Social Human-Robot Interaction is Personalized Interaction

Kathrin Pollmann
kathrin.pollmann@iao.fraunhofer.de
Fraunhofer IAO, Institute for Industrial Engineering
Stuttgart, Germany

Daniel Ziegler
daniel.ziegler@iao.fraunhofer.de
Fraunhofer IAO, Institute for Industrial Engineering
Stuttgart, Germany

ABSTRACT

Previous research has indicated that robots that show social behavior when interacting with humans are better accepted. In this paper we argue that the robot behavior does not only need to be social, but also tailored to individual user characteristics, in order to be experienced as positive by the user in long-term use. To realize such personalized human-robot interactions, we need to identify differences among users, represent them in a user model and develop a number a design variants for the robot behavior. We propose to augment the conventional human-centered design process to focus on obtaining the relevant user information and creating matching design variants. We describe the different phases of the HCD4Personalization and illustrate them with examples from the NIKA project which is aimed at developing acceptable and positive interaction strategies for social robots that support older adults in their homes.

KEYWORDS

social robots, personalization, human-centered design, methodology

1 SOCIAL HUMAN-ROBOT INTERACTION

In the past decades we observed a shift from applying robots in industrial context to putting them in everyday life situations where they are expected to provide assistance and service for people. It has been shown that in such scenarios, it is important that the robot shows some social interaction skills to ensure a natural and successful interaction. Thus, the term of *social robots* has been introduced, describing robots that can interact and communicate with humans by following the behavioral norms expected by the people with whom the robot is intended to interact [1].

In the past years, much research has been conducted to improve the technical features and interactivity of robots to make them appear more social. However, their application in real-world scenarios is still limited, and insufficient answers have been provided for how to ensure the acceptance and long-term use of social robots, especially in private spaces such as our homes.

In this paper we argue that, while social robot behavior is widely regarded as a fundamental prerequisite for successful human-robot interaction (HRI), it is not sufficient to guarantee acceptance and long-term use of a robot. Existing approaches often neglect how the user experiences the interaction with the robot and that this experience is very subjective and personal, depending on individual characteristics, needs and abilities. When designing social robots for long-term private use it is hence crucial to consider the question of how we can provide a personalized positive interaction experience for the individual user.

2 WHAT IS PERSONALIZATION AND WHY DOES IT MATTER?

Personalization has been discussed in the field of human-technology interaction as a design approach to create technical products that can be tailored or tailor themselves to individual user characteristics [3]. In the context of HRI this means that the robot takes into account individual user characteristics as well as the situational context and automatically adapts its behavior to them. Different studies have shown positive effects of personalized robot behavior on the user experience (UX), perceptions [2] and long-term acceptance of the robot [7].

To realize personal HRI, it is first necessary to create a user model that contains all user characteristics and attributes relevant to the process of personalization [6]. Later, individual user profiles can be generated for single users based on this model. The user model should best be created based on user data gather during an extensive user research.

In addition, it is not sufficient to design only one designated interactive behavior for the robot. On the contrary, it is required to have different combinable variants of the behavior, one for each different type of user profile. Based on the individual user type the matching behavior can then be selected and displayed by the robot. Although these steps are based on the general idea of the human-centered design process (HCD) [5], they cannot be fully addressed by existing user research and design methods.

3 HCD4PERSONALIZATION: A METHODOLOGICAL FRAMEWORK FOR PERSONALIZED INTERACTION DESIGN

Planning the HCD in particular includes the selection of suitable methods for the activities in the subsequent phases according to the requirements of the specific project. Especially, the selected methods have to be aligned to the project's schedule and the availability of human and technical resources, not to forget the availability of the potential target user groups. The conventional HCD and its methods are centered around identifying similarities between users and building design solutions that address those as much as possible. The concept of personalization, on the other hand, builds upon the differences between users and the ideas to provide different design solutions for different user types. Therefore, when planning the HCD to design personalized HRI there are additional questions that need to be taken into account:

Workshop on Behavioral Patterns and Interaction Modelling for Personalized Human-Robot Interaction 2020, March 23–26, 2020, Cambridge, United Kingdom

- Which methods are required in order to identify and implement relevant potentials for personalization that match the users' needs and requirements?
- How to select the right samples out of the target user groups for user involvement activities in order to be able to identify relevant differences and meaningful user characteristics?

We developed a methodological framework that augments the well-know HCD with new research questions and methods to bring user differences in the focus of design and to develop personalized social robot interaction experiences. The framework is called HCD4Personalization and contains the following four steps that are integrated into the four iterative phases of the HCD: analysis, interpretation, design and evaluation.

The following sections describe the methods and research questions applied in each step, in order to focus on personalization. The description is illustrated by findings from the NIKA project. The project is aimed at developing interaction strategies for social robots that promote the independent living of older adults in their home. In the project, we applied the HCD4Personalization process to identify different user types and develop the matching behavioral variants. For demonstration purposes, in this paper, we focus in one particular use case of the project: brain training. To maintain the users' mental health and keep them active, the NIKA robot can initiate a quiz game. To make playing the game a personalized experience for the user, it is necessarily to create user model with the relevant characteristics and needs as well as design variants of the robot's behavior during the game.

3.1 Identify relevant user characteristics

The goal of the analysis phase in HCD is to understand the context of use in which the social HRI will take place. This context investigation includes specific behaviors, views and attitudes of the potential users. The methods applied in this phase usually focus on the identification of similar characteristics across the target group to be able to derive user requirements that apply to the whole user group.

However, to allow for a personalized design of social HRI, the analysis needs to put special emphasis on users' individual needs and requirements. In particular, the activities in this phase should be based on the following questions:

- How do users differ?
- Which differing characteristics are relevant for the personalization of HRI?
- How can relevant user characteristics be collected and stored in a user model?

In the NIKA project, the target group are older adults that live in their own homes and are still quite active and not cognitively or motorically impaired. To analyze the context, we conducted contextual inquiries (observations combined with interviews) in the homes of eight older adults and gathered insights about their daily routines, characteristics and psychological needs. In this phase, the adaptation of the HCD lies not so much in the applied methods, but rather in the type of information recorded and questions asked during the interview, as well as in the processing of the gathered data.

Apart from traditional user research results like personas, a key result for personalization is a candidate user model. It defines which characteristics should be known about each individual user and how these characteristics will be stored by the system (see [6]). The definition of a candidate user model allows to refer to a well-defined set of characteristics when specifying the personalization logic in further steps of the design process. The NIKA candidate user model contains attributes that represent personality traits according to the Big Five model [8] (such as extroversion, agreeableness and neuroticism) as well as a subset of user needs taken from the UXellence® framework [4] (such as competence, stimulation and competition).

3.2 Derive personalization hypotheses

To specify user requirements in the second HCD phase, the findings from the context of use analysis need to be interpreted and further processed, in order to derive ideas for personalizing the robot behavior. In the context of personalization this interpretation again needs to be focused on the variability of user characteristics and the corresponding variability of the design space:

- Which specific properties comprise the HRI design space?
- Which combinations of user characteristics necessitate HRI solutions with different properties?

In the NIKA project, we used the concept of personalization hypotheses to structure the interpretation process and document its results. Each personalization hypothesis describes the possible variation of a specific design dimension as well as its relation to specific user characteristics. To reduce initial complexity, we focused on extremes of the design space in a first step. To provide an example, the design dimension of *user motivation* was derived from the analysis in phase 1. This means that the user's performance and willingness to do the brain training can be increased by creating specific robot behavior to motivate the user during the quiz game. This might be realized in different ways. Opening up the design space for this *user motivation* dimension we came up with the following two extreme ideas for design variants: In one extreme the robot might behave supportive and extensively praise the user for her performance and effort. In the other extreme the robot might challenge the user e.g. by questioning if she knows the correct answer to the next question. Based on our prior user research findings we would expect users with a low level of neuroticism or a negative basic mood to prefer the supportive behavior, while users with a strong need for competition most likely experience the challenging behavior as more positive.

3.3 Create HRI design variants

In the design phase, the concepts outlined in the personalization hypotheses are transformed into concrete design solutions, with the following questions in mind:

- What different variants of HRI need to be designed?
- How can the concepts for the variants be represented by prototypes that can be experienced and evaluated by users?

In general, a personalized system needs to be designed in a modular way that allows to keep parts of the interaction the same for all users and change some parts depending on the individual user profile. For example, in the quiz game all users basically get the

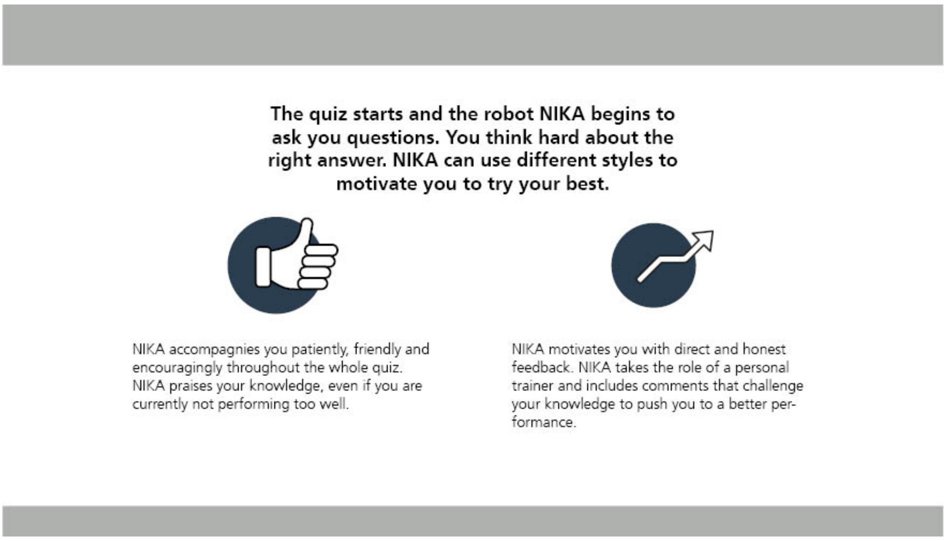

Figure 1: Prototypes for two different motivation styles the robot can show during the quiz game.

same course of the game, while aspects like the motivational behavior of the robot might vary between individual users. Thus, in the NIKA project, we created different variants for the robot behavior, building upon the design space defined through the personalization hypotheses. As the effort to implement behavior on a actual robot is often high, in this early stage of the project we worked with low fidelity prototypes of the behavioral variants. Concretely, we created a textual description for each variant which was accompanied by a rather abstract illustration. Figure 1 depicts an example of the prototypes for the different motivation styles mentioned before.

3.4 Evaluate personalized HRI

In the evaluation phase, the prototypes developed in the design phase are evaluated together with users. When evaluating different design variants for personalized HRI the following questions need to be addressed:

- Are the designed variants for the robot behavior the right ones?
- Have the design variants been assigned to the right user types or combinations of user characteristics?
- How can the design variants be optimized to better meet the variation of preferences within the target group?

In the NIKA project the evaluation was conducted as an online study. In this study 101 participants aged 60 or higher provided their feedback on the prototypes presented as text and illustration by rating how much they liked them on a 5-point Likert scale. In addition, they filled in a questionnaire to assess their stampings on the personality traits and psychological needs included in the candidate user model. The ratings of the prototypes were used to determine whether the variants were correctly chosen as a basis for personalized HRI. Variants whose ratings show a broad statistical dispersion are suitable to address different user types and are thus good candidates for personalized HRI. If statistical dispersion is low, this does, on the other hand, indicate that this behavior is evaluated equally by all users and that this variant is hence not suitable for personalization. Moreover, the questionnaire results were correlated with the ratings for the design variants to identify connections between certain combinations of user characteristics and preferences for specific design variants. Thus, we can conclude whether we assembled the right characteristics in the candidate user model and whether our hypotheses how certain combinations of characteristics are related to specific design variants are correct.

3.5 Iterative process

As the conventional HCD, the HCD4Personalization needs to be conducted in multiple iterations, in order to arrive at a final user model, definition of the design space and suitable design variants. In this paper, we only presented results and experiences from a first iteration conducted within the NIKA project. For the next iteration, the candidate user model and design variants will be refined based on the results of the evaluation. In addition, the fidelity of the prototypes need to be gradually increased to finally implement the behavioral variants on an actual robot and collect user feedback during the real-life interaction with this robot.

4 SUMMARY AND CONCLUSION

In this position paper, we argued that HRI needs to be personalized in order to be truly social. Concretely, this means that the interactive behavior needs to be tailored to the individual user's characteristics and needs. We proposed the HCD4Personalization, a methodological framework for developing personalized HRI which is based on the conventional human-centred design process, but was augmented with relevant research questions and methods to focus on personalization. We use an example from the NIKA project to illustrate a first iteration of gathering relevant characteristics for a user model, develop personalization hypotheses, translate them into design variants and test these variants and how they can be mapped to specific user profiles (combinations of user characteristics).

ACKNOWLEDGMENTS

The NIKA project was funded by the German Federal Ministry of Education and Research (BMBF 16SV7941).

REFERENCES

[1] Christoph Bartneck and Jodi Forlizzi. 2004. A design-centred framework for social human-robot interaction. In *RO-MAN 2004. 13th IEEE International Workshop on Robot and Human Interactive Communication (IEEE Catalog No. 04TH8759)*. 591–594.

[2] Nikhil Churamani, Paul Anton, Marc Brügger, Erik Fließwasser, Thomas Hummel, Julius Mayer, Waleed Mustafa, Hwei Geok Ng, Thi Linh Chi Nguyen, Quan Nguyen, Marcus Soll, Sebastian Springenberg, Sascha Griffiths, Stefan Heinrich, Nicolás Navarro-Guerrero, Erik Strahl, Johannes Twiefel, Cornelius Weber, and Stefan Wermter. 2017. The Impact of Personalisation on Human-Robot Interaction in Learning Scenarios. In *Proceedings of the 5th International Conference on Human Agent Interaction (HAI '17)*. ACM, New York, NY, USA, 171–180. https://doi.org/10.1145/3125739.3125756

[3] Haiyan Fan and Marshall Scott Poole. 2006. What Is Personalization? Perspectives on the Design and Implementation of Personalization in Information Systems. *Journal of Organizational Computing and Electronic Commerce* 16, 3-4 (2006), 179–202.

[4] Nora Fronemann and Matthias Peissner. 2014. User Experience Concept Exploration: User Needs as a Source for Innovation. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: fun, fast, foundational*. ACM, New York, NY, 727–736.

[5] ISO. 2010. Ergonomics of human-system interaction: Part 210: Human-centred design for interactive systems.

[6] Alfred Kobsa. 2001. Generic User Modeling Systems. *User Modeling and User-Adapted Interaction* 11, 1/2 (2001), 49–63. https://doi.org/10.1023/A:1011187500863

[7] Maarten H. Lamers and Fons J. Verbeek (Eds.). 2011. *Human-Robot Personal Relationships - Third International Conference, HRPR 2010, Leiden, The Netherlands, June 23-24, 2010, Revised Selected Papers*. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, Vol. 59. Springer. https://doi.org/10.1007/978-3-642-19385-9

[8] Sebastiaan Rothmann and Elize P Coetzer. 2003. The big five personality dimensions and job performance. *SA Journal of Industrial Psychology* 29, 1 (2003), 68–74.