RODECA: A Canvas for Designing Robots

Nielsen, Sara; Ordoñez, Rodrigo; Hansen, Karl Damkjær; Skov, Mikael B.; Jochum, Elizabeth

Published in:
HRI 2021 - Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction

DOI (link to publication from Publisher):
10.1145/3434074.3447173

Publication date:
2021

Document Version
Version created as part of publication process; publisher's layout; not normally made publicly available

RODECA: A Canvas for Designing Robots

Sara Nielsen
Electronic Systems
Aalborg University, Denmark
snie@es.aau.dk

Rodrigo Ordoñez
Electronic Systems
Aalborg University, Denmark
rop@es.aau.dk

Karl Damkjær Hansen
Electronic Systems
Aalborg University, Denmark
kdh@es.aau.dk

Mikael B. Skov
Human-Centered Computing
Aalborg University, Denmark
dubois@cs.aau.dk

Elizabeth Jochum
Communication and Psychology
Aalborg University, Denmark
jochum@hum.aau.dk

ABSTRACT

Although there are existing frameworks for designing robots within the field of HRI, there is not yet a viable, all encompassing framework that bridges the gap between academic research, industry development and users in the design process. Through two online workshops and an individual company assignment, we identified industry needs, concerns and challenges relevant to the development of the Robot Design Canvas (RODECA). We present our preliminary work with seven industry partners and scientists from three research institutions. This research will inform the development of a versatile robot design framework that accounts for user experience early in the design process that can be validated through systematic investigation across research and industry applications. Such a tool would help bridge the gap between HRI research and commercial robot development.

CCS CONCEPTS

• **Human-centered computing → User centered design**.

KEYWORDS

Robot Design Canvas; Human-Robot Interaction; Design Process

ACM Reference Format:

Sara Nielsen, Rodrigo Ordoñez, Karl Damkjær Hansen, Mikael B. Skov, and Elizabeth Jochum. 2021. RODECA: A Canvas for Designing Robots. In *Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction (HRI '21 Companion), March 8–11, 2021, Boulder, CO, USA*. ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3434074.3447173

1 INTRODUCTION

There exist numerous evaluation methods within human-robot interaction (HRI) research that evaluate various aspects of interaction. These methods are frequently used after a robot design has been chosen, and thus offer little guidance for developers when it comes to designing robots. To address this gap, several researchers have called for a shared, standardized approach to designing and evaluating robots [2, 17]. A design strategy that focuses on user involvement, context-awareness and cross-pollination through mixed-methods would enable comparisons between studies and help bridge the gap between academic research and commercial robot development. Furthermore, industry increasingly prioritizes design frameworks that integrate UX best practices in the effort to develop commercially viable robots [13]. The importance of integrating UX best practices was raised in [9], who emphasized that positive user experiences do not naturally occur, but rather must be systematically designed and evaluated through the design process. According to [9], there is a lack of expertise in integrating and adapting UX best practices and defining UX goals in the context of HRI. Current design frameworks focus on specific aspects of design, for example robot behavior [6, 15], or on a participatory design approach [1, 5, 8] but stop short of encompassing the entire design process. These frameworks are conducive for academic study, but have yet to be validated in wider industrial contexts. What is needed is a versatile robot design framework that accounts for user experience early in the design process that can be validated through systematic investigation across research and industry applications. Such a tool would benefit and bridge the gap between HRI research, users and commercial development of robots, and should extend beyond the laboratories [3, 7, 9, 14, 20].

The present work summarizes initial steps in formulating the Robot Design Canvas (RODECA), which seeks to address the limitations of existing literature by providing a case-flexible, easy-to-use and industry-oriented framework for designing robots.

We draw inspiration from existing HRI design frameworks and offer some fresh perspectives on the topic from an industry perspective. The main objective of the two design frameworks that we first consider is designing robot behavior. Hoffman and Ju [6] propose a movement-centric design approach that positions movement as a primary design consideration for designing new robots. They relied on involvement and participation from animators and puppeteers during design iterations of the robot's behavior. Contrarily, the Outside-in Design process offered by Šabanović et al. [18] initially focused on the design process as a whole, but gradually narrows in on designing, implementing and evaluating non-verbal behavior. Both approaches make valuable contributions to thinking through robot design requirements from research-led perspectives. Šabanović [17] prioritize user involvement as one of the cornerstones of the Outside-in Design process, but choose the problem domain based on personal interests and previous experiences rather than targeting actual real-world problems experienced by users [18].

HRI '21 Companion, March 8–11, 2021, Boulder, CO, USA

ACM ISBN 978-1-4503-8290-8/21/03…$15.00
https://doi.org/10.1145/3434074.3447173

They also emphasize the need to create a common language within multidisciplinary teams, an aspect that is crucial for communicating successfully and minimizing potential misunderstandings [3, 19]. While both frameworks provide a good foundation for RODECA, our contribution is to create a versatile design framework that is informed by the needs of industry, specifically robotics startups as they develop and test products to bring to market, and that encompass the entire design process. RODECA aims to help bridge the gap between academic research, industry partners and end users.

One design framework that encompasses the entire design and development of a robot based on user inputs and Lean methodologies and that encourages multidisciplinary collaboration between researchers and industry partners is proposed by Tonkin et al. [13]. Their framework has a few shortcomings that we try to address in RODECA to make our framework more usable. For example, [13] specifically targets commercially available, humanoid social robots. Thus, we do not know whether it is appropriate for other types of robots, designing new robots or robots meant for one-way communication. That is, [13] assumed that the robot would engage in a direct, two-way interaction with people, i.e. that there would be a primary user interacting with the robot, without considering the *Incidentally Copresent Persons* (InCoPs) [16], which refer to bystanders and passerby who happen to be within the same vicinity as the robot. InCoPs will be considered in RODECA, as they likely make up most of the robot's encounters [12, 16]. Also, their methodology has only been applied by a highly experienced and well-resourced team [13], who did not work under extreme uncertainty, a characteristic of many (robotics) startups [11].

We report on lessons learned from collaborating with industry partners and researchers, and outline future work for developing a framework (RODECA) that is versatile and responsive to the needs of industry while also contributing more broadly to HRI research.

2 THE STUDY

Through two online workshops and an individual company assignment, we first identified whether there was interest in a user-centered robot design framework as well as key requirements based on industry needs and concerns (workshop 1). Secondly, the initial version of RODECA was evaluated by the industry partners based on a former, current or future robotics project, providing us with critical insights into potential challenges that RODECA users might encounter (individual company assignment). Lastly, we facilitated a workshop to explore those challenges in detail (workshop 2). Industry participants included UX Researchers, a Project Developer (PD), CTOs, CEOs, a CXO, Engineers, specifically four mobile robotics startups, an AI startup, and two UX consultancies. Participating researchers comprised two Assistant Professors (within Automation & Control and Cognitive & Developmental Robotics), a Technology Consultant and a Robotics Researcher.

2.1 Workshop 1: Identifying Needs

The long-term goals of RODECA were presented and discussed in an online workshop with seven industry partners and researchers from three institutions. To spark the discussion, we asked the following questions; 1) *what would it take for RODECA to be valuable and useful for your organization?*; 2) *what are your main concerns about such a canvas? and how might we address these?*; and 3) *what kind of expertise would be needed for a project at your company to follow the design process?*. The workshop was recorded after receiving verbal consent from all participants. Afterwards, it was transcribed and coded by one of the authors, and subsequently analyzed and discussed with co-authors to identify emerging themes pertaining to the need for; a) a common language to ensure a better workflow between, e.g. UX designers and developers, similar to the Outside-in Design process [18]; b) embracing diverse expertise within a project and knowing when and whom to include in the different stages, because designing robots are not a one-discipline endeavor [19]; c) best practices for each robot attribute and knowledge of how they affect one another; d) a flexible approach, where resource and platform limitations are easily incorporated; e) consideration of physical and behavioral attributes together; and f) designing robots with certain degrees of social awareness and compliance with social norms, also mentioned by industry partners in [4]. Participants were free to suggest other attributes to consider when designing robots. We synthesized the inputs and requirements from Workshop 1 into the initial version of RODECA, shown in Figure 1.

2.2 Individual Company Assignment

Industry partners were given an assignment in two parts based on RODECA (Figure 1). Part 1 asked them to apply RODECA based on a former, current or future robotics project in their company. They were encouraged to elaborate on the activities, processes and methods for each of the questions they were able to answer. For those questions they were unable to answer, participants were encouraged to elaborate on; 1) what prevented them from answering the question or carrying out the activity; 2) how they would overcome this challenge in the future; and 3) whether there were other questions or activities they expected to be relevant in relation to that particular topic. Part 2 prompted the participants to reflect on whether something; 1) is missing from RODECA, which should be added; 2) should be changed, rephrased or relocated; or 3) should be omitted or only used in special circumstances. The assignment was explained and distributed in a text file to allow respondents to provide their answers directly into the template.

A PD and a CXO from two robotics startups completed the assignment on behalf of their companies. Both companies clearly addressed an actual user or customer need as well as the robot's primary function (detecting breaches in fences and transporting goods in supermarkets). However, the user-perspective was consistently explained from the primary user's perspective, thus neglecting InCoPs who share the environment with the robot (e.g. in the supermarket scenario). Also, both companies acknowledged that they require expertise that they do not currently have in-house. According to the respondents, they require expertise from experienced practitioners and researchers within HRI, UX design/research, and in safety and risk assessment. Surprisingly, neither of the companies explicitly mentioned limitations of their robots, when asked. This omission raises questions about whether participants were unaware of limitations or deliberately chose not to disclose that information. However, the PD shared that they had resolved a privacy issue regarding the use of cameras by blurring people's faces. Respondents stated that they had not identified success criteria (i.e.

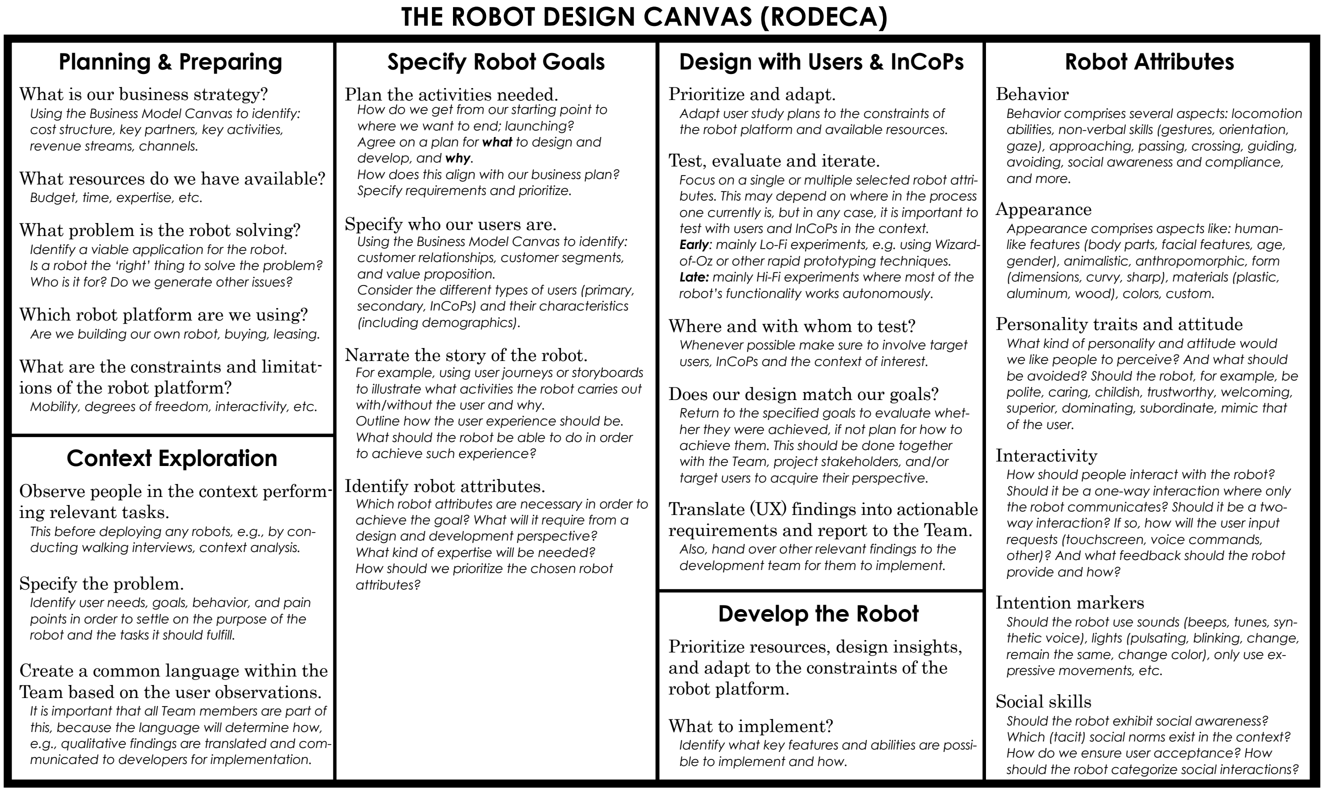

Figure 1: The initial version of the Robot Design Canvas (RODECA) comprises six interrelated activities: planning and preparing, context exploration, specify robot goals, designing with users, develop the robot, and robot attributes.

whether the design matches the goal) for their robots or considered how to evaluate such criteria. The stated reason was that because they are still in the early phases of their projects, it would be too early for such an evaluation.

To the question of how their teams formed a common language, the CXO replied that they use affinity diagrams, personas, user stories and user journeys reflecting insights gained from user studies. After returning the assignment, the CEO of this company shared that ideally, UX findings should be easily converted into how a robot senses the world through onboard cameras and other sensors. The PD stated that all internal communication was conducted in English. From these responses, it is clear there was a misunderstanding about what was meant by "creating a common language within the team", or else they already presumed good communication because the team comprised like-minded individuals. Thus, future versions of RODECA should make this aspect more clear.

2.3 Workshop 2: Identifying Challenges

From the individual company assignment, we identified several potential challenges with the initial version of RODECA that we wanted to dive further into together with all our project partners. We selected four challenges and allocated 10 minutes for plenum discussion via an online platform, and participants were encouraged to use the chat function to provide additional comments. This section presents the findings of Workshop 2.

Forming a common language: This challenge was selected based on the former replies. Thus, we asked the following follow up questions; 1) *in what other ways could this [forming a common language] be realized in the future?*; and 2) *in your opinion, what is your preferred format when receiving findings from qualitative user studies, if you were to implement features on a robot based on those findings?*. A CTO suggested drawing inspiration from how different terms are taught in educational contexts. Participants voiced several possible formats wherein findings from user studies could be shared within the team. For example, the CXO commented that: "*[...] we sometimes need to show videos or maybe even bring developers in the field to allow them to better empathize with users. But we also need ways to gather findings and 'save them for later' in the process.*". Participants also suggested producing infographics, figures, animations and user stories. The same participant commented in the chat: "*We like to summarize findings with user stories, since they combine the user need and functionality, so that both human and technical aspects are considered. User stories allow us to document and discuss findings at different stages of the development process.*". To this comment, the UX Analyst agreed and followed up with: "*I perfectly agree with [the other participant] regarding user stories. I always use [them] when explaining the insights, but I also like to organize workshops with the team to talk about the insights and try to answer all questions the team has.*". This response indicates how RODECA might leverage some methods commonly used by industry professionals working with UX. Thus, perhaps UX findings should not conform to the robot's sensing capabilities, but rather the other way around, so the robot design is informed by user studies. However, we are also aware that this might not be feasible for robots already designed.

The applicability of robot attributes: According to the PD's written response, a majority of the robot attributes were seemingly not applicable for robots that are not meant to engage in a two-way, "walk-up-and-use" interaction. This was surprising given the robot attributes were identified in Workshop 1 and validated in existing HRI literature. We therefore, asked; *what is your opinion about the applicability of the different robot attributes?* in plenum. Participants all claimed that the robot attributes listed in RODECA were relevant, thus they had a hard time answering this question. This could mean that the PD may not have discussed this topic within the company. Nevertheless, participants suggested that the relationship between the robot attributes be visualized on the canvas, together with information about how to prioritize these attributes with regards to context.

Using the Business Model Canvas: The PD and a CEO questioned whether the Business Model Canvas is relevant for robotics. Thus, the following questions were raised; 1) *what is your opinion about the use of the Business Model Canvas in relation to robotics projects?*; 2) *do you see the Business Model Canvas as a useful element to be included in RODECA?*; and 3) *what else could we do?*. Some participants claimed that of course we should consider the Business Model Canvas, or at least some other business strategy tool, and one participant wanted to know who exactly said the opposite. While a few participants reacted to this inquest by stating that it was not them whom had made such argument, others (incl. the respondents) remained silent. Returning to the questions, the UX Analyst mentioned that although they would always start a project together with a business developer, it may not be essential for all team members to participate in the development of the business model and strategy. From this, we learned that having a business plan is important, because it gives structure to a project while allowing the company to position themselves in the market. However, there was no consensus about which business strategy tool was best, which thus warrants further investigation.

Identifying success criteria: Respondents indicated that it was too early to identify and settle upon success criteria for their robots. Thus, we asked the following; 1) *how do or would you identify success criteria for your robotics application?*; and 2) *how do or would you evaluate whether they were met?*. Participants offered vague descriptions of success criteria, which we divided into three types of answers reflecting; 1) a robot-perspective, where success criteria are defined as a smooth and predictable interaction, where people would not feel threatened, and that the robot is accepted socially; and 2) a user/business-perspective, where success criteria are based on user insights and/or settled with business clients, while not focusing on sales alone. These two perspectives were shared by the industry partners, while two researchers argued for 3) a methodological-perspective, where success criteria are not defined at the outset but evolves continually through the use of RODECA.

Our findings indicate that some of the disagreements may have been a symptom of the industry partners not having discussed the assignment with their colleagues, as encouraged. That is, when discussing the use of the Business Model Canvas and the applicability of the suggested robot attributes, some participants became defensive and contradicted what they had replied in the assignment. These differences also highlight the need for establishing a common language. Additionally, we speculate that our findings might be different had we chosen to work with more mature robotics companies that already have several products on the market, which we plan to do in the future.

3 CONCLUSION AND FUTURE WORK

This paper presented our preliminary work regarding the development of RODECA, which involved seven industry partners and researchers from three research institutions. Through two structured, online workshops and an individual company assignment, we identified industry's needs and concerns, and discussed challenges regarding a robot design canvas. In particular, we saw a need for a framework that can:

- Provide a structured way of designing and developing robots that solve problems experienced by real people (both users and InCoPs) in the actual context.
- Strengthen multidisciplinary collaboration, while mitigating potential miscommunication and expectation gaps between academia, industry and users, as well as across disciplines through a common, shared language.
- Facilitate exploration and comparisons of (new) market and application opportunities.
- Identify competencies both in-house and those missing.

Going forward, these are the needs that we will further explore and specify for RODECA. However, as authors from diverse background of human-computer interaction, engineering, psychology, communication and arts, we acknowledge that we do not possess high-level expertise in all aspects suggested in RODECA, shown in Figure 1. Thus, we invite both HRI researchers and industry professionals to take part in the discussion in order to advance the field of HRI as well as increase business potential. Likewise, we acknowledge that RODECA is still in development, hence it will be subjected to revisions both in terms of scope, content and layout. This will be achieved through continuous collaboration and cross-pollination by involving potential users, researchers and industry representatives throughout the design and development of the framework. The idea is to incrementally develop, implement and evaluate RODECA through repeated iterations, and the philosophy is that learning comes from both the development and use of RODECA. Further, we draw inspiration from the Business Model Canvas [10], the Lean methodology [11], which were adopted in [13], and from the field of HRI, UX and HCI.

ACKNOWLEDGMENTS

This research was funded by the Ministry of Higher Education and Science (grant nr. 8101-00015B) through the RoboCluster initiative, now called Odense Robotics. We thank all of our project partners for sharing their experiences and providing invaluable feedback. We look forward to continue the collaboration.

REFERENCES

[1] Shiri Azenkot, Catherine Feng, and Maya Cakmak. 2016. Enabling Building Service Robots to Guide Blind People - A Participatory Design Approach. In *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, Christchurch, New Zealand, 3–10. https://doi.org/10.1109/HRI.2016.7451727

[2] Christoph Bartneck, Tony Belpaeime, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, and Selma Šabanović. 2020. *Human-Robot Interaction - An Introduction*. Cambridge University Press. https://www.human-robot-interaction.org

[3] Paul Baxter, James Kennedy, Emmanuel Senft, Séverin Lemaignan, and Tony Belpaeme. 2016. From Characterising Three Years of HRI to Methodology and Reporting Recommendations. In *The Eleventh ACM/IEEE International Conference on Human Robot Interaction*. IEEE Press, Christchurch, New Zealand, 319–398. https://doi.org/10.5555/2906831.2906897

[4] Bohkyung Chun and Heather Knight. 2020. The Robot Makers: An Ethnography of Anthropomorphism at a Robotics Company. In *Transactions on Human-Robot Interaction*, Vol. 9 (3). Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3377343

[5] Aduén Darriba Frederiks, Johanna Renny Octavia, Cesar Vandevelde, and Jelle Saldien. 2019. Towards participatory Design of Social Robots. In *Human-Computer Interaction – INTERACT 2019. INTERACT 2019. Lecture Notes in Computer Science*, David Lamas, Fernando Loizides, Lennart Nacke, Helen Petrie, Marco Winckler, and Panayiotis Zaphiris (Eds.), Vol. 11747. Springer, Cham, 527–535. https://doi.org/10.1007/978-3-030-29384-0_32

[6] Guy Hoffman and Wendy Ju. 2014. Designing Robots with Movement in Mind. In *Journal of Human-Robot Interaction*, Vol. 3 (1). Journal of Human-Robot Interaction Steering Committee, 91–122. https://doi.org/10.5898/JHRI.3.1.Hoffman

[7] Malte Jung and Pamela Hinds. 2018. Robots in the Wild: A Time for More Robust Theories of Human-Robot Interaction. In *Journal of Human-Robot Interaction*, Vol. 7 (1). Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3208975

[8] Hee Rin Lee, Selma Šabanović, Wan-Ling Chang, Shinichi Nagata, Jen Piatt, Casey Bennett, and David Hakken. 2017. Steps Toward Participatory Design of Social Robots: Mutual Learning with Older Adults with Depression. In *Proceedings of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*. Association for Computing Machinery, Vienna, Austria, 244–253. https://doi.org/10.1145/2909824.3020237

[9] Jessica Lindblom and Rebecca Andreasson. 2016. Current challenges for UX evaluation of human-robot interaction. In *Advances in Ergonomics of Manufacturing: Managing the Enterprise of the Future*, Christopher Schlick and Stefan Trzcieliński (Eds.), Vol. 490. Springer, Cham, 267–277. https://doi.org/10.1007/978-3-319-41697-7_24

[10] Alexander Osterwalder. 2004. *The Business Model Ontology - A Proposition in a Design Science Approach*. Ph.D. Dissertation. Universite de Lausanne.

[11] Eric Ries. 2017. *The Lean Startup - How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses* (first international edition ed.). Currency, Crown Publishing Group, New York, NY, USA.

[12] Silvia Rossi, Alessandra Rossi, and Kerstin Dautenhahn. 2020. The Secret Life of Robots: Perspectives and Challenges for Robot's Behaviors During Non-interactive Tasks. In *International Journal of Social Robotics*, Vol. 12. Springer, 1265–1278. https://doi.org/10.1007/s12369-020-00650-z

[13] Meg Tonkin, Jonathan Vitale, Sarita Herse, Mary-Anne Williams, William Judge, and Xun Wang. 2018. Design Methodology for the UX of HRI: A Field Study of a Commercial Social Robot at an Airport. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. Association for Computing Machinery, Chicago, IL, USA, 407–415. https://doi.org/10.1145/3171221.3171270

[14] Silvia Tulli, Diego Agustin Ambrossio, Amro Najjar, and Francisco Javier Rodríguez Lera. 2019. Great Expectations & Aborted Business Initiatives: The Paradox of Social Robot Between Research and Industry. In *BNAIC/BENELEARN 2019*. 1–10.

[15] Gentiane Venture and Dana Kulić. 2019. Robot Expressive Motions: A Survey of Generation and Evaluation Methods. In *Transactions on Human-Robot Interaction*, Vol. 8 (4). Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3344286

[16] Astrid Rosenthal von der Puetten, David Sirkin, Anna Abrams, and Laura Platte. 2020. The Forgotten in HRI: Incidental Encounters with Robots in Public Spaces. In *Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*. Association for Computing Machinery, Cambridge, United Kingdom, 656–657. https://doi.org/10.1145/3371382.3374852

[17] Selma Šabanović. 2010. Robots in society, society in robots: Mutual shaping of society and technology as a framework for social robot design. In *International Journal of Social Robotics*, Vol. 2. Springer, 439–450. https://doi.org/10.1007/s12369-010-0066-7

[18] Selma Šabanović, Eric Meisner, Linnda R. Caporael, Volkan Isler, and Jeff Trinkle. 2009. 'Outside-in' Design for Interdisciplinary HRI Research. In *AAAI Spring Symposium: Experimental Design for Real-World Systems*. Association for the Advancement of Artificial Intelligence, Stanford, California, USA, 41–48.

[19] Selma Šabanović, Marek P. Michalowski, and Linnda R. Caporael. 2007. Making Friends: Building Social Robots Through Interdisciplinary Collaboration. In *Multidisciplinary Collaboration for Socially Assistive Robotics, Papers from the 2007 AAAI Spring Symposium*. Stanford, California, USA, 71–77.

[20] Selma Šabanović, Marek P. Michalowski, and Reid Simmons. 2006. Robots in the Wild: Observing Human-Robot Social Interaction Outside the Lab. In *9th IEEE International Workshop on Advanced Motion Control, 2006*. IEEE, Istanbul, Turkey, 576–581. https://doi.org/10.1109/AMC.2006.1631758