CoCoCo: Co-designing a Co-design Toolkit for Co-bots To Empower Autistic Adults

Abstract: Autism impacts 5 million people in the EU. Research has shown social robots as enabling robot-assisted therapy or providing assistance in everyday activities. However, given the strong heterogeneity of the target group, it proves to be difficult to design generic, one-size-fits-all assistive applications. Various toolkits have emerged for self-building of robots, yet these still require considerable technical skill. More importantly, such toolkits lack guidance in a structured design process, to uncover and translate real needs into coherent product concepts that can actually be built. To fill this gap, we engaged in CoCoCo (Co3), an exploratory study to empower autistic adults to truly design their own (non-pre-programmed) collaborative robots. The Co3 toolkit of linkable building blocks guides designer and autistic participant through an iterative co-design process. The toolkit itself has been co-designed, evaluated and tested with autistic adults at a FabLab-inspired activity centre for autistic individuals. We discuss how the toolkit elements are padded with cognitive and communicative scaffolding to bridge imagination and communication-related gaps in the interaction between designer and autistic participant. We present Co3, a first step in open-source, scalable, democratized design of social assistive robots, with the aim to increase inclusiveness and democratization.

Keywords: Participatory Design; Autism; Social Robots; Socially Assistive Robotics; Empowerment; Co-design.
Frictions and Shifts in RTD

Introduction and Relevance

The Co Project

In this paper we report on a project that entailed Co-designing a Collaborative/assistive Robot co-creation Toolkit: Co. In this project we considered collaborative or assistive robots to be a class of social robots whose purpose is to work collaboratively with humans in their daily tasks. Our collaborative, assistive social robots are social, with which we mean robots deliberately designed with a ‘social interface’, that is, a form of interaction that has social significance to the human user (Hegel, Muhl, Wrede, Hielscher-Fastabend & Sagerer, 2009). A social interface is not just a visual appearance with opportunities for input but includes the necessary social behaviors—i.e., social robots do the kinds of things to which a human user would attribute sociality. This does not necessarily mean that social robots have a humanoid shape or even a face. Social interaction may be characterized by patterns of interactive behavior that respond to another social agent so as to establish some form of social coupling (see e.g. Lévy et al, 2011).

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, “Art and robotics will be integrated into nearly every aspect of most people’s daily lives”. Agents with social intelligence will become increasingly competent at handling the tasks of our daily lives and will become ubiquitous in households, with impact beyond the general public: “Advances in AI and robotics will be a boon for the elderly, disabled [physical or mental impairments], and sick”. Recent research in Human-Robot Interaction (HRI) literature points out that robots are only going to become increasingly embedded within society, across functions and across domains (Royakkers & van Elst, 2015; Young, 2010). Lohse, Hegel and Wrede’s (2008) claim that their study provides substantial evidence on the significance that social robots will achieve in the future, within domestic settings. Fong, Nourbakhsh and Dautenhahn (2003) had also already concluded: “It seems clear that social robots will be an ever larger aspect of our daily lives”. Agents with social intelligence will become increasingly competent at handling the tasks of our daily lives and will become ubiquitous in households, with impact beyond the general public: “Advances in AI and robotics will be a boon for the elderly, disabled [physical or mental impairments], and sick”.

Autism and social robots

According to the DSM-5 theory (see DSM-5), three primary symptoms are all present to various degrees in an autistic individual: Impairments in social communication (linguistic impairments, difficulties in understanding and generating facial expressions, gestures or body language), Impairments in social interactions (difficulties with handling own and recognizing others’ emotions; avoiding group activities; difficulties with social relationship development), Impairments in imagination (difficulty in abstract thinking; difficulty with generalizing insights and skills; difficult to live or think outside routines; problems with imagination and unfamiliar situations) (Happe & Ronald, 2008; Cabibihan, Javed, Jr. & Aljunied, 2013). In line with this characterization, social robots have seen a long international debate on how to assist and support different social assistive technologies for autistic people (Dielh et al, 2012). Traditionally this is attributed to robots’ predictable, deterministic nature, their simpler anthropomorphic appearance and their technological capabilities. Their envisioned function of such assistive robots is geared towards offering help with social or emotional deficiencies and training certain skills. So, for example, it has been claimed that social robot’s propensity for simple stimuli avoids overstimulation that autistic individuals can be prone to (Cho & Ahn, 2016). Secondly, because robots make uniform and predictable responses, they can be easier to trust and respond to (since they lack complex human nuances) (Cho & Ahn, 2016). Finally, because a social robot does not invoke the recollection of past negative experiences that a person might have had with humans, it feels more approachable and easier to interact with (Cho & Ahn, 2016).

This potential of social robots for people on the autistic spectrum is shown by various research projects: KASPAR robot at University of Herfordshire (KASPAR’s potential) by Hü Jnjen, Lévy et al., 2011). Traditionally this is attributed to robots’ predictable, deterministic nature, their simpler anthropomorphic appearance and their technological capabilities. Their envisioned function of such assistive robots is geared towards offering help with social or emotional deficiencies and training certain skills. So, for example, it has been claimed that social robot’s propensity for simple stimuli avoids overstimulation that autistic individuals can be prone to (Cho & Ahn, 2016). Secondly, because robots make uniform and predictable responses, they can be easier to trust and respond to (since they lack complex human nuances) (Cho & Ahn, 2016). Finally, because a social robot does not invoke the recollection of past negative experiences that a person might have had with humans, it feels more approachable and easier to interact with (Cho & Ahn, 2016).

Co3 Project aims to accomplish.

Social robot DIY toolkits

As said, there is a growing trend in social robots for domestic/household environments. Increasingly, such home systems allow some degree of customization. This is further supported by emerging toolkits for full-blown Do-It-Yourself (DIY) design and customization of robots, like Ichib, Pappy and Lego Mindstorms (Vandeveld, Wyfelsy, Vanderborgh & Saldien, 2017). MIT’s social robot (Siro) toolkit project (Gordon, Ackermann & Breazeal, 2013) is another such example. However, the social robot toolkit that stands out the most is the one behind the Ono robot (pictured in figure 2), and is called Opsoro (Open Platform for Social Robotics). Opsoro (and Ono) is an open-source, low-cost, DIY social robot toolkit that wants to democratize and simplify the building of social robots that are for fun and tasks and research surrounding social expressiveness and emotions (Vandeveld et al., 2017). It derives its value from its tinkering-oriented DIY approach, from the freedom for modifications of robots it gives users and from its (relatively greater than typical) ease of robot development. While social robot toolkits share a lot of common ground with the pre-manufactured, discrete social robot embodiment concepts, they are unique in that they put the authority and freedom of building or customizing certain aspects of the robot at the hands of the user. They tend to flip the manufacturing or robot design paradigm from a top-down approach, where a researcher or a designer develops a robot and thereafter puts it to use for a user; towards a more bottom-up approach, where the researcher/designer develops the building blocks that are needed to customize or develop a social robot, and delivers those blocks to the user—such that the process leaves some (or all) of the robot’s design decisions up to the user. It is this paradigm shift that the Co3 Project aims to accomplish.
Three Gaps Concerning Social Robot Toolkits and Their Use for Autism

Opsooro (and Ono) takes a major step at advancing the state of the art of social robot toolkits and of HRI research using social robots, by giving a DIY reproducible design to enable HRI research with and for autistic children. Participatory design, they claim, is about “empowerment, assistance and/or improvement can be about much more than just improvement of autism interventions regarding emotion recognition and expression—something that we aimed to achieve by enabling the emergence of robot concepts or assistive technologies that go beyond emotion recognition and expression.”

Opsooro builds on a long tradition of research on the use of social robots for autistic children. This tradition can be divided into three main lines: (1) developing robot technologies specifically targeted towards autistic children. Within this line of research, the Co3 Project was an example of research that engaged autistic children in design research using social robots. They proposed HRI design recommendations concerning, amongst others, robot: appearance, behaviors, affective interactions and adaptation.

Gap (1): Prevalence of social robot designs that are conventionally anthropomorphic and whose interaction modalities cannot be fundamentally customized.

This gap is illustrated by, for instance, the modalities Opsooro offers that are mainly related to a robot’s lips, head, eyes and eyebrows; and by Hoffman and Ju’s (2014) conventionally anthropomorphic child-like or cartoon-like robots. However, HRI research and design can gain a lot of advantages by developing non-anthropomorphic robots. As Hoffman and Ju point out (2014): Non-anthropomorphic robots lower user expectations regarding robots’ abilities, capabilities and efficiencies that arise from anthropomorphic embodiments (Duffy, 2003; Nomura et al., 2008), and that non-anthropomorphic robots avert the uncanny valley that was first conceived by Mori (1970). Furthermore, a non-anthropomorphic robot offers more “freedom of exploration”, as the robot is not directly being designed to be a human replica and it is not compared against humans to gauge its capabilities and potentials in so-called “art of social robot toolkits and of HRI research using social robots. The Co3 Project was an example of research that engaged autistic children in design research using social robots. They proposed HRI design recommendations concerning, amongst others, robot: appearance, behaviors, affective interactions and adaptation. What if robot users were empowered to be able to customize these robot concepts or design concerning robot design? It could be the case that the resulting social robot designs are more impactful and effective and give users a feeling of having something that is genuinely useful for them—another research and design opportunity that we address by incorporating customizable participatory opportunities for deeper interaction modalities of robots.

Gap (2): Social robots being typically designed, designed, and only then applied to the autism target group; rather than being co-designed with and for them.

This was true for almost the entire state of the art: Opsooro, Zeno, Kaspar, Darwin-OP2, Probo, Nao etc., were all designed and thereafter put to use for HRI research with and for robot-assisted therapy for autistic children. This assumes that the researchers already knows that the problem is that needs to be addressed, and often this would take us to expertise that oversimplifies the dimension of the person’s impairment. We are however more interested in what people on the spectrum themselves define as problematic, and how can themselves come to define what they would need to be empowered in daily life. Frauenberger et al. (2017) clearly demonstrate the value of participatory design in their own co-designing experiences with autistic children. Participatory design enables designers and researchers to effectively learn the fundamental principles of design and technology specifically for them; and is particularly powerful if the groups’ lines and perspectives are distant from their own (Frauenberger, Makhaea & Spiel, 2017). Merter and Hasirci (2016) also show that for autistic individuals, it is not just their impairments that create problems for them, it’s also “the inappropriate design of their material surroundings”. They show that if such individuals are empowered through participatory design, they can overcome their surroundings to live a more fulfilling life. For instance, in the case of autism, Merter and Hasirci (2016) demonstrate how participatory design techniques for HRI designs can be used to create new robots that are better suited for autistic individuals. This is particularly important because autistic individuals often have unique needs that differ from those of typical individuals. Therefore, it is crucial to design social robots that are tailored to their specific needs and are capable of adapting to their individual preferences. The study by Merter and Hasirci (2016) provides valuable insights into how participatory design can be applied to create social robots that are more effective and user-friendly for autistic individuals.
Frictions and Shifts in RTD

Research Methodology

Participatory design (PD) as the central philosophy behind the research methodology

As mentioned earlier, the purpose of making decisions about robot applications and design has mostly been restricted to the robot designers or the researchers working on the human-robot interactions. But as Lee et al. (2017) point out, the depth and breadth of the societal impact such robots can have demands a more inclusive design toolkit. However, 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 and should be much more than informants. They can be as equally authoritative as the researcher, as part of a process where there is mutual learning between the researcher and the participants, enabling participants to actively articulate their ideas and concerns about the embedding of robots in their lives. This form of a bottom-up, participatory approach is also greatly encouraged by Gaudion et al. (2015) in their research, and is the philosophy that forms the foundation of this paper’s research methodology.

Empathizing with the target group and co-designing a collaborative robot toolkit

The overall purpose of the study was to co-design a social robot co-creation toolkit. However, this purpose would be entirely defeated without including the target group right from the start. Thus, after having done some initial research and having identified some preliminary social robot toolkit ideas, an interview session was conducted with the target group that consisted of autistic adults at an autism centre in the Netherlands. The session involved understanding experiences of autistic adult's and introducing them to social robots. And this was done in line with Lee et al.’s (2017) effective methodology. This session allowed the researcher to empathize with the target group and to expose the co-design participants to and engage them in a discussion about existing social robots. Participants were encouraged to reinterpret the state of the art of social robots, and to think about them in ways beyond what they would conventionally imagine social robots to be. For this, images, characteristics, physical embodiments and videos of existing social robots were used as prompts for the participants to discuss with the researcher. This process allowed the participants to engage with the thoughts of Malinverni et al. (2014), who demonstrate that within creative co-design processes, the “balance between creative and reflective steps, managing the reflective and creative process; and (3) Generating guidelines for facilitating a robot-oriented thinking, mixing, reflecting, diverging, reframing, in an iterative way. As such, the process not only creates a common blueprint, and promotes a reframing of the initial problem and a widening of the solution space (thinking out of the box) by the participant. The participant is nudged towards choosing, reconsidering, mixing, reflecting, diverging, reframing, in an iterative way. The process as described was packaged into a concrete toolkit with physical cards representing the steps of the process (Figure 3: (1) the choice-based “Choose” and “Blueprint” steps and (2) the robot building “Prototype” and “Test” steps.)

For (1), the toolkit features CoCo cards which divide the workspace into a problem space and a solution space (figures 4 and 5). The problem space (left-hand side of workspace) consists of a collaborative robot concept’s aspects related to the participant’s need(s), problem(s), or interest(s). It consists of cards regarding the application category of focus (e.g. domestic chores, offering information, task management, well-being) and regarding robot type and tasks (e.g. cooking robot that reads recipes and fetches food, companion robot that serves as a play partner etc.). And this problem or need space is where a participant starts with the process of blueprinting. Once decisions are taken regarding these aspects, the participant is iteratively moved to the adjacent solution space on the right-hand side of the workspace. This space consists of cards related to aspects of the social robot concept solution being developed: robot abilities (robot should be able to do X, Y, etc.) and robot building blocks (robot should have speech recognition, mic, camera, wheels, arms, LEDs etc.). Meanwhile the facilitator creates a narrative-type scaffolding around the cards, in order to facilitate the choice-making process of the participant. The overall process is divided into eight activities, whereby side problem and solution space is to encourage continuous and rapid iterations between the two spaces, through which the participant’s idea at hand can co-evolve in a Schönian manner (Schön, 1998), where the left-hand side of the workspace co-evolves with and is informed by the right-hand side of the workspace (figures 4 and 5). And as the process advances, the problem is reframed into a pragmatically useful need and the participant considers various new combinations of robot building blocks. For (2), the toolkit contains co-creation process of the project. Firstly, it was confirmed that for a co-creation process of the nature of that in the Co3 project, it can be said that fundamentally it is about managing, facilitating and consciously guiding the interplay between freedom and structure. This was shown by one participant seemed to need a lot of structure and guidance to help him with imaginative or abstract thinking. He constantly asked for examples and needed explicit demos before he could himself start thinking about how social robots could help him. Another participant found it way easier to be creative and abstract in thought, and was naturally divergent in thinking: that, however, also meant that he was really easily distracted and found it hard to remain on topic. Thus, it was clear that the main principle to inform the toolkit’s design would have to be a flexible way to balance structure and freedom. It was decided in conducting co-design sessions for developing social robots. This process was done in line with Tanguy and Lee et al.'s (2017) effective methodology. This session involved understanding experiences of autistic adults and introducing them to social robots. And this was done in line with Lee et al.’s (2017) effective methodological approach. This session allowed the researcher to empathize with the target group and to expose the co-design participants to and engage them in a discussion about existing social robots. Participants were encouraged to reinterpret the state of the art of social robots, and to think about them in ways beyond what they would conventionally imagine social robots to be. For this, images, characteristics, physical embodiments and videos of existing social robots were used as prompts for the participants to discuss with the researcher. This process allowed the participants to engage with the thoughts of Malinverni et al. 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The Co³ toolkit was developed through both empathizing with the target group (as shown in previous subsection) and through ideas contained within PD and robot literature. The idea of dividing the content up into application-type and technology-type categories aligns with the nature of the proven effective “Inspiration Card Workshop” concept from Halskov and Dalsgård (2006) where they also have a collaboratively, card-based tool for general co-design. Research of Makhaeva, Frauenberger and Spiel (2016), validates how a process where there are physical, methodological and social elements that together strike a balance between a guiding structure and freedom to be creative and contribute. Together this serves to empower participants to discover their own pathway for letting their creativity unfold. Cards were chosen as one of the primary methods for embodying the process, firstly because they align with the values behind Frauenberger et al. (2017) co-designing tool; and secondly, because they align with the ethos of the successful “Inspiration Card Workshop” concept from Halskov and Dalsgård (2006) where their co-design cards can be combined, re-combined and co-created into new concepts for design in general.

The symbols used on the cards have been hand drawn at first. In a second iteration of the process, the cards have been re-designed by one of the autistic participants with a background in design, to have a validation of interpretation and to safeguard a certain uniformity. However, the ‘hand drawn’ nature of the original cards have a strong impact on the affordance during the process and stimulate to add more cards which can be drawn on the spot on a set of blanks present for this very purpose.

Testing and further research using the toolkit

Once the toolkit was developed it had to be tested. Two further co-design sessions were conducted: a blueprinting session and a prototyping session. The third author took the role of facilitator (with his professional role at the autism care institute where this study was conducted) and co-designed with three autistic adults (two males and one female). With all three participants the sessions were conducted in two iterative rounds (spaced some days apart) of 45 minutes each.

The blueprinting session involved, firstly, getting a participant acquainted with the Co³ process and Co³ cards 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 Co³ cards. Thirdly, nudging a participant towards making their own choice(s) in the process by combining, recombining and reinterpreting the existing (pre-defined) Co³ cards, and adding the emergent cards to the present Co³ cards to further personalize them. 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 can discuss how the concepts could be embedded into their household spaces. Secondly, prototyping and testing of already generated concept(s) from the blueprinting session by using Co³ blocks 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.

Insights from the test sessions

In this section we highlight two example designs from our test sessions, designed by Tom and Liz (not their real names, see Figure 6 and Figure 7). A third test session with Martin yielded results supporting our findings but have been left out. We discussing how the designs are personalized solutions and we point to a number of specific ways in which the toolkit served to scaffold (or in some cases failed to scaffold) the co-design process that led up to these designs.

The test sessions took place in a quiet room at the care institute. Prior to the session the table was laid out with the cards on piles, supporting robot components in the background. Participants were explained the procedure, with as goal to both help in (co-design) of a personalised robot solution, as well as evaluate the method itself.

In the first session with Tom it took a relatively long time to make the process clear. He went along in the process, the ‘aha’ moment came only during the second session “oh, but this paper game is in fact the design! So now I can give it to somebody else to do the something and building”. Participant Liz had more background knowledge as a designer, so the goal of the process did not need elaborate explanation.

Insights concerning the resulting designs

Tom wanted to create a kitchen robot that would help with recipe following, ingredients addition or tracking, motivation for cooking etc. This became apparent during the first session. In the second session as grounding exercise the question was posed where to put this system in his home environment. A sketch of his home (floor-plan) was made on the spot with aid of the facilitator. His prototype ended up as a system mounted in the kitchen, under one of the cabinets right above the work surface. As quick prototype to visualize this, during the session a robot arm was attached to a cardboard screen that had a digital face and a separate touch menu (yellow post-it in figure 6, to the right) for choices.
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The Co3 facilitator was surprised with the design choices that Tom was able to make, especially because at the beginning of the process (first session), Tom wasn’t able to even grasp the idea of having a personalized robot, and here he was now making really intricate design changes to his concept prototype. Prototyping social robot concepts empowers detailed, specific design preferences of participants to be uncovered.

One key aspect in his explicit articulation of a need he had regarding his robot design, he said about his concept, “A system that gives feedback, but does not tell me that I am wrong.” And this very personal and intrinsically important design need was a great outcome for use as a design requirement; as the facilitator noted “such a comment gives a designer an important ingredient to translate in the rest of design.”

In the first session with Liz, one of the key aspects became ‘feeling secure’. Since Liz has a hearing impairment as well, this means that (sudden) sounds of unknown origin can startle her. She has also other personalization needs doing real, personal and very specific tasks. Hence, the Co3 toolkit truly did add a second layer to the process by which physical stuff was lying around.

The Co3 facilitator, when evaluating the process’s proceedings, said, “These kind of little things (referring to Tom’s change in the position of the robot arm and Liz’s need for avoiding speech interaction with voice box) only happened when and because physical stuff was lying around.” He went on to say, “Both [Liz and Tom] highlighted that the fact that we had some physical stuff lying around made the idea really concrete and visual”.

Having simple, paper-based and hand-drawn Co3 cards could create an affordance of the cards themselves being a modifiable prototype, that can be made a participant’s own.

This affordance was also highlighted by Liz herself, who said, “My fordsance of these [Co3 cards] is good. Easy to expand the cards with building blocks and functions.” However, she also noted that: “It is harder to do this with the ‘categories’. Tasks within categories however offer shifting around, that already solves a bit.” She was referring to the category ‘A’ cards in the problem space (left-hand side) that are about application categories.

The Co3 facilitator noted: “This [Co3 process] is really good because it asks a second layer to the process where you talk about the objects and material on the table instead of the [autistic] participants and their problems.” The figures 6 and 7 show the results of two of the participants from both their blueprinting sessions and their prototyping sessions.

The project empowered autistic adults to draw their own problems. Perhaps Liz’s session is the best example of true co-design and participant empowerment: “I was a bit skeptical at first but I have the feeling that I really created a system concept here.” Hence, participant empowerment through the process is not necessarily technology-centric and about creating solutions that can sense and do everything. The solutions are tailored to individual needs doing real, personal and very specific tasks.

The project created active engagement and inclusion of autistic adults in the Co3 design process. According to the facilitator, active engagement in the process was manifested and achieved by for example: “Asking them [participants] to draw their rooms for grounding”.

The project greatly advanced the social robot state of the art. The state of the art went beyond anthropomorphic designs, beyond just typical emotion recognition and expression therapy, beyond the typical autistic children target group and beyond what can be created by a designer themselves. In words of the Co3 facilitator: “Concepts that one usually only ever at the edge. Beyond the logic of the simplest first solutions. Flic buttons combined to a screen with a simple light. Having speech but no hearing. I would not have come up with this on my own.” Hence, the Co3 toolkit truly did empower autistic individuals to develop truly novel and personalized concepts that could not have been thought up solely by a designer. And that might have been because of how the Co3 toolkit physically embodied and externally represented the Co3 process on a table, which made the process sufficiently scaffolded for the target group. As the Co3 facilitator noted: “This [Co3 process] is really good because it asks a second layer to the process where you talk about the objects and material on the table instead of the [autistic] participants and their problems.”

Figure 6. Tom designed a cooking assistant with a digital face, an interactive touchscreen, an arm for cooking-related tasks

Figure 7. Liz designed a secure, maintenance and well-being collaborative robot (system) that provides non-intrusive, task-oriented feedback through an LED ring or through localized button-activated speech action modalities (voice interfaces, touch, speech, motion etc.).
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Figure 8. The Co3 toolkit was designed to allow participants’ creativity to emerge, by providing the right contextual materials. Materials that afford the occurrence of highly situat ed and personalized concepts.

The project showed flexibility and appropriateness of the Co3 process to various situations, preferences and participant; and led to the emergence of diverse concepts. It can be concluded, with confidence, that the process’s flexibility was an asset. In the facilitator’s evaluation of the 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, clutter detector, cooking arm… 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. Perhaps the biggest insight that the project revealed was that, contrary to popular belief, it’s not that autism is not “typical”. It’s just that people who have it aren’t provided with a context that is appropriate, situated and suited to their specific quirks, qualities, preferences and mindsets. Viewing autism as such and providing the right context for such situatedness to happen makes autism pragmatically “neurotypical” when it comes to the task at hand. For instance, the Co3 facilitator said, “But it [Co3 process] was a meaningful thing… So, yes, I think and also based on his concepts, he [Tom] liked it and felt that he achieved something useful. Also, for [J.C.] the same holds.” 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 for a particular participant, their personality, personal problems and quirks (part of the more “physical” context provided by the Co3 toolkit is featured in figure 8). A context that is best appropriated to them and their preferred balance of structure and freedom. And when that happens, “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. Isn’t that as competent as what one would imagine a neurotypical individual to be in such a creative task? That is how powerful providing the right situated cognitive scaffolding and the right context for co-design can be.

Conclusion

This exploratory 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 (co-)design of all users – to evoke questions on which human-robot interactions to design in the first place and why.

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