be used for analysis. They are, roughly, one minute in length on average. As one can see from the still (Fig. 2), the camera angle behind and/or above the Nabaztag shows the participants not only in close-up while interacting with it, but also in their movements around the room, passing by, or going out/coming in.

III. DATA ANALYSIS AND METHOD

Data were distributed among the project partners who undertake their analysis in parallel, using both quantitative and qualitative methods [11]. As laid out above, the primary goal was neither to evaluate the qualities of the system with a view to its improvement, nor the effects on users' actual health-related behaviour and lifestyle, but to enrich the body of knowledge about people relating and interacting with companion technologies. The approach to data analysis is therefore explorative in nature, to which qualitative methods are deemed particularly appropriate. Furthermore, the small sample (which is being increased for the following iterations of the field study, but never to numbers which would allow for serious quantitative analysis across subjects) is an additional factor that invites qualitative analysis.
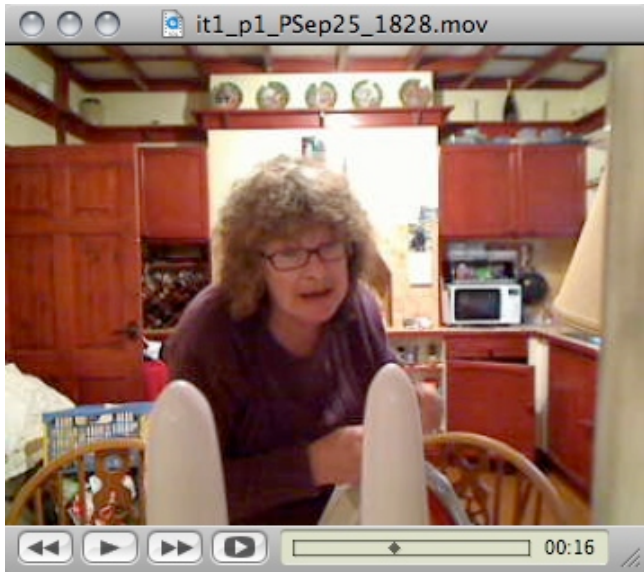
Fig. 2: Example of video data material

Video interaction analysis is, to date, rather a collection of methods and practices [23] than a well-defined methodology for the empirical investigation of the interaction of human beings with each other and with (objects in) their environment. It investigates human activities such as talk, nonverbal interaction, and the use of artifacts and technologies, identifying routine practices and problems and the resources for their solution. Its roots lie in ethnography (especially participant observation), sociolinguistics, ethnomethodology, conversation analysis, kinesics, proxemics, and ethology [12].

The field of human-robot and human-agent interaction has always acknowledged the relevance of nonverbal interaction, so that the method seems to come naturally to it. Two remarks, however, need to be made on the notion of "interaction":

- From an ethnomethodological viewpoint, only the participants themselves establish whether they regard the exchange with an artifact as an *inter*action [24].
- Where human-human interaction is the issue, it is understood as more or less synonymous with communication, or conversation [13].

The field of human-machine interaction has always taken this concept more widely in both senses: here it includes both communication (social interaction) and operation (physical interaction), and action-reaction sequences as well as interaction proper. This is the sense in which we will use the concept here.

If one wants to study the relationship between companions and their owners, one must not preclude, by misleading terminology, that this relationship can be both social and a-social – at different times or even at the same time: the companion can be seen both as something to talk to and as an object or machine.

Video interaction analysis allows to include in the analysis other semiotic fields [25] than language use, and studies how participants mix and relate them. Transcripts of human-robot interactions usually leave these out. The reason simply is that robots are, to date, heavily deficient in sharing the semiotic fields of objects, spaces, gestures etc. One example of such a shared semiotic field in our field study is the house key, whose presence or absence is "known" to the Nabaztag through a micro-switch in the key hook, so that the meaning of the key as "going out" and "coming home" can be shared. On the other hand, the Nabaztag has no access to the semiotic field of any other household object. When one participant takes the key off with the trash bag in the other hand, the meaning of the action – taking the bag to the bin outside – is obvious to human observers from the same culture, but not accessible to the robot. Tests that limit the potentially relevant semiotic fields by clever design (e.g. in the lab) bear the risk that others than the targeted channel of interaction (e.g. language) are neglected. In studying human-robot interaction "in the wild", they make themselves felt and have to be taken into account, even if, at this stage, as not accessible to the machine.

Observational data on real-life, long-term use of companions are extremely rare as yet, and in such cases, formulating hypotheses that can be tested in analysis can lead research far off the mark. Inductive explorative analysis is the approach of choice to prepare the field for later systematic hypothesis-based research, in that it can point to new and interesting phenomena and generate the concepts and questions with which to work in the field.

The instruments used in this part of the study owe much Conversational Analysis (CA) [15] and Grounded Theory (GT) [14]. From CA, we take the microscopic look at the interaction, where the constant questioning of the data and the perspective of the particpants' orientation toward the interaction is used to attend to every potentially relevant detail. GT inspires the open approach to coding the material, as well as the research interest in uncovering not only the mechanisms of interaction, but also the attitudes, socio-cultural stance and practical theories that subjects develop and apply to their relationship with companions.

The verbal interaction of the videos was transcribed roughly. Through repeated viewing, these transcripts were extended to full descriptions, including position, posture, gestures, facial expression and actions of the subjects. An effort was made to rigorously separate the description from any other remark, note, or thought that would inevitably present itself, following the procedure recommended by the documentary method [16]. Such interpretations were written down separately in notes and memos. Common keywords or titles to the notes started to present themselves, and these were noted down separately as the first tentative, low-level concepts. Other data invited to use the same or related concepts. In this process, the attention is drawn not only to those cases where the phenomenon giving rise to the concept is present, but also to the cases of its absence, as well as to its different dimensions.

IV. CLOSINGS IN HUMAN-COMPANION CONVERSATION

Thus, closings of interactions in our data were first brought into focus by a few video sequences where participants concluded an interaction with a greeting. Subsequently, we analysed systematically for the different ways in which interactions were terminated. Only through taking both presence and absence of closings into account was it possible to develop the concept of "closure".

Closure as a concept is here distinguished from the conversational segment "closing". Rather than to observed behaviour, it refers to the orientation of participants to the social norm of bringing interaction to an orderly end. It is part of everyday politeness not to terminate a conversation strictly unilaterally. If it is done nonetheless, reasons or excuses have to be given, or else such behaviour is sanctioned. While closings are the mechanisms by which this is achieved, closure as a concept points to an attitude toward the other which makes them necessary and desirable. In human-human interaction, this orientation is taken for granted to such a degree as to be invisible. This is different in human-machine interaction.

In our data, we could distinguish, roughly, five different types of termination:

- greeting: a verbal closing ending with a formal greeting, e.g. "bye", by the participant
- verbal: the participant closes with an utterance which marks a termination or adjournment of the conversation, but no greeting.
- nonverbal: in most cases, this is a nod by the participant before leaving or turning away. Turning away alone is not qualified as a closing, as it is already part of the action that follows the end of a conversation.
- waiting: this behaviour can occur, in principle, in addition to and typically before any of the other ways of terminating an interaction, but in most cases, no closing follows. It cannot be said with certainty what exactly the participants are waiting for in these instances: it can be a continuation, a new topic, or a move towards closing by the Nabaztag. The identification of these pauses as "waiting for closing" resides in the observation of the contrasting cases where a closing of some kind occurs.
- no closing: none of the above signs occur. The participant takes up whatever action occurs after the interaction: turning away, leaving the room, taking up some household task, etc.

For the participant from whom most data were collected (P1), we mapped these types of closing (Fig. 3). Sequences where, for some reason or other, the end of the interaction was not recorded were ignored.
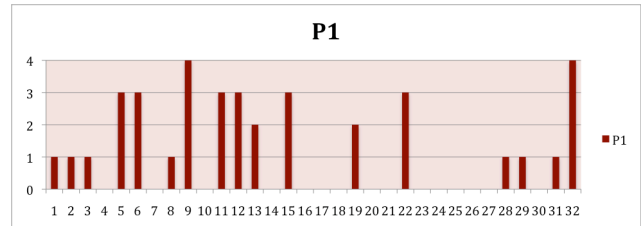

Fig. 3: Types of closings and their distribution over time for P1; 0 = no closing, 1 = waiting, 2 = nonverbal, 3 = verbal, 4 = greeting

What can be seen is that the cases of no closing become more frequent as the field study goes on. There are, roughly, three stages: the first is characterized by pauses (waiting), the second is a stage of more frequent verbal closings, culminating in greeting, while afterwards the closing sequences decrease in frequency. Contrary to expectations, however, they do not disappear, and we even find again a sequence with greeting towards the end of the data collection period. With such a small number of relevant interactions even in our best sample, this kind of analysis does not allow any conclusions on the development over time. The map is shown here only to illustrate occurrence and distribution of closing-types.

In what follows, two selected cases of closing will be described and discussed in more detail (cases 5 and 31 respectively in Fig. 3). In example 1, we reproduce the second part only of the dialog which, on the side of the Nabaztag, is the same as that – reproduced in full – in example 2. N is the Nabaztag, P1 the participant (see also Fig. 2):

```
Example 1: it1_p1_PSep26_0948.mov
(beginning snipped)
[P1 stands close to N, bent over a little
    because N is below eye level]
N: have you weighed yourself yet today?
P1: yes [presses the yes-button at the same
    time]
N: okay. thanks
P1 [smiles] ... anything else? [unbends,
    increasing the distance, gesture:
    "teacher-like" raised index finger]  I
    even know I weighed 82.7 kilos or in
    english 12 10 and a half pounds well
    stones and pounds. [starts to turn and
    move away, looks at her watch; she stops
    and turns back, opening her arms] and
    there we go. and it's nearly time for
    saturday kitchen. so you won't get much
    out of me [turns and moves away] in the
    next hour and half. [She ends up at the
    sink and starts to do housework].
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Schegloff and Sacks [17] talk of the closing of conversations as a "problem", not for the analyst, but for the participants in the conversation itself, in the sense of a task that participants have to execute at the end of each conversation with different partners, situations, contents, and modalities. The end of a conversation is (except for the intervention of external forces) not something that just happens, but has to be brought about by the participants in a collaborative way. Schegloff & Sacks have shown that

closings and changes of topic are closely related, and that the closing problem can be seen as the opposite of the "turn-taking machinery" which is fundamental in generating turn after turn of a conversation in an orderly manner. To arrive at an orderly end of this stream, the participants have "to organize [their] simultaneous arrival ... at a point where one speaker's completion will not occasion another speaker's talk, and that will not be heard as some speaker's silence" [17].

At first sight, a terminal exchange e.g. of a greeting ritual, may appear as the closing of a conversation. But a closer look shows that a conversation cannot be brought to an orderly end just by greeting. It rather contains a closing sequence in which the greeting stands at the end as a formal sign which can occur in many different forms, or not at all. This sequence, in it's almost shortest form, could be (from [17]):

```
A: okay
B: okay
A: bye bye
B: bye
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The pair of "okay"s here (with falling intonation) has been called a pre-closing: A's "okay" typically closes the previous topic. By the intonation and by intentionally missing the point where a new topic could be brought up, A signals readiness for closing the conversation, to which B agrees. The "proper closing" only comes afterwards. By themselves, typical forms of this pre-closing like *okay*, *we-ell*, *alright* do not signal closing of the conversation. They can be found at other points, too, and with different functions. Beach's [18] study of *okay* reveals a number of such uses where most involve a "pivotal" role, such as acknowledgement of prior matters and transition towards next matters. So A's "okay" above remains ambiguous, because it leaves open the possibilities to bring up new matters that each one of the participants might want to mention. A could do this by complementing it with a fuller turn, as speakers often do. And B could go on, even with the same topic, after A's okay.

In our examples, N (the robot) thus offers a potential point of closing with the utterance of "okay thanks" which is not followed by a topical extension of the turn. In example 1, P1 smiles at the polite expression "thanks", then orients toward the potential ambiguity of "okay". The question "anything else?" could be used, in a human-human conversation, to resolve this ambiguity. The speaker refrains from introducing new topical talk herself, but signals that new topical talk by the other would be acceptable. Standing alone, this question would be a polite form of pre-closing, because it passes the initiative of choosing between closing or continuing the conversation to the other.

However, in this case P1 does not leave a pause for N to answer, so that the invitation to take the initiative appears to be made only formally. She continues immediately with some topical talk of her own. She does not, at first,

introduce a new topic, but adds to the last topic of the conversation (her weight). Her offer of closure, then, was obviously not "meant" as such. Rather she makes sure that she has the floor for her final utterances. After adding information about her weight, she proceeds to signalling the closing on her side by "there we go" after – visibly to N – looking at her watch. The final utterance is an explanation for her closing this conversation and for adjourning it to some later time. P1 here shows full respect of the social norm of "closure": she invokes external constraints (day and time) and obligations ("Saturday kitchen") that make it necessary to end the conversation, and implicitly promises to continue the conversation after a given delay. By turning and moving away, and by starting some other activity in the same room, she shows that the closing has actually entered into force.

Although we usually tend to associate "politeness" to surface forms such as greetings, the closing in example 1 appears perfectly polite on a deeper level in that P1 takes care to justify and mitigate the termination of the conversation. Example 1 was the first time in the study that this dialog was initiated by the Nabaztag. Things have changed in the second recording we discuss here, which was made towards the end of the study:

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Example 2: it1_p1_POct04_0956.mov
P1 [moves past, waves hand in „waving-off"
    gesture?)
N: Please could you press the video button if
    it's okay to record you now? Would you
    like to hear what the weather forecast is
    today?
P1 [approaches N to press 2 buttons, then
    steps away, quarter turn away, and stops ]
N: recordning on ...  The weather forecast is
    mostly dry and sunny.
P1 [nods, thumbs up gesture with both hands]
N: Have you weighed yourself yet today?
P1 [breathes in , opens her mouth, approaches,
    and presses button,  she stays close and
    waits]
N: okay thanks
P1 [lowers gaze, waits a little more, then
    turns and moves away]
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The occurrences of P1 talking to N have decreased over time. At the same time, the intervals between N's utterances and the pressing of the buttons in response have become shorter. In between P1's approaches to press the input buttons, she now moves around the room to pursue other activities. She appears to know the sequence and length of N's utterances, and has adapted her movements and rhythm so that interacting with the robot is woven fluently into her everyday activities in the house. The closing of this interaction also shows the way in which the relationship has developed. P1 knows already that there ought to be an acknowledgement of her pressing the yes-button in response to the weighing-questions, and waits for it, then waits some more after the "okay thanks". The duration of this final wait is much shorter than e.g. that in the first recorded interaction. This shows that she is familiar with the maximum pause between pressing a button and N's

reaction. When this interval has elapsed without N coming back into activity, she leaves N without further signal.

The closing in the second case can hardly be qualified as as social. It has more resemblance to the action of turning off a machine that needs a few instants to shut down. The dialogs in our field study were not designed for conversational closings except when participants left the house. There are however frequent "okay"s built into the dialogs which were intended to invite interpretations as acknowledgement, topic transition, or closings. "Okay" is not enough for a "canonical" two-step closing. In the first example, the participant makes up for this violation by offering an unilateral extensive closing sequence. In the second example, she seems to have learned that the Nabaztag's "okay thanks" is here – in contrast to what use humans usually make of it – actually the Nabaztag's last turn in this dialog. More generally, she has learned how to interact with the robot effortlessly and efficiently without dispensing with its functionality.

V. CONCLUDING REMARKS: CLOSING AND CLOSURE

At the beginning of section IV, we introduced the difference between "closing" as the conversational mechanism and "closure" as the participant's normative orientation. Through the discussion of two examples, we have made this distinction clearer, it remains to point out its relevance for the design of companion technologies.

At this time, a dialog engine that can do closings will be considered better and more advanced than one that cannot. By doing closings, however, it invokes the social norm of closure and compels the human to comply with it. Example 1 shows how easy that is if the human is willing: the ambiguity of "okay" is sufficient to induce an extensive closing in a situation where the participant is interacting socially with the robot. The same utterance in example 2 leads to no such social closing. Repetitiveness and habituation are certainly an important reason for this, but we do not know whether a human would be willing to be drawn into social interaction with a machine at all times: note that the way of interaction in example 2 has its benefits for the participant.

Dialog design today is struggling with the workings of conversation, and this is what conversational analysis provides. It is necessary to go one step beyond this level and to analyze also for the social norms invoked by such mechanisms. We have to consider carefully where it is legitimate and acceptable for machines to play this compelling game with humans, and where it is better to leave participants to their own choices.

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