Co-designing a Tangible Communication Device to Enrich Communication over Distance

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Abstract

The initial phase of innovative product design is marked by uncertainty and complexity. This paper examines the use of participatory workshops to navigate this phase within the ToCaro research project. The project aims to develop tactile and multisensory interfaces for remote communication to mitigate feelings of loneliness by promoting a sense of physical proximity. Fourteen co-design workshops were conducted with senior participants (age $\geq$ 65) to examine their communication behaviors, identify latent needs and evaluate physical sensations elicited by various materials and forms of interaction. The workshops included semi-structured interviews, sensory perception tests, interaction concept evaluations, and "quick-and-dirty" prototyping. This paper outlines the facilitators' experiences, the challenges, and learnings. Results indicate that while participants exhibited varied levels of engagement, those with a perceived need for new communication devices contributed effectively to the creative process.

CCS Concepts

• **Human-centered computing** → **Haptic devices**; **Participatory design**; **Interface design prototyping**; • **Social and professional topics** → *Seniors.*

Keywords

Tangible Devices, Participatory Design, Co-creation Workshops, Elderly Participants, Aging Population, Design Process and Methods, Prototyping, Human Computer Interaction, Lessons Learned

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1 Motivation and Objectives

The COVID-19 pandemic has highlighted the importance of social and physical interaction for personal quality of life. While video conferencing and virtual encounters bridged gaps, it became clear that "something was missing" [5]. Physical presence appeals to other senses and supports an "embodied experience" facilitating implicit, non-verbal communication and the transmission of emotions [19]. Research shows that the sense of touch has the potential to elicit, influence, and display emotions, and it is an important communication channel, potentially capable of alleviating feelings of social isolation [3, 8, 12].

1.1 The ToCaro Research Project on Emotion and Tactile Interfaces in Remote Communication

The ToCaro project investigates the potential for technology and tangible interaction to convey physical proximity in remote communication. The objective is to enable interaction between two or more individuals using ToCaro devices, which have a textile surface equipped with sensors to detect touch and pressure. These interactions will be mediated through "artificial muscles" (dielectric elastomer actuators [9]; HASEL actuators [11]) and actuators that transmit signals. e.g. light, sound and heat. The device must be capable of modifying its shape and surface area with centimeter precision and achieving large displacements using hydraulic or pneumatic elements. This capability is intended to enrich remote communication on sensory and emotional levels, thereby alleviating feelings of social isolation caused, for example, by pandemics, physical distance, or health constraints. The design and functionality of the device have not yet been precisely defined and are in the preliminary stages of development.

1.2 User Involvement in the Early Development Phase

The ToCaro project follows a participatory approach actively involving potential end-users and stakeholders in the initial stages of problem definition and ideation. The aim is to "make the decision process richer and more varied [. . .]" [1, p. 121] by collecting different perspectives, experiences and desires, and thus achieve "an impact with positive, long-range consequences" [14, p. 9]. At the heart of the Scandinavian tradition of participatory design, which emerged in the 1970s [2], is the idea that "[. . .] the people destined to use the system play a critical role in designing it" [16, p. 11].

The initial project phase of ToCaro focuses on problem definition and the exploration of preliminary ideas and concepts for elderly people (age ≥ 65) - a social group susceptible to loneliness in Germany, as longitudinal data on long-term trends indicate [15]. To limit the Gray Digital Divide [10], which states that elderly people are less able to access new technologies, we are involving the target group by exploring their needs and feelings in "design partnerships" [17, p. 164] following the participatory approach [18]. This aims to enable developers and designers to empathize with potential users and create tacit knowledge, which is difficult to articulate verbally [13].

This paper reflects on a co-design workshop format the ToCaro project has employed, along with the challenges, limitations, and lessons learned from the practical experiences with the target group.

2 A Reflection on a Co-design Workshop With Elderly People

2.1 Overview

Fourteen co-design workshops were held to explore the diverse life experiences of potential users and to experimentally investigate emotional and physical perceptions of materials and haptic interactions. The participants' expertise was utilized to define relevant target groups and usage scenarios for the ToCaro device.

Participants were recruited through community centers (2), a newspaper article (10) and personal inquiries (2). The 14 participants, aged 65–81, included 11 women and 3 men with diverse professional backgrounds, including engineering, art therapy, sales, teaching, psychology, and social pedagogy. None had severe cognitive or motor impairments. They stated a medium level of technology affinity (M=2.9; SD=0.38) and slightly negative attitudes towards technology (M=3.5; SD=0.70) compared to positive attitudes (M=2.5; SD=0.72), according to the "Affinity for Technology-Electronic Devices" (TA-EG) questionnaire, using scales from 1 - 5 [6]. The 90-minute individual workshops were divided into three parts: 1) semi-structured interviews on communication behaviors and related needs; 2) testing stations for haptic perception; and 3)"quick-and-dirty" prototyping of an ideal ToCaro device. The following sections present the workshops' hands-on exercises and key findings, highlighting the challenges and limitations of the methods and tools employed.

2.2 Hands-on Part I: Touch & Feel and Haptic Interaction Testing

2.2.1 Objectives and Procedure. Hands-on Part I is based on peoples' ability to associate tactile stimuli with qualitative adjectives [12]. It thus focused on participants' physical perceptions and emotional sensations in relation to different materials and interactions. This task was designed to explore our target group's subjective sensory associations, linked to attributes, memories, and judgments.

At the Touch & Feel Station, participants evaluated four materials with different tactile and visual properties (birch plywood, translucent silicone sheet, cotton fabric, and tinplate steel) that are representative of potential material types for ToCaro devices. Participants explored the materials in both blind and unblinded conditions. At the Haptic Interaction Station (see Fig. 1), interactive prototypes were designed with basic technologies - e.g. a thermoelectric cooler and a telephone vibration motor - to simulate five potential interaction scenarios of the ToCaro device. These scenarios involved (body) heat transfer, vibration, touch (pressure or counter-pressure), motion (wiggle, nudge, transfer of movement at a distance), and playful interaction using a balloon-based tactile dot matrix. For both stations, participants were asked to state their associations and to rate their subjective perception using a set of bipolar scales with pairs of opposing terms, e.g. "attractive"/"repulsive", "valuable"/"inferior", "exciting"/"boring".

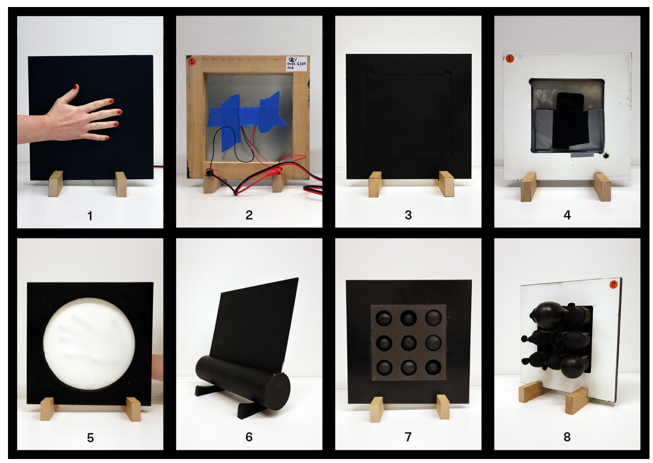

Figure 1: Interaction toolkit to test 1-2: (body) heat, 3-4: vibration, 5: touch, 6: motion, 7-8: playful interaction

2.2.2 Results. In the Touch & Feel Test, on average, all materials were perceived as rather "familiar," with cotton being the most "comfortable," "warm" and "soft," in contrast to the "technical," "cold" and "hard" perceptions of tinplate steel. No considerable differences were found between the blind and unblinded conditions. However, there is a wide range of values for the different materials and opposing connotations, suggesting that perceptions vary considerably. The only consensus among the participants was that steel is perceived as hard and silicone as soft.

In the Haptic Interaction Test, the warm interaction item (1-2) was perceived as "pleasant," "soothing," and "familiar" (see Fig. 2, orange graph). Most of the participants associated these sensations with soft items such as "blanket," "soft/fluffy," or "warm garment," and often with human qualities like "handshake" or "warmth of the body." The touch element (pressure and counter-pressure) (5), involving interaction with another (invisible) hand, was rated similarly, tending to be "attractive," "pleasant" and "soothing," but also "interesting," and "special" (see Fig. 2, dark green graph). In contrast, the vibration item (3-4) was perceived as mainly “technical,” rather “repulsive,” “unpleasant,” and “disturbing” (see Fig. 2, blue graph). Associations to this vibration were linked to physical complaints and unpleasant stimulation current in physiotherapy. The results

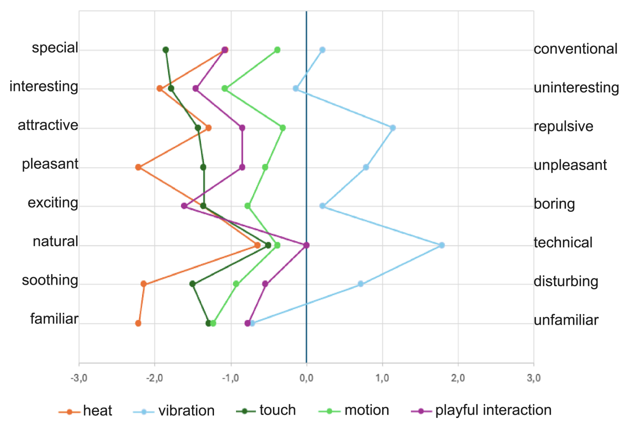

Figure 2: Interaction concepts evaluation results

are relevant to ToCaro's material selection. They indicate that incorporating warm elements or materials transferring body heat can evoke a pleasant, human sense of connectedness, potentially enhancing user experience. Contrary to our expectations, the touch object was perceived as pleasant rather than eerie. This result is valuable for our research on avoidance of eeriness in emotional tactile communication. The perception of vibration will be further investigated since studies show that vibration stimuli can evoke various emotions, including happiness and alertness, depending on amplitude, frequency, and its combination with other stimuli such as heat [8, 12].

2.2.3 Challenges and Limitations. Participant observation revealed frequent uncertainties in assigning material- and interaction-related perceptions to the opposite connotations on the scales. We assume that this often led to marking in the middle or filling in the scales arbitrarily. For both the Touch & Feel Tests as well as for the Haptic Interaction Tests, the sensory perceptions of the participants varied considerably. Therefore, given the limited sample size of fourteen participants, the study provides preliminary findings that suggest trends that require further investigation. In the blinded condition, participants often guessed the materials rather than relying solely on haptic perception, which presented a challenge in distinguishing haptic feedback from other sensory cues.

2.3 Hands-on Part II: “Quick and Dirty” Prototyping

2.3.1 Objectives and Procedure. In the final part of the workshop participants created low-tech prototypes using various materials within a limited time frame. This method aimed to rapidly transform ideas into physical models and facilitate the identification of unanticipated [4] or latent user needs [14], application contexts, and target groups. This approach aligns with the principle of “thinking through prototyping” [7], which encourages the hands-on exploration of ideas.

Participants were asked to envision themselves on a futuristic planet with limitless technology and to design a new device that enables remote communication and the exchange of emotions and touch with a loved one, without using a screen. They were asked to consider several aspects of the device's design, including features, appearance, and, handling. Participants received materials such as cardboard, clay, textiles, composite materials, and tools such as glue, scissors, and needles. Finally, five key questions had to be answered about the device's functions, context of use, handling, emotions conveyed, and methods of interaction.

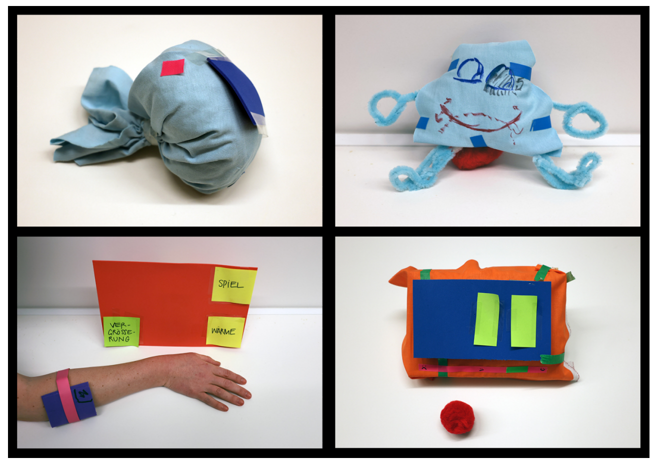

Figure 3: Selection of "Quick-and-Dirty" prototypes created by the participants

2.3.2 Results. The prototypes are designed in a way to facilitate communication between seniors, including nursing home residents, and their family, friends, and neighbors. They are meant to accommodate seniors with cognitive or motor impairments, such as dementia or osteoarthritis, and support independent and inclusive interaction with senior-friendly controls, such as large buttons and color-coded fields. Voice control and tactile feedback, such as vibrating or shaking of the device for incoming calls, were suggested for seniors with sensory impairments. Evaluations indicated a desire to convey emotional closeness over distance through heartbeat, hand warmth, and facial expression, activating sensory responses and achieving mood-enhancing or calming effects. Some participants added an 'I'm thinking of you' feature to provide a subtle communication option for seniors who may not have the cognitive capacity to actively participate in the lives and daily activities of others. Other features included safety and support functions such as appointment and medication reminders, emergency buttons, and playful interactions. Participants often envisioned their devices as soft objects with textile surfaces that were large for easy handling or that could be worn as accessories. Based on the identified target groups and usage contexts, 7 personas were created and used in a subsequent workshop with team members from the design and technology departments to further define the use case and features of the ToCaro device.

2.3.3 Challenges and Limitations. The prototyping task was received with varying degrees of enthusiasm and engagement. Half of participants approached the task without hesitation, expressing their ideas, needs, and desires bringing up issues and questions that might not have come up in a mere verbal discussion. However, others felt overwhelmed by the practical nature of the activity and expressed a strong aversion to the creative technique, preferring verbal or written notes instead. Despite clear instructions that aesthetic perfection was not the goal, many cited a lack of creativity or skill as reasons for their reluctance. Additionally, participants often did not perceive a need for a completely novel tool, complicating the ideation process. In most cases, the supportive (guiding) questions to facilitate entry into the creative process proved to be helpful to encourage idea generation. However, translating these needs into a tangible technological object remained challenging.

3 Lessons Learned and Discussion

In the initial phase of the project, we aimed to generate new, tangible communication ideas in co-creation with elderly participants. This posed several challenges due to the novel nature of the device and its need to address latent, often unconscious needs, complicating requirement elicitation and conceptualization. Furthermore, in particular our target group of elderly people may have found it difficult to translate their needs into concepts for a digital device, as they have less experience with new technologies and appear to be less open to technological innovation [10] (see TA-EG results in 2.1). An additional challenge was that the emotional and physical qualities associated with materials and interactions in different contexts are still underexplored [12] in research.

The generative co-design activity described in section 2.3 faced challenges due to participant disengagement. While this task yielded inspiring outcomes, methodological improvements are needed in participant recruitment, tools, materials and workshop implementation. Involving participants with relevant expertise or interests, such as those in the creative field, could have improved interactions and outcomes. Nevertheless, we consider participant diversity as a key strength of the participatory design, emphasizing its importance in reflecting diverse life realities to enrich the outcome. A clearer workshop description emphasizing the workshops practical aspects might have helped participants better assess their fit in the study. The provided tools and materials also have an impact on participant motivation and results. The materials did not appeal to all participants, indicating a need for more neutral options. Alternatively, a pre-built toolkit with modular components could encourage broader and more diverse engagement. It remains a challenge to provide materials that stimulate creativity, without biasing the design direction or discouraging participants. Emphasizing that prototypes do not have to meet aesthetic standards has not always been effective. Showing examples of simple "quick-and-dirty" prototypes could have reduced fear of failure. Individual sessions provided an intimate space for sharing experiences. However, group sessions could have fostered mutual inspiration and support, as described in [4], leading to more dynamic and collaborative prototyping. Group work might have also reduced stress as the individual tasks of the workshops were very demanding on the participants' attention. Therefore, it is strongly recommended to limit the duration to 90 minutes and to include regular breaks. The unfamiliarity with digital technology issues was a challenge for all participants. When working with elderly people, it is particularly important to clearly and comprehensibly communicate the workshop's structure and objectives.

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References

[1] Nigel Cross. 1972. Design participation: proceedings of the Design Research Society's conference, Manchester, September 1971. (1972).

[2] Pelle Ehn. 2017. Scandinavian design: On participation and skill. In *Participatory design*. CRC Press, 41–77.

[3] Mohamad A. Eid and Hussein Al Osman. 2016. Affective Haptics: Current Research and Future Directions. *IEEE Access* 4 (2016), 26–40. https://doi.org/10.1109/ACCESS.2015.2497316

[4] Gabriela Gómez and Ricardo Lopez-Leon. 2019. Impossible Design: fostering creativity by quick and dirty prototyping. In *Insider Knowledge - Proceedings of the Design Research Society Learn X Design Conference, 2019*. Design Research Society. https://doi.org/10.21606/learnxdesign.2019.14026

[5] Dora Hopf, Ekaterina Schneider, Monika Eckstein, Corina Aguilar-Raab, and Beate Ditzen. 2021. COVID- und Social Distancing bezogene Sorgen und ihre Beziehung zu psychischer und körperlicher Erkrankung. *PPmP - Psychotherapie · Psychosomatik · Medizinische Psychologie* 71, 02 (Feb. 2021), 57–60. https://doi.org/10.1055/a-1347-7393

[6] Katja Karrer, Charlotte Glaser, Caroline Clemens, and Carmen Bruder. 2009. Technikaffinität erfassen–der Fragebogen TA-EG. *Der Mensch im Mittelpunkt technischer Systeme* 8, 2009 (2009), 196–201. Publisher: Düsseldorf.

[7] Scott R. Klemmer, Björn Hartmann, and Leila Takayama. 2006. How bodies matter: five themes for interaction design. In *Proceedings of the 6th conference on Designing Interactive systems*. ACM, University Park PA USA, 140–149. https://doi.org/10.1145/1142405.1142429

[8] Shaun Alexander Macdonald, Frank Pollick, and Stephen Anthony Brewster. 2022. The Impact of Thermal Cues on Affective Responses to Emotionally Resonant Vibrations. In *Proceedings of the 2022 International Conference on Multimodal Interaction*. ACM, Bengaluru India, 259–269. https://doi.org/10.1145/3536221.3556572

[9] Marc Matysek, Peter Lotz, Klaus Flittner, and Helmut F. Schlaak. 2010. Vibrotactile display for mobile applications based on dielectric elastomer stack actuators, Yoseph Bar-Cohen (Ed.). San Diego, California, USA, 76420D. https://doi.org/10.1117/12.847358

[10] Farooq Mubarak and Reima Suomi. 2022. Elderly Forgotten? Digital Exclusion in the Information Age and the Rising Grey Digital Divide. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing* 59 (Jan. 2022), 004695802210962. https://doi.org/10.1177/00469580221096272

[11] Philipp Rothemund, Nicholas Kellaris, Shane K. Mitchell, Eric Acome, and Christoph Keplinger. 2021. HASEL Artificial Muscles for a New Generation of Lifelike Robots—Recent Progress and Future Opportunities. *Advanced Materials* 33, 19 (May 2021), 2003375. https://doi.org/10.1002/adma.202003375

[12] Katri Salminen, Veikko Surakka, Jani Lylykangas, Jukka Raisamo, Rami Saarinen, Roope Raisamo, Jussi Rantala, and Grigori Evreinov. 2008. Emotional and behavioral responses to haptic stimulation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, Florence Italy, 1555–1562. https://doi.org/10.1145/1357054.1357298

[13] Elizabeth B-N Sanders. 2002. From user-centered to participatory design approaches. In *Design and the social sciences*. CRC Press, 18–25.

[14] Elizabeth B.-N. Sanders and Pieter Jan Stappers. 2008. Co-creation and the new landscapes of design. *CoDesign* 4, 1 (March 2008), 5–18. https://doi.org/10.1080/15710880701875068

[15] Janosch Schobin, Céline Arriagada, and Martin Gibson-Kunze. 2024. *Einsamkeitsbarometer 2024*. Technical Report. Berlin. https://www.bmfsfj.de/resource/blob/240528/5a00706c4e1d60528b4fed062e9debcc/einsamkeitsbarometer-2024-data.pdf

[16] Douglas Schuler and Aki Namioka (Eds.). 1993. *Participatory design: principles and practices*. Erlbaum, Hillsdale, NJ.
[17] Clay Spinuzzi. 2005. The methodology of participatory design. *Technical communication* 52, 2 (2005), 163–174. Society for Technical Communication.
[18] John Vines, Gary Pritchard, Peter Wright, Patrick Olivier, and Katie Brittain. 2015. An Age-Old Problem: Examining the Discourses of Ageing in HCI and Strategies for Future Research. *ACM Transactions on Computer-Human Interaction* 22, 1 (March 2015), 1–27. https://doi.org/10.1145/2696867
[19] Lucy Yardley. 1999. Understanding Embodied Experience: Beyond Mind-Body Dualism in Health Research. In *Qualitative Health Psychology: Theories and Methods*. 31–46.

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