Participatory Design of a Social Robot Toolkit for and with Adults with Autism

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ABSTRACT

Autism impacts around 5 million people in the EU (Autism-Europe). Research has shown that social robots, due to their deterministic nature, simplified appearance and technological capabilities, can enable therapy or become assistive technology for empowering autistic individuals with household activities. Consequently, toolkits have emerged for prototyping social robots. Regarding such toolkits, there is a methodological, inclusion gap: there is no comprehensive co-design process to include cognitively disadvantaged users in decision-making regarding robots' fundamental design choices. To overcome this gap and empower autistic adults to truly design their own (non-preprogrammed) robots, this research explores a social robot toolkit's well-scaffolded participatory design.

Keywords

Participatory Design; Autism; Social Robots; Socially Assistive Robotics; Empowerment; Co-design.

INTRODUCTION AND RELEVANCE

Introducing this paper's research: The Co³ Project

The research project that this paper addresses is termed the Co³ Project and encapsulates: *Co*-designing a *Co*llaborative So-bot *Co*-creation Toolkit. And this is what the project is about. What is so-bot co-creation? A so-bot, or a social robot, is a robot whose purpose is to work collaboratively (collaborative so-bot) with humans to assist them with various tasks. It comes with a "social interface", which is essentially all the characteristics related to its form, function and context due to which one would attach social qualities to it (Hegel, Muhl, Wrede, Hielscher-Fastabend & Sagerer, 2009). And so-bot co-creation entails inclusion of relevant stakeholders (especially the disadvantaged or vulnerable ones) in all phases of the design process, rather than just during the final phases–where contributions to fundamental changes and decisions regarding the robot concepts are no longer possible.

Increasing importance and ubiquity of social robots

Social robots, in one form or another, are becoming increasingly ingrained into society. The American think tank, Pew Research Center, predicts that by as early as 2025, "AI and robotics will be integrated into nearly every aspect of most people's daily lives". It claims that such agents with social intelligence will become increasingly competent at handling the tasks of our daily lives and will become ubiquitous in household and have an impact beyond general public and households: "Advances in AI and robotics will be a boon for the elderly, disabled [physical or mental impairments], and sick". The recent research within robotics and Human-Robot Interaction (HRI) literature also points out that robots are only going to become increasingly embedded within society, across functions and domains (Royakkers & van Est, 2015).

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Social robots for autism

This ubiquity and importance of so-bots is especially true for their use within the autism domain. According to the triad of impairments theory (Happé and Ronald, 2008), Autism Spectrum Disorder is composed of three symptom classes: Impairments in social communication (related to linguistics, facial expressions or body language), impairments in social interactions (related to emotions recognition and expression or social relationship development) and impairments in imagination (related to abstract thinking or generalizing insights). So-bots have the potential to aid autistic individuals due to: their predictable nature (making them easier to trust), their simple appearance (preventing overstimulation) and their greater approachability (due to absence of negative past experiences with them) (Cho & Ahn, 2016).

Fong et al. (2003) emphasize the need for effective design of the interaction between social robots and humans. Their study magnifies that so-bot development should not just be about adding technical capabilities to perform limited tasks, but also about designing human-robot interaction (HRI) in such an inclusive, human-centered way that social robots can "participate in the full richness of human society". Within the autism domain, the biggest state of the art gap that prevents such "full richness" participation is that so-bots are typically designed, developed, manufactured, and only then applied to the autism target group; rather than being co-designed with and for them.

This gap holds true for almost the entire state of the art: so-bots like Opsoro, Zeno, Kaspar, Darwin-OP2, Probo, Nao etc., were all designed and thereafter put to use for HRI research within autism. Research projects that do adopt participatory design to design products for the autistic population tend to achieve more engaging and effective results. Participatory design enables researchers to effectively learn about vulnerable groups and to design technology specifically for them particularly if the groups' lives are distant from their own (Frauenberger, Makhaeva & Spiel; 2017). Merter and Hasırcı (2016) also show how participatory design for "special user groups" increases their life quality and illuminates their unique capabilities. Hence, this study incorporates participatory design, to broaden the usefulness and impact of HRI research.

Research question

This gap regarding inclusion of autistic adults in so-bot development is going to be bridged by the research outlined in this paper. The Co^3 Project was built upon the opportunity for advancing the research on the use of social robots for autistic individuals, and on the participatory design methodology for co-designing such social robots. The purpose of this research project was, therefore, to explore the co-design of a so-bot toolkit for and with adults on the autistic spectrum at an autism care institute in Oldenzaal, The Netherlands. The following research question guided this purpose of the Co^3 Project:

How might we co-design a toolkit for co-designing social robots for and with autistic adults? How effective is such an approach and what insights can it reveal?

RESEARCH TOOL AND METHODOLOGY

Why participatory design (PD) or co-creation as the central philosophy behind the research methodology?

The authority for decision-making about robot applications and design has mostly been restricted to the robot designers or researchers working on the human-robot interactions. But as Lee et al. (2017) point out, the depth and broadness of the societal impact such robots can have demands a more inclusive design process that is driven by participatory design methodologies. The success Lee et al. (2017) have regarding participatory design of social robot concepts with a group of extreme users suggests that users/participants can be much more than informants and this form of a bottom-up, participatory approach is the philosophy behind this paper's research methodology.

So-bot Co-creation Process (SoCo Process) and So-bot Co-creation Toolkit (SoCoToolkit)

The overall purpose of the study was to co-design a so-bot co-creation toolkit by including the target group right from the start. Thus, after some initial research and ideation of preliminary so-bot toolkit ideas, an interview session was conducted with the target group at an autism care institute. The session involved: Understanding experiences of autistic adults and introducing them to social robots. The session revealed the need for a process-centricity rather than primarily a technological one. A technology-centric approach where so-bot building blocks are presented to the target group and they are expected to develop useful so-bot concepts was not possible. Having solely a technological toolkit cannot automatically bring technical familiarity, imagination-related skills and collaborative skills to an autistic target group (that is deficient in these). Thus, the project was led to be more process-centric: Where a process or a narrative would be established as extra scaffolding around technological building blocks.

Continuing with this process-centricity, the process designed for the Co^3 Project's research can now be discussed. It is called the So-bot Co-creation Process (SoCo Process), and figure 1 shows it at a high level. The first step involves the participant making choices or decisions about various aspects (robot type, robot tasks, robot functions etc.) of a so-bot concept through a narrative-driven approach (facilitated by a facilitator). The choices made by the participant about these aspects then form a recipe or a blueprint for the participant's so-bot concept. Once such a blueprint is drafted, a prototype of the entire or parts of the so-bot concept can be built, which can then be tested. These four steps are conducted in a flexible, iterative way with participants encouraged to move back and forth between them. Moving along the SoCo Process, the specificity increases, the practical constraints increase and the real-world "prototypability" at the final step is fed back to the previous steps. As such, the process promotes reframing of the initial problem and divergence of the possible so-bot solution(s).

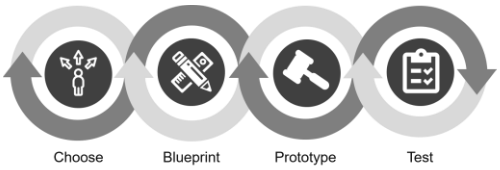

Figure 1: The four iterative steps of the SoCo Process

The SoCo Process still had to be made "usable", and for that it had to be packaged or embedded into the So-bot Co-creation Toolkit (SoCoToolkit). The SoCoToolkit (summarized in figure 2 that depicts *actual* portions of the toolkit) comprises materials corresponding to the steps of the SoCo Process: The toolkit's SoCoCards facilitate (1) choice-based "Choose" and "Blueprint" steps and the toolkit's SoCoBlocks facilitate (2) robot building "Prototype" and "Test" steps.

For (1), the toolkit features SoCoCards (so-bot co-creation cards) which divide the workspace into a problem space and a solution space (figure 2). The problem space consists of a so-bot concept's aspects related to the participant's need(s) or problem(s). It consists of cards regarding the application category of focus (e.g. domestic chores, offering infotainment, task management, well-being) and regarding robot type and task(s) (e.g. cooking robot that reads recipes and fetches food or companion robot that serves as a play partner etc.). And this problem or need space is where a PD participant starts with the process of blueprinting a so-bot concept. Once decisions are taken regarding these aspects, the participant is iteratively moved to the adjacent solution space. This space consists of cards related to aspects of the so-bot concept solution being developed: robot abilities (robot should be able to speak, hear, move, grasp etc.) and robot building blocks (robot should have speech recognition, mic, camera, wheels, arms, LEDs etc.). The facilitator also creates a narrative-type scaffolding around the cards, to facilitate co-design. Having a side by side problem and solution space encourages continuous, rapid iterations between the two, promoting co-evolution of problem and solution (figure 2).

For (2), the SoCoToolkit contains SoCoBlocks (so-bot co-creation building blocks like a robotic arm, LED ring, robotic lamp etc.) for rapidly prototyping, integrating and testing (parts of) so-bot concepts (figure 2). SoCoBlocks help with grounding into the real-world of and testing of the so-bot blueprint(s) generated through the first two steps of the SoCo Process.

The toolkit was developed through both empathizing with the target group and through ideas contained within PD and so-bot literature. The idea of dividing the content up into category cards aligns with the nature of Frauenberger et al.'s (2017) card-based co-design planner and with the proven effective "Inspiration Card Workshop" concept from Halskov and Dalsgård (2006) where they also had a generic, card-based co-design tool. Makhaeva, Frauenberger and Spiel (2016), validate how a process with physical (e.g. SoCoBlocks), methodological (e.g. SoCoCards and SoCo Process) and social (e.g. SoCo Facilitator) structure-freedom interplay elements enhances a PD participant's personal creativity path's discovery.

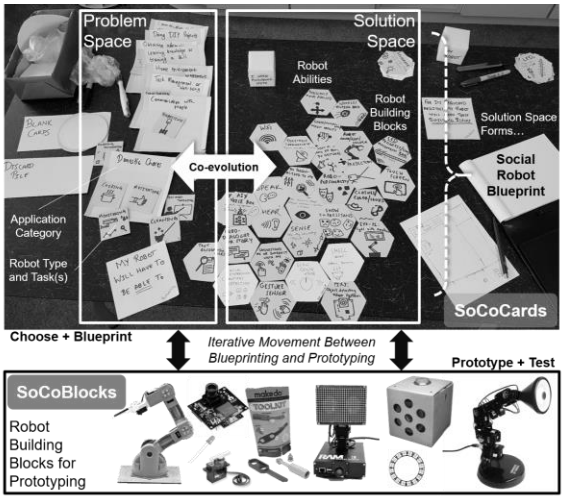

Figure 2: The constituents of the SoCoToolkit

Conducting research through and on the SoCoToolkit

Once the SoCoToolkit was developed based on the SoCo Process, it had to be tested as a research tool/probe for gathering insights (conducting research through it) and its own effectiveness had to be reflexively evaluated (conducting research on it). To achieve that, two further co-design sessions were conducted: a blueprinting session and a prototyping session. These sessions were conducted by an external so-bot co-creation facilitator (SoCo Facilitator) who was chosen for his similar "technical/DIY" facilitation role at the autism care institute where this study was conducted with three autistic adults (two male and one female).

The blueprinting session involved, firstly, getting a participant acquainted with the SoCo Process and SoCoCards by creating a narrative full of question prompts around it. Secondly, generating several (generic) social robot concept ideas through iterations between the problem and the solution space of the SoCoCards. Thirdly, nudging a participant towards personalizing, combining, recombining and reinterpreting the existing SoCoCards.

The prototyping session involved, firstly, the grounding of concepts generated in the blueprinting session into a participant's actual household environment by asking the participant to describe or draw their rough floor plan and household, after which the facilitator could discuss how the concepts could be embedded into household spaces. Secondly, prototyping and testing of already generated concept(s) from the blueprinting session by using SoCoBlocks in a way that a concept can be prototyped as far as possible (even if the prototype involves role-play). Thirdly, feeding back the results from prototype testing to modify the blueprint(s) and to retest the changes made.

RESULTS AND INSIGHTS

The blueprinting and the prototyping sessions outlined in the previous two paragraphs were conducted and became the primary source of insights and inferences derived from the Co^3 Project's research. Here is an overview of the main insights (Liz, Martin and Tom are pseudonyms used for participants' names to protect their privacy):

The project greatly advanced the social robot state of the art. The state of the art went beyond typical anthropomorphic designs and beyond the typical autistic children target group and beyond what can be created by a designer themselves. In words of the SoCo Facilitator himself, *"Concepts that came out were personal. Right there on the edge. Beyond the logical, simple first solutions. Flic buttons combined to a screen with a simple light. Having speech but no hearing. I could not have come up with this on my own."*. Hence, the SoCoToolkit did empower autistic individuals to develop truly novel and personalized concepts that could not have been thought up solely by a designer. The figures 3 and 4 below show Tom's and Liz's results from both their blueprinting and their prototyping sessions.

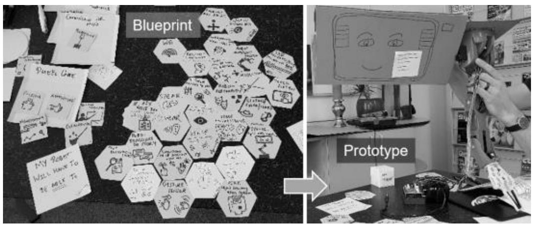

Figure 3: Tom's cooking assistant so-bot with a digital face, an interactive touchscreen and an arm for cooking tasks

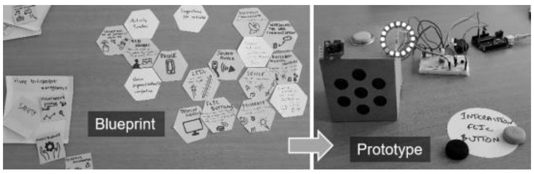

Figure 4: Liz's security, maintenance and well-being so-bot that provides non-intrusive, task-oriented feedback through an LED ring or through localized button-activated speech

The project empowered autistic adults to solve their own problems. Perhaps Martin's session is the best example of an unexpected form of participant empowerment. When coming up with a blueprint for his so-bot concept and when describing his preferences for the so-bot, he said, *"It shouldn't do the work for me…it should only tell me when something needs to be done"*. Hence, participant empowerment through the SoCo Process is not necessarily technology-centric and about creating so-bot solutions that can sense and do everything. It could, in fact, mean the reduction of offloading of tasks to the so-bot, such that the so-bot becomes merely a passive assistant.

The project created active engagement and inclusion of autistic adults in the so-bot design process. According to the SoCo Facilitator, active engagement in the process was manifested and achieved by for example: *"Asking them* *[participants] to draw their rooms for grounding"; "Not having too open imagination"; "A problem explicitly asked from them was a source of active engagement."*. The SoCo Facilitator further remarked about participant engagement: *"Each [participant] came up with a pretty original concept really tailored to specific and very personal issues…"; "The level of depth in which concepts arose were not just sketching exercises…[they were situations] where a robot had to solve a real problem".*

The project showed flexibility and appropriateness of the SoCo Process to various situations, preferences and participants; and led to the emergence of diverse concepts. It can be concluded, with confidence, that the process's flexibility was an asset. In the SoCo Facilitator's own evaluation of the SoCo sessions: *"If you see how the process facilitated three different people, with three different needs, in achieving the outcome. And coming up with radically different concepts. Security system with remote buttons [figure 4], clutter detector, cooking arm [figure 3]…the process went completely different with the three of them. And accommodated their different ways of working and mindsets. It was open-ended in terms of outcome. So yes, flexibility criteria were met.".*

The project highlighted the situatedness of autism and dependence of creativity on the right context. Contrary to popular belief, it is not that autism is not "typical". It is just that people who have it are not provided with a context that is appropriated, situated and suited to their specific quirks, qualities and mindsets. Viewing autism as such and providing the right context for such situatedness to happen makes autism pragmatically "neurotypical". For instance, the SoCo Facilitator said, *"But it [SoCo Process] was a meaningful thing...he [Tom] liked it and felt that he achieved something useful. Also, for [Liz] same holds and for [Martin]."* The facilitator reasoned about this usefulness of process and concepts by saying, *"Because…for them [participants] it was really about problems that were important to them"*. And this is what situatedness can achieve. It involves providing the right context appropriated to a particular participant, their personality and their problems. And when that happened, *"Concepts that came out were…beyond the logical, simple first solutions… I could not have come up with this on my own."*, as the facilitator noted. Is that not as competent as what one would imagine a neurotypical individual to be in a creative task? That is how powerful the right cognitive scaffolding and the right co-design context can be.

CONCLUSION

The Co^3 Project has produced a toolkit of linkable social robot building blocks centered around which is a holistic, novel process for conducting social robot participatory design with cognitively impaired individuals. That process has artefacts meticulously designed with the participants in mind–giving the artefacts sufficient scaffolding to make co-design navigable by bridging the impairments in imagination and social interaction of the involved participants. The project aims to inspire a movement of open-source, scalable and democratized social robot co-design, which in the end can be facilitated by a social robot itself (which works with participants to co-design itself) and which can empower egalitarian inclusiveness in design of all users–to evoke questions on which human-robot interactions to design in the first place and why.

ROLE OF STUDENT

Suhaib Aslam was an undergraduate honors student at University of Twente's University College. He was responsible for the project's literature research, research methodology and design of the artifacts of the project. He was also responsible for writing about, processing the results of and drawing conclusions about the project. He worked under the supervision of dr.ir. Edwin Dertien (robotics and mechatronics) dr. Jelle van Dijk (human-centered design) and dr. Pascal Wilhelm (psychology).

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