Case-Sensitive Methods for Evaluating HRI from a Sociological Point of View

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Abstract. Evaluating and shaping the quality of interaction between humans and service or "social" robots from a genuine sociological point of view is still a pivotal methodological challenge at stake in the development of successful Human-Robot Interaction (HRI). In this regard an interdisciplinary research group, dedicated to the study of HRI in general, is developing a theory-driven method based on sociological interaction models with the goal of identifying the most important aspects in achieving satisfactory interaction experience. The method is suitable for experimental settings, e.g. in the context of laboratory research and development environments as often encountered in Fabrication Laboratories (FabLab). The method uses Harold Garfinkel's concept of breaching experiments as a core instrument in combination with Erving Goffman's Frame Analysis. The baseline of the method is a genuine sociological definition of Social Action on the basis of theories belonging to the paradigm of Symbolic Interactionism.

Keywords: Breaching experiments · Ethnomethodology · Frame analysis · Symbolic interactionism · Bionical creativity engineering

1 Introduction

The main focus of the proposed method is to address two key questions related to successful and pleasant interactions between humans and robots: First, which are the dominant factors that determine whether the interaction is fluid and smooth? Second, to what extent do humans prefer an interaction model with a strong orientation towards the conventional interaction experiences they have with other humans – or do they prefer a type of interaction similar to typical human-machine interactions? Both dimensions are intertwined and have to be considered as two sides of the same coin. We are convinced that a method using Harold Garfinkel's instrument "breaching experiments" is highly suitable for the detection of both in equal measure. In this paper our aim is to present the method as a concept. The goal of the aforementioned research group's future empirical research is to deliver robust and reliable findings based on these concepts or theoretical frameworks. We will not be able to provide an answer to the two key questions raised, instead what we are presenting is the theoretical backing for thoroughly conducted research capable of doing so. In this regard we

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also promote and encourage theoretically grounded research in the field of HRI. Even though it would have been beneficial to create an experiment, describe the process exactly, and provide a comparison with other existing empirical situations, we decided to elucidate the abstract, theoretical qualities of the suggested method. For a detailed, concrete, and "less abstract" picture of such a setting, we would like to refer the reader to the cited papers using similar approaches.

The theoretical framework of the presented method is mainly defined by Erving Goffman's "Frame Analysis" [1] within his work on "Microstudies on Social Interaction" [2], [3] and Harold Garfinkel's "Ethnomethodology" [4]. The baseline of our approach involves assumptions as to how every social interaction is depicted by situated (i.e. contextual) expectations, the way these expectations are held stable over a relatively long period of time (according to Goffman), and which mechanisms are used – or commonly established as viable among the interacting entities – to negotiate an alignment of the predicted expectations on both sides (according to Garfinkel). With such a framework and the adoption of breaching experiments within the scope of experimental settings in a FabLab environment, we assume that we can develop a suitable method that can be applied independent of the particular cultural context and to generate reliable findings regarding the aforementioned key factors in HRI.

Comparative studies analyzing the development of social robots in Europe and Japan conclude that from a sociological point of view, they differ highly in respect to both the understanding of robot agency and the concept behind an appropriate user-robot interaction [5], [6], [7]. In Europe, the assumed interaction is dominated by the autonomy of the robot (however it manifests). However, on the basis of ethnographical research (to be published in the journal Artificial Intelligence and Society), Hironori Matsuzaki asserted that in Japan, the autonomy of the robot is overruled by the attempt to predefine or standardize the HRI sequence, which leads to a completely different concept of HRI. Both approaches could be described and analyzed in equal measure by adopting the proposed method based on Garfinkel's breaching experiments [4] – in light of Goffman's Frame Analysis [1], [8]. This method takes into consideration the specific cultural "bias" related to successful social interaction between two entities. This is due to the fact that it always operates within the culturally shaped margins of what is seen as a functioning interaction. Zooming into one culture, the method is also perfectly suitable for obtaining results on the basis of variations and differences among subgroups or individuals. One study identified several different strategies for dealing with the induced crisis [9], adopting a similar approach to the method we are aiming to refine and develop further It is specifically these kinds of previously undertaken empirical work within the scope of similar theoretical frameworks that show the method's potential to capture case sensitive key factors within a wide range of HRI situations.

2 General Assumptions Regarding HRI from a Sociological and Biomimetics Point of View

HRI research is still trapped within a psychological, and in this respect – as one would name it in sociological terms – in a methodological individualistic view (see e.g. [10], [11], and most of the paper presented in [12]). A genuine sociological approach is

seldom undertaken by relying on sociological models, definitions, and theories of social action and interaction (see e.g. [13], [14]). Similar ideas regarding genuine interactional perspective have also been brought forward and experimented in HRI from the disciplinary field of interactional linguistics based on "Ethnomethodological Conversation Analysis," which is closely connected to Garfinkel's ethnomethodology [35], [36], [37]. These similar approaches should be taken into account for future research, with the goal of unifying them in an interdisciplinary frame of analysis for empirical studies in HRI. However, most of the research starts from the assumption that the interaction is somehow the result of two monolithic minds that are autonomously able to build a consistent meaning of the world and adjust their beliefs with other minds from time to time. In contrast to this view, the typical sociological perspective presented here follows the baselines of George Herbert Mead's pragmatic theory [15]. Mead's concept of symbolically mediated interaction leads to a completely different conclusion regarding the relationship between the two entities (ego and alter) that interact with each other. In Mead's definition of action, the meaning of a symbol is negotiated in a social interaction and therefore depends on the reaction of the other (alter). In a similar way, he understands the formation of identity as an interaction between the "I" (ego) and the "Me" (how alter sees ego). In other words, the meaning of a symbol constitutes itself ex post according to alter's reaction to it. In these terms, "knowing" something means anticipating alter's (most probable) reaction/understanding. Mead emphasizes the so-called "vocal gesture" because humans have the physiological ability to hear the "spoken symbol" (e.g. word) in the same way and at the same time as alter [15]. From a biological and physiological point of view, language played a useful role in social evolution as a tool for successful interactions. In the end, Mead's action theory is also the core model for Niklas Luhmann's [16], [17] micro-level theory of social systems (interaction system) and could be used to explain how consciousness is linked to the social world (in both cases, of course, as systems): The ego's psychological system (self-awareness, consciousness) is constantly observing the interaction between alter and ego, but it remains in the environment of the interaction/social system.

To analyze and capture HRI in a genuine sociological way, we choose the standard framework of Social Constructivism, conceptualizing an ideal situation of interaction by referring to ego and alter. The sociological interaction model we choose defines the social world as an outcome that is strictly interconnected with the interaction between at least two entities, also known as social actors. Social reality develops in an inter-subjective dimension; there is no reliable reality or any reality at all without interaction between social actors. The main assumption of this model is that the meaning of an action, a word, a sentence, or an object that the ego relies on is primarily defined by the reaction of alter. This also means that (social) reality (or social meaning) is always constituted ex post: it is an effect of successful interaction between two entities due to the fact that the reaction of alter related to the prior action of ego is the only way to give ego's action meaning. The next step could consist of extending this model to identity-building processes (as it was done early on by one of the forefathers of this model, George Herbert Mead [15]).

In the end it is contingently that today in many cultures, humans are the only ones who qualify as social actors [18], [19]. Ego constantly has to decide if his or her interaction partner, alter, is a social actor or not; if he, she, or it could provide a proper reaction to build a common, valid, and reliable social reality or not. The basic assumption of this argument is that who we are, what we know, what we think to be real or not real are the outcomes of interaction. For ego's beliefs and relation to reality, it is extremely vital to know whether or not alter is an entity with the proper skills that are needed to build a common reality. Ego will never know if alter is constantly deceiving him or her because ego's reality and ability to question it are dependent on alter's reactions. This is due to the fact that alter's reactions give ego the material to define reality (including identity, the horizon of meaningful questions, indisputable facts, and so on). With regards to researching HRI in different cultural contexts, this means analyzing, transferring, and implementing symbols in interaction as well as triggers for crisis carefully so that culture- as well as case-sensitive generalizations can be targeted [20].

As a matter of fact, the presented method for evaluating the quality of HRI from a genuine sociological point of view is highly suitable for use with robots developed by following a new paradigm within the robotics community. In the sense of technology development, robotics is experiencing several new orientations towards a more or less strong human-centered design. One of the most powerful new paradigms arises from the broader field of bionics and biomimetic robots. There is a very strong affinity between the sociologically oriented evaluation of HRI and biomimetic robots in achieving human-robot interactions that are not only successful, but also satisfying. Assuming that human-human interaction is the best interaction for us humans, the robot has to be humanoid or humanized. From a biomimetic point of view, the assumption is that the more biological principles are combined in a biomimetic robot, the more it can be assumed that the robot approaches its biological role model in its properties and its behavior. Technology is not yet advanced enough to develop completely functional humanoid robots. Therefore the evaluation might be limited to the examination of certain human or human-like aspects. One of these aspects may be, for example, the hand shake between human hands and humanoid hands or giving and receiving objects from a human hand to a humanoid hand and vice versa. For this, the success of human-robot interaction scenarios could be affected by, for example, visual properties such as having five fingers and/or haptic properties such as compliance in hand/arm movements. The hypothesis is: the more similar the robot hand and the human hand look, and the more similar the robot's compliance is to human skin and muscle, the more successful the interaction.

The successful application of biomimetics is characterized as the creative transfer of knowledge and ideas from biology to technology, i.e. technological development inspired by nature that usually passes through several steps of abstraction and modification subsequent to the biological starting point. The field of biomimetics is highly interdisciplinary, which is indicated by the high level of cooperation between experts from different fields of research, for example among biologists, physicists, and engineers: "Biomimetics combine biology and technology with the goal of solving technical problems through the abstraction, transfer, and application of knowledge gained

in interdisciplinary cooperation from biological models." [21] Within robotics, which is a broad area in the field of engineering, the application of biomimetic methods is similarly widespread in the design, control, and operation of robotic systems. In this regard, an officially accepted definition of biomimetic robots is: "A robot in which at least one dominant biological principle has been implemented and which is usually developed based on the biomimetic development process." [22]

3 Evaluating the Quality of HRI with Breaching Experiments

Although several studies have used the instrument of the breaching experiment (sometimes even without naming it, but definitely adopting its primary aspects) none of them has developed a systematic approach for establishing a general method for the evaluation of Human-Robot-Interaction HRI [23], [24], [25], [26], [27], [9], [28], [29], [30]. As an instrument, the breaching experiment is highly suitable for the evaluation of HRI for several reasons. First, it operates on a very high level with respect to understanding social action demands. Second, it is not subject to most of the common biases derived from the notion of delivering a socially desirable answer, in that the framing of the situation is taken into consideration. In a typical setting to evaluate quality of interaction qualitatively, the test persons are asked several questions regarding their subjective impressions of the experience after performing an interaction sequence with a robot. Compared to the well known Human-Human-Interaction (HHI), HRI is often disappointing and to some extent similar to it. The interaction sequence is mostly carried out by and determined by the human. The human fills in the gaps that arise in the course of the interaction sequence due to the robot's inability. In HRI experiments, this specific – although typical – situation tends to result in a positive assessment of the experienced quality of the interaction. While assessing the situation, the test person will most probably either highlight their own efforts to let the interaction flow or emphasize what they thought were the researchers' expectations. As an instrument, breaching experiments could deliver an authentic response insofar as the test persons will perform repair strategies just in case, since he or she expects a positive outcome. If the test person assumes that his or her attempt to reestablish a functioning interaction is condemned to be a failed repair, he or she won't try to repair it. However, the frame of the situation is of paramount importance.

In their study, Muhl & Nagai [9] show that the breaching experiment – put in the right setting with respect to framing – is able to deliver impressive results. Without reflecting their experiment design by theoretical means, they used a typical deception strategy and in doing so bent the frame in their favor. However, they were able to identify six different strategies to cope with the unexpected behavior of the robot and repair the undertaken interaction. Even if the interaction was quite rudimentary, the performed repair strategies show that the test person believed in the robot's interaction capabilities to a certain extent. In a nutshell, they successfully showed that within a clearly laboratory experimental setting, breaching experiments lead to satisfying, fruitful results. In a lab scenario, people are instructed to show a robot objects and how to use them. In this scenario, the robot is just an animated baby face [31] displayed on a screen. Its eyes, eyelids, eyebrows, and mouth are animated. The robot is equipped with a biologically inspired saliency mechanism [32]. Thus, the

robot's gaze follows the most relevant feature in the scene. This is how the robot addresses/displays its attention to the human interaction partner. The robot is not equipped with acoustic sensors or a speech processing system [9]. By interacting with it, humans can learn that the robot follows the salient point with its gaze. Human actors apply strategies of repair if an irritation of their expectation appears. They try to re-attract the robot's attention to the object by adopting several strategies (e.g. point to the object, show the object closer to the robot, getting the robot's attention, making noise, and so on) [9].

In this experiment, crisis in interaction has been induced systematically: The cognitive framing applied by ego to the state of the interaction partner (alter) is relevant for the overall judgment about alter, and in its consequence, the selection of how to approach alter in the next turn. In this regard a thoroughly conducted frame analysis is able to deliver highly important factors that are primarily responsible for the overall outcome of HRI testing and therefore shaping the way humans deal with the breaching. Taking the frame into account, one may see that repairing strategies (as well as the fact that repairing strategies are undertaken at all) depend on the humans' definition of the situation, which is strictly linked to the assumed frame. Putting the emphasis on the framing is not just important in terms of awareness of which framing strategy the researchers are adopting and being able to achieve a high degree of transparency, it is also important in estimating the viability of the breaching experiment as an instrument itself. By comparing the previously mentioned study of Muhl & Nagai [9] with a research conducted in a stationary care facility for the elderly, Compagna & Muhl [14] showed how important the frame is for the accomplishment of a reliable outcome in breaching experiments.

However within the setting (and therefore the framing) of an everyday life context, breaching experiments were not possible. A service robot was asked to serve a glass of water to the residents of a home for elderly people [33], [34]. The task was to take the person's order and then serve the glass to the correct person. The robot was also asked to address the human by talking. Often, the people did not reply to the robot and preferred to address the other people present. In the cases in which humans accepted the drink, the robot thanked them, which was mostly ignored by the humans. The robot was not capable of reacting flexibly and turning the rejection into a request, e.g. by commenting on it, which would have led to communication. The likelihood of successful communication would have improved. Social robots do not necessarily offer communication to which humans respond positively. If an action expected of the robot does not occur, it will probably be repaired by the involved actors, and the reaction to such a maneuver is often as unexpected. This does not refer back to any attempt to establish understanding in which the action of ego would semantically be constructed by the reaction of alter. In those cases, interaction in a sociological sense is not only endangered by its failure, but it cannot occur at all. This contrasts to the interaction experiments in the laboratory with the robot baby face in which, as mentioned above, the human actor tried – with more or less patience – to settle meaning/semantics with the robot as his or her alter ego. After several non-successful trials the interaction is abandoned.

Comparing these two cases the paramount importance of framing becomes visible: The breaching experiment method obtains very fruitful findings in an experimental setting. There are indications that the method also works properly if the experiment is not mentioned at all, and if encountering an interaction with a robot is not expected [24]. The framing related to the expectations raised by the humans seems to be the key issue here. Without a doubt framing is very important, however further research has to be done to determine the main aspect that is entangled by the frame within which the HRI is carried out.

4 Summary

A method built on breaching experiments as core instruments with a strong emphasis on framing issues is most likely highly suitable for generating reliable results with regard to the quality and rate of interaction between a human and a robot even from a genuinely sociological perspective. The observation as to whether and how a crisis (explicitly induced by the researchers) is repaired by a human could lead to a significantly meaningful evaluation of HRI that is also suitable for identifying differences between individuals [9], [14]. In order to set the right framing, it is very important to reflect the framing as a highly influential variable. Without a proper frame analysis, the findings of HRI breaching experiments are probably useless. However, if the frame is chosen wisely, the outcome could be very helpful in judging whether the HRI is successful or not. If the human adopts strategies to repair the interaction, the interaction can be described as a social interaction insofar as the human is assuming that it is worth being repaired. Even if the human is fully aware that the robot is a machine that is not capable of repairing the course of the interaction itself (one may say the robot is not able to process double contingency or elaborate on these grounds on a hypothesis as to how to reestablish a smooth flow (16)), the humans nonetheless consider the robot to be an entity that can be treated as a social actor. The comparison to a washing machine could be helpful for further understanding of the nonsymmetrical capabilities between the interacting entities: If a washing machine does not “react” as expected, the user will most probably abort the “interaction” assuming that the machine is simply malfunctioning. However, even here a certain number of repairing strategies can be observed, but these certainly do not include trying to ask or behave in a different way. In conclusion: If the framing is taken into consideration and chosen correctly, the way repair strategies were undertaken by the human (in combination with the observed frequency, quantity, and timespan) could be used to define the quality of the HRI. By doing so, the researcher could gain helpful information for the further development of social robots in regard to their interaction capabilities.

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