Designing Robots for Aging: Wisdom as a Critical Lens

HEE RIN LEE*, Media and Information, Michigan State University
LAUREL D. RIEK†, Computer Science and Engineering, UC San Diego

Although the concept of wisdom is ancient, empirical research on it has only recently received attention in gerontology. This coincides with a critical turn away from a deficit model of aging, viewing aging as a series of losses, toward a more supportive and developmental model. This paper draws on this recent work to consider how wisdom can be a critical lens for HRI researchers and other technology design researchers to pay more attention to the coping strategies that older adults accumulated throughout their lives. We engaged in a six-month collaborative design process with community-dwelling older adults. The contributions of this paper are twofold. First, we found that wisdom as a design concept helps researchers to critically examine how they define knowledge. Wisdom as an accumulation of experiential knowledge of older adults helps researchers rethink the definition of knowledge—valuing computational and technological knowledge—in the field of HRI. Second, wisdom leads researchers to the past experiences of older adults. Although past experiences are as important as current experiences, they are not actively considered in robot design studies for older adults. We hope wisdom as a critical lens could allow researchers to integrate the invisible aspects of older adults' aging experiences into the existing practices of designing robots for aging users.

1 INTRODUCTION

> *An older adult couple are drinking tea together at home. Suddenly, the woman disappears and a semi-humanoid Care-o-Bot appears. The robot delivers tea to the man, but he appears lonely and sad without his partner. The robot then brings him a blood pressure monitor to measure his vital signs. In another scene, the robot finds that the man has fallen. Upon recognizing the fall, the robot moves to his side and connects him to emergency staff in a service center.* (see Fig 1)

This is a promotional video for the early version of Care-o-Bot [1], an assistive robot renowned within HRI. The video depicts the robot as a solution for older adults' potential problems (e.g., social isolation, physical decline, and emergency situations). These representations of older adults convey a deficit model of aging: aging as a series of losses. This model has been widely criticized in both the gerontology and the technology design communities, and instead researchers are shifting to embrace social, supportive, and developmental models [26, 32, 35, 68, 73].

As a part of this shift toward adopting different models, an increasing number of gerontologists have investigated older adults' accrued wisdom as an alternative research direction that avoids a deficit model of aging [7]. Researchers found that wisdom is experiential knowledge of how to deal with the uncertainties of the world through understanding oneself (self-understanding), being open to one's own limitations (openness), and developing a sense of humor (sense of humor) [5, 7, 28, 62]. Considering wisdom as a coping mechanism for dealing with life's uncertainties, studies found wisdom to be particularly important for emotional well-being of older adults, as well as for their physical health, their quality of life, and their quality of relationships [28, 42, 51, 57, 75]. These studies commonly utilize this concept of wisdom as an alternative frame to the deficit model of aging—focusing on the experiential knowledge older adults gain through aging, rather than the capabilities they lose through aging.

Several technology design studies mention wisdom as a potential design theme [46, 49]; however, to our knowledge, few HRI researchers have delved into wisdom as a key consideration in their robot design research. This paper addresses how older adults use wisdom as a coping mechanism

Authors' addresses: Hee Rin Lee, heerin@msu.edu, Media and Information, Michigan State University, East Lansing, MI; Laurel D. Riek, lriek@eng.ucsd.edu, Computer Science and Engineering, UC San Diego, San Diego, CA.

Fig. 1. A promo video of Care-O-Bot: In the first two scenes, an older adult is depicted as a person who is socially isolated after his partner passes away. In the last two scenes, an older adult is described as a person who falls due to his limited physical capabilities and is saved by a robot. In this video, aging is primarily portrayed as negative experience—being lonely and loosing capabilities.

for dealing with health issues as part of the uncertainty in their lives, while also exploring how they want that wisdom incorporated into robot design.

In this paper, we bridge the gap between wisdom research from the fields of gerontology and assistive robotics research from HRI. We propose how wisdom emerged as a promising design concept, and explore alternative robot designs for aging through our collaborative research process with older adults. We conducted a six-month long collaborative design process with community-dwelling older adults, which included a series of interviews and collaborative design activities.

The contributions of this paper are twofold. First, wisdom as a design concept helps us more holistically represent older adults when researching robots for aging. As wisdom includes socio-cultural experiences of older adults from their past till now, we were able to design robots that understand older adults more than simply as people who need help. For example, an older adult with a mild memory issue can choose what they want to remember, such as the names of important people who makes them who they are now, rather than a robot that simply repeatedly tests memory functions via drill and practice tasks. Second, wisdom as a design concept enables us to create alternative robots that prioritize the autonomy of older adults, such as a self-affirmation robot that reflects their wisdom and abilities.

2 BACKGROUND

2.1 Wisdom as a critical lens in psychology/gerontology

Researchers in psychology define wisdom as the intelligence that one might obtain as a result of aging [5, 6, 20, 62, 64, 71]. In contrast to factual knowledge (e.g., memorizing facts), wisdom is considered experiential and procedural knowledge (e.g., having strategies to manage difficult life situations such as a suicidal impulse) [64].

Researchers have explored wisdom through implicit and explicit theories [63]. In studies on implicit theories, researchers examined how laypeople conceptualize wisdom to uncover its meaning and important characteristics [20, 71]. In explicit studies, researchers empirically measured the wisdom of older adults in terms of personality characteristics [4], or their performance on uncertain life tasks (e.g., suicide impulse [6], family vs. career choice [64]). While there remains no firm consensus around the definition of wisdom, both types of studies agreed that wisdom is experiential knowledge that enables people to deal with difficult life questions. Researchers across studies maintained that wisdom is a multifaceted concept [7, 28].

This paper particularly pays attention to how wisdom research has provided a critical lens that engenders epistemological questions to the psychology community —asking what types of knowledge have been devalued within psychology [3]. In contrast to most other studies in psychology, wisdom research acknowledges that complex sociocultural contexts can be crucial factors [63, 71] (e.g., wisdom has different meanings depending on cultures, subcultures, or even from person to person [71]) . Due to its complexity and multiplicity, wisdom is widely considered intractable knowledge that is difficult to be computed by standardized measurements [63]. Wisdom exemplifies a type of knowledge that goes beyond the limitations of what traditional approaches can reveal within lab-based tasks [3].

In this paper, we adopt the concept of wisdom within the context of robot design for aging. As wisdom research initiated from the fields of gerontology and psychology, few researchers have qualitatively investigated wisdom and have incorporated the individuality of each older adult into their studies. We describe wisdom as experiential knowledge of how to cope with life issues. This is a concept that emerged from our deliberate choice to avoid stereotyped representations of older adults. We found that wisdom as a conceptual tool could help other HRI researchers to understand the strengths and capabilities of older adults — aspects which, due to a deficit model of aging, are less discussed.

2.2 Representations of older adults in assistive robotics and assistive technologies

The fast-growing population of older adults has inspired HRI and other technology design researchers to investigate assistive robots [9, 29, 30, 52, 53, 65, 67, 68, 72]. Initially, many researchers focused on the decline of older adults, and broadly assumed that these individuals would be unable to perform activities of daily living (ADLs) as they get older [24]. Thus, most robots focused on compensating for potential human decline, reflecting a deficit model of aging [9, 54]. For example, one group of robots designed to assist older adults can provide physical assistance like fetching and carrying objects, mobility assistance, and carrying people (e.g., Care-O-Bot, Riman). Another group of robots provides psychosocial support like social companionship or telepresence, which aim to prevent the social isolation of older adults (e.g., Paro, Hasbro Cat, IRobiQ). Assistive robots also provide monitoring functions that notify healthcare staff or caregivers of older adults' emergency situations (e.g., Hecter, Pearl, Wakamaru). Many of the robots that provide companionship have a zoomorphic appearance, such as Paro, while others have humanoid forms.

Recently, HRI and other assistive technology design researchers have questioned the framing of older adults as people with problems, and have started exploring alternative ways to avoid ageism in technology design [10, 21, 26, 32, 43, 68, 73]. Several researchers have noted that older adults dislike being represented as a group of people with cognitive and physical declines within the context of assistive robotics and technologies [33, 35, 44]. The gap between their self-perception of the aging experience and the stereotyped images of older adults in robot design research decreases their adoption of assistive robots [44]. To bridge the gap, HRI researchers have adopted collaborative and participatory design methodologies as a way to include the perspective of older adults [15, 36, 56, 59] In the HCI community, researchers focus on the abilities of older adults as a way of identifying alternative technologies for older adults. For example, researchers described older adults as digital content producers [70], bloggers [13], or artists [32].

However, when researchers need to address the health problems of older adults, it is difficult to avoid centering on their health issues. The original goal for our own current project was to explore healthcare robots for older adults. We wanted to avoid an ageist view in our research but had to talk about participants' current (health) problems. Thus, we focused more on *reflexivity* [23, 25, 40] in our research process rather than completely avoiding discussion of the older adults' health problems, since reflexivity addresses more fundamental problems of how researchers can manage their biases towards their research participants.

When ethnographers realized that their ethnographic work describing their research subjects contains their own biases and prejudices [40], the concept of reflexivity emerged. Reflexivity involves being self-cautious about how the understanding of research participants is influenced

Fig. 2. The three stages of interviews: collaborative map-making (left), artifact analysis (middle), envisioning interaction with a design probe (right).

by researchers' sociocultural identities, including race, gender, nationality, class, and professional status [58, 66]. It is especially important to be reflexive around the specific social identities of researchers that could generate power imbalances between researchers and research subjects. For example, when HRI researchers conduct fieldwork with older adults, the cultural practices of their field might hinder their understanding of who the research subjects are from the research subjects' point of view. The significance of reflexivity has been the subject of multiple papers in the HRI communities [8, 34, 35], and this study builds upon them.

To be reflexive in our study, we adopted collaborative research methodologies inspired by situated analysis [19] and collaborative ethnography [31]. Among various social identities, we were self-cautious about our position as HRI researchers with assistive robotics knowledge and our age, which could prevent us from viewing older adults from their own perspective. Throughout our study, we found that wisdom was a powerful design concept to guide us in being more reflexive. It is also a practical design concept that can assist HR researchers who are new to reflexivity. We discuss this aspect of our study further in the discussion section.

3 METHODS

This project had two goals: 1) designing robots that enhance older adults' health management; 2) avoiding the deficit model of aging. Because of the first goal, we needed to focus on how older adults experience their health issues; however, due to the second goal, we needed to not frame older adults solely as people with health issues. To resolve this potential paradox, we investigated not only their health issues, but also their abilities to manage these issues. Considering our social identities as researchers within a discipline which has long adopted a deficit model of aging, we endeavored to be reflexive throughout the research processes by consistently checking if we were framing older adults mainly as people with problems [47, 55, 58].

For that reason, we employed collaborative design methods which include three phases: 1) collaborative map-making [37], 2) artifact analysis [38], and 3) envisioning interaction with a design probe [69] (see Fig. 2). As a collaborative design study, its process prioritizes sensitization of the relationships between researchers and research participants, which enables a dynamic negotiation process between the two regarding robot design goals. For this process, how older adults map out their aging experience in Phase 1 becomes a guideline for the next two phases. For example, in the first stage, participants selected words that describe their aging experience without any restrictions (see Fig 2 left). The maps created in the first stage were frequently revisited throughout the research process, both with and without the presence of the participants. The map making process did not include any technical components by which older adults could freely map out their experiences as domain experts of their lives. During the second and third phases, we always began by checking the maps from Phase I. Additionally, the participants and interviewer

Fig. 3. A design probe to examine the embodiment of robots for aging

(first author) revisited the maps together whenever they had conflicting views on robot designs. Because the maps were revisited multiple times throughout the study, participants could pick and choose how to represent their aging experience throughout our collaborative design process. All interviews were conducted individually in participants' homes in 2018.

3.1 Phase 1. collaborative map-making

In the first stage, we conducted a collaborative map-making study [35, 37] where participants illustrated their aging experiences from their own point of view. We provided them with three keywords ("aging," "yourself," and "health") that we are interested in and let participants build their maps of words associated with those three words. We then asked them to write 15-20 words (or short phrases) related to the three keywords. After writing down each word on a Post-It, we asked the participants to categorize their words to find emerging themes and to pick the most important words (see Fig. 2 left and Fig. 5). When they were done making their maps, we asked participants to explain them (e.g., Why did you select each word?, How did you categorize the words?). Additionally, because one of our goals was designing robots that support their health management, participants were asked to provide their health issues if they don't provide the information in their maps.

This first stage was crucial to be sensitive to potential biases that we, the researchers, have in that we let participants choose their own words and categorize them from their perspectives without any restrictions. The maps helped us to reflect on whether we have biased assumptions about older adults. Through the mapping process, they had the chance to freely associate "aging" with words other than "decline" or "problems." We intentionally did not talk about robots or any other technical terms at this stage, but instead allowed participants to focus on the important aspects of their experience. We reused these maps in Phase 2 and Phase 3, to reposition us closer to the participants' point of view.

3.2 Phase 2. Artifact analysis

In the second phase, we explored morphology of robots through artifact analysis (See Appendix for the images that we used) [38, 39]. As a first step, the first author showed the participants the maps they had developed, and reminded them of the most important themes describing their experiences as well as health issues that they wanted to focus on. After that, the interviewer presented various images of intelligent technologies from the Internet of Things (e.g., smart fridge to recently released personal robots (e.g., appliance-like personal robots such as Jibo and Relay) to more conventionally bio-morphic assistive robots (e.g., Paro and Care-O-Bot). We included diverse intelligent technologies so that participants could escape their preconceptions about what robots were. When the interviewer presented the images, she briefly explained the purpose and functions of each technology.

As in the first interview, the interviewer asked participants to categorize the technologies according to the perceived similarities in terms of robot morphology (see Fig 7). The interviewer did not provide any pointers for participants to focus on, so that participants could frame the robots from their own perspectives. After categorizing the robots, the participants made a title for each category, and explained the rationale behind their categorization. After that, the participants were asked to pick technologies that could be most useful in their daily lives, and technologies that they would never use. The interviewer also asked about the rationales behind these choices. If participants had questions about the technologies (e.g., specific functions), the interviewer answered them. Throughout the second section, participants were free to change their categorization at all times.

Phase 2 helped us to find what design features should be incorporated within participants' ideal robots. Originally, we planned to ask participants to first criticize the existing robots, and then to sketch their ideal robots. However, six of our eight participants found sketching difficult, and were reluctant to try. Since we were using a collaborative design process and participants were our collaborators, we were willing to negotiate a new approach. Therefore, we instead developed a robot design probe based on the participants' preferences on existing technologies and their rationales for robot categorization.

3.3 Phase 3. Envisioning ideal robots with a design probe

Phase 3 was began by debriefing our Phase 1 participants. We shared each participant's map to remind both the interviewer and the participants of how they had depicted their experiences and health issues. Then, the interviewer presented a design probe (see Fig 3) [11, 69] not as the final product of our study, but as a flexible prototype that participants could redesign. We explained that the design probe was generated based on the participants' opinions gathered in Phase 2. We also explained that, due to the participants' difficulties in visualizing ideal robots, we were instead providing a design probe as a starting point to envision their ideal robots and help them to verbally express their design ideas.

We created this design probe based on the artifact analysis interviews in Phase 2, wherein participants demonstrated preference for appliance-like shapes, tablet-based interfaces, storage, and mobility. For example, all participants selected Relay (see Fig 6 left) as potentially useful for them, due to its less human-like shape, its mobility, its ease of storage, and its tablet-based interface which they were already familiar with.

To facilitate negotiation with participants as to the probe's construction, we ensured that each design item (e.g., tablet, wheels) was modular and detachable, by using cardboard and magnets. It is a 9" x 6" x 4" box, with a tablet on top to support interaction (see Fig. 3). Participants could open the box and store small objects like water bottles, remote controls, pens, or cosmetics. The screen displays a smiling face, to provide the affordance of being open to communication. In addition, in order to not limit participants' imaginations, any potential functions that participants inquired about (e.g., detect behavior, hold conversations) could be added to the device through re-design.

Participants were explicitly told that the design probe will be redesigned as they envisioned it. They were then asked to verbally and physically demonstrate how this prototype can interact with them to address their health issues (e.g., 'how would this robot help you enhance your health management?'), how it communicates with them (e.g., 'how are you going to communicate with this robot?'), how it can be placed in their home environments (e.g., 'where are you going to interact with this robot? where do you want to place the robot in your apartment?'), and how they want to change the design (e.g., 'would the size of this design probe be appropriate?').

Fig. 4. Pictures from the retirement community: Apartment doors, library in a common area, decorations near a door, a living room of one participant's apartment (from left to right).

As this was a collaborative study, the participants were able to add any comments regarding their ideal robots. During the negotiation process, if participants experienced difficulties in conceiving of methods to address the issues they raised, the interviewer made multiple open-ended suggestions. However, the final design decisions were made by participants. Unlike in Phase 1 and Phase 2, the participants designed robots for each household and shared the design goals of the household robots. These decisions were made by the participants as partners.

3.4 Participants and data analysis

We recruited eight participants from a retirement community (see Fig 4) in winter 2017. The study was conducted between January and July 2018. Each interview took 45 minutes to an hour. We met three times per participant. All interviews were recorded and transcribed. Our colleagues hosted a research outreach event as part of a larger healthy aging research project at the community, which is where the recruitment process took place. The recruitment efforts were approved by the IRB at our institution. The two authors introduced themselves as HRI researchers who investigate healthcare robots. Participants signed up if they were interested in projects relating to healthcare robotics.

All participants were retired, and two participants were either single, or widowed and living alone. The two male participants were each cohabiting with a female participant. One participant had a mobility impairment and used an electric wheelchair, and another used a walker. None of the participants were officially diagnosed as having cognitive deficits. Although two participants in their 90s mentioned experiencing mild memory loss, their primary doctors told them that this was part of the normal aging process. The consent process was done individually right before each Phase 1 study. Participants ages ranged from 72-92 (mean = 82 years old). We assigned each participant a pseudonym to anonymize their information. Rather than assigning code numbers, we chose to employ pseudonyms to preserve each participant's individuality and agency. We chose pseudonyms from a social security database [2] based on the birth year of each participant.

As briefly explained above, we had two potentially conflicting aims. The first aim was to design robots for older adults' health issue management; however, at the same time, we did not want to frame them entirely as people with health problems. We had to identify health problems without defining older adults solely through them – which, despite our efforts to avoid the deficit model, was difficult, because our focus on health issues naturally led us to discuss aging in terms of problems.

Especially in Phase 3, when the participants and the interviewer discussed the use or redesign of design probes to address their health problems, the interviewer sometimes suggested robots that could detect problem behaviors to provide remedies. Participants typically disliked this. Throughout

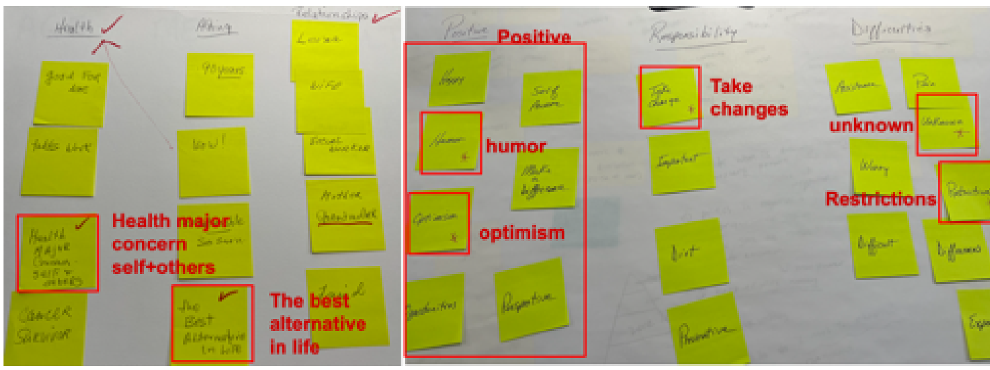

Fig. 5. Two maps from participants showing the importance of their coping strategies as the most important factor in their aging experiences (Phase 1). Left: Barbara's map marking "the best alternative in life" as the most important word; Right: Judith's map marking "optimism" as the most important word

Phase 3, the participants strongly argued that robots need to focus on their capabilities and coping strategies, rather than on the problems themselves. As we revisited the maps developed by the participants in Phase 1, we found that the significance of older adults' coping strategies – or "wisdom" – was also actively discussed in the participants' maps. Considering the importance of wisdom as a way to achieve the two goals, during the analysis process we focused on how participants discussed their capabilities, and on how their views conflicted with those of the interviewer.

The collected data from each phase were analyzed immediately after completion, to facilitate preparation of the next phases by following an initial line-by-line coding of grounded theory [17]. After all interviews were finished, the data were thoroughly analyzed again. In the second analysis, following incident-by-incident coding of grounded theory [17], we collected lists of incidents from our transcriptions. These were about wisdom, participants' existing coping mechanisms, and conflicting views between participants and researchers. Then, we coded the incidents with labels and created categories by grouping similar codes together to generate main themes. As following constructivists' grounded theory, analysis was a dynamic process in that the labels, and the categories were updated as needed throughout the coding process. The entire study was coded together; however, the results of each phase are reported separately in each subsection of the results section below. The main narrative flows from 1) understanding older adults' coping mechanisms (Section 4.1), to 2) older adults' interpretation of existing robots (Section 4.2), and then to 3) older adults' ideal robot design (Section 4.3).

4 FINDINGS

4.1 Wisdom as a coping mechanism developed throughout one's life

In this section, we report our findings from the first phase of our study, collaborative map-making, where we asked participants to map out their experience regarding "health" "aging," and themselves ("myself"). The most salient discussion was about how they have been resiliently managing various life challenges and become "content" with their aging experiences despite new health issues. All participants mentioned their health issues including healthy eating, weight issues, mild memory loss, sleep apnea, and pill taking. The participants shared their coping strategies accumulated through various stages of their lives, which we refer as *wisdom*. One participant explicitly used the term "wisdom" to describe experiential knowledge, while others used phrases like "the best alternative in life" and "optimism" for dealing with the "unknown" (see Fig 5). In general, all participants were content with their aging experiences and had no negative connotations on aging similar to our findings in [35].

Similar to the notion of wisdom in previous studies, participants develop their wisdom as experiential knowledge, which has been developed based on their accumulated experiences of dealing with their life challenges [6, 63, 64]. Below, we explain how the participants developed wisdom as personalized coping strategies based on their life experiences. Participants shared three sources of wisdom: 1) managing their difficulties in childhood, 2) learning from families, and 3) accepting their vulnerabilities.

4.1.1 Wisdom learned from difficulties in childhood. Barbara (90, retired social worker) said she was a "Depression baby" who experienced the Great Depression when young, which taught her a lesson of "adjust or die." When she introduced herself, she said:

> *I was a Depression baby. You know the depression we had, the financial crash in the market and stuff in the [late] '20s; that's when I was born...a lot of people lost their jobs, including my father. So, we had to move away... I think that was a big factor in changing my life. Because it was a big change living with families, living in a big city, and moving to the small town. I went to a good public school in New York. In Connecticut, I was in a country school with two classes together and... no other Jewish people... that was a big factor in my life. I had to adjust to it. And I guess that's why I was able to adjust to Navy life [due to my husband's job], and moving [often]... making new friends, new places, and new customs (She had 18 moves in her life due to her husband's job in the Navy). So... I think ... although the first move was the hardest. That was the lesson that I learned. "Adjust or die!" If you don't change, you are stuck there. You have to adopt changes.*

Her lesson taught her to find the "best alternatives" throughout her life, which she continues applying to the issues she is encountering in her 90s. She said:

> *I do have some memory issues, and I've been participating in all kinds of studies. I joined a research network. I went to lots of places like the Alzheimer's Association.*

To find the best alternatives, she has been actively engaged with local organizations for people with memory issues to find resources. Thanks to her wisdom, she knew to seek out resources to be more prepared and more resilient for the potential challenges that memory issues can bring.

Similar to Barbara, James (81, retired civil service officer) experienced precocious puberty [41], and reached his adult height at the age of six. He too learned how to handle life challenges thanks to his experiences. Although there is now a treatment for precocious puberty, he has "no regrets and no lingering desire for what would have been a very different life" and he will continue doing what he has been doing until he dies:

> *I recognize and adapt to my changing circumstances, pass on information about my circumstances to friends and family, make appropriate decisions about my personal needs and will be prepared to relinquish control of my affairs as my capabilities decline, I will maximize the opportunity to have a good death.*

Although the participants experienced difficulties when they were young, this helped them to be who they are, and influenced how they manage life challenges. These coping mechanisms are still the most important strategies for them to manage new health issues.

4.1.2 Wisdom learned from family. Judith (83, retired principal) explained that "positive" is the keyword to describe herself and her aging experience. In her map (see Fig 5 left), she had a group of words describing being "positive," which includes the most important words for her such as "humor" and "optimism." Being positive has helped her to keep her mental and physical health, which also has been good for maintaining and nurturing relationships. Judith learned the importance of positivity as a part of her family culture. When she was little, her parents, particularly her mother, had a great sense of humor and she had memories of laughing a lot. Those experiences taught her that it is vital to "look forward than to settle in the mud where you are and look back." Her beliefs on positivity, cultivated as a part of her family culture, was reinforced when she experienced sex discrimination in her workplace. She said there were no female high school principals before her in her school district and she shared how she became the first one.

> *I was an assistant principal, and applying for principalship one summer. I didn't get the first one, didn't get the second one, and didn't get the third one. I got a call from an assistant superintendent who said "tonight is your night." So, I thought. Oh. Alright. But, didn't get it. Then, one of the board members said "this is terrible." I was the number one recommendation of the superintendent for every open position in summer and I had been passed over each one for a male candidate. It was like "Wham!"*

When she consulted with members of a women's organization, half of them said, "Don't do it [file a lawsuit]. It's career suicide," and the other half said, "Go and get it." Attorneys also were divided into the two groups. In the end, she decided to file a lawsuit.

I was driving to work one day... And I thought "Okay. Knowing what I know. Can I live with myself?" It was unique because it was revealing. You knew what was going on. A lot of time you know what is going on but you don't really know anything. But this was revealed. "No. I can't." And I said "file the papers."

She won the case, became a principal, and later, district office director. To this day, Judith continues employing a positive attitude as a means of coping with her progressive stages in life. After discussing her "worries" (e.g., financial issues and "unknown" future health issues), she went back to the word "positivity" (see Fig 5) and said:

> *My dad had a little saying taped on his bathroom mirror and it said every day. He looked at it every day and he said, "If it is to be, it's up to me." So, it's kind of that outlook.*

She said her positive attitude helps her to deal with unknown difficulties in her current and future life and to enjoy every moment of it. Carol (92, retired high school teacher) had a similarly positive attitude due to her family situation. She lost both of her parents before she was ten, and had to transition to her uncle's care. Although it was difficult, she found that she could not keep mourning her losses, and tried hard to be humorous and laid back about her difficulties. Carol has kept applying her laid back attitude toward the memory issues she has been experiencing lately. While she does worry about these issues, she wanted to address them by drawing on her wisdom.

4.1.3 Wisdom of accepting vulnerability. Dorothy (73, retired recreation therapist) said the most relevant word in describing who she is today is "able," of which she feels very proud. She said:

> *I've not always been able. I've not always had courage. And it's a growth that I've gone through and today I feel able. Particularly with aging that when I look back I've seen myself as very introverted, very quiet, and not wearing my feelings on my sleeve.*

She explained that her identity originated from her being "a good woman" in her earlier life. Being a woman has meant being asked to do or not do certain things, which, according to her, was very much a "suppressing type of thing." Her identity was originally built upon her gender but has evolved through the knowledge she has gained from some failed relationships with life partners and other people. One thing she found out was that everyone, even men, can get scared of anything and it is okay to be afraid.

Fig. 6. Participants disliked the first three robots (CoCo, Papero, Keepon) due to their toy-like color schemes; Kuri (fourth) was disliked due to its unclear functions; Mabu (fifth) and Relay (sixth) were perceived as useful due to their tablet-based interfaces.

> *I don't have to be perfect. I can look at something that works and know and see if that works.*

As she was wrapping up her story, she explained how she redefined the meaning of "strong" based on her aging experience:

> *Strong just isn't always muscle power. Strong is, I believe, sometimes being weak. And sometimes being vulnerable and afraid. I think that's maybe called total strength.*

Through her aging experiences, she found strength comes from accepting one's vulnerabilities and appreciating herself as she is rather than trying to hide certain parts of her. She said that she might encounter new difficulties in the future, but she would like to stay strong enough to be resilient in accepting her vulnerability and establishing what she can do when new situations arise.

Similar to Dorothy, Sandra, born with achondroplasia (83, retired childcare provider), said that her gender identity of being woman influenced her life. Her disease was particularly difficult for her because as a woman, she is often expected to have a certain appearance. However, after accepting herself as she is, she was able to distance herself from societal gender expectation and cherish her own life. Also, it helps her come to terms with the difficulties brought on by her disease. Positivity was an important asset to Mary (90, professional artist and actor), who called herself "Pollyanna [48]", referring to the 1913 novel by Eleanor H. Porter, whose titular character is perpetually cheerful and optimistic. Throughout her caregiving experiences for her husband with dementia, Mary's positive attitudes helped her to navigate difficulties.

As all participants explained, their past experiences helped them develop their own ways of dealing with various life challenges. When they told us about their aging experience and who they were, their wisdom was the most meaningful and crucial narrative that they wanted to share.

4.2 How existing robots intersect with participants' aging experiences and values

Since this paper's goal is the exploration of robots for older adults, seen from their viewpoint, this section explains how participants critically analyze existing robots based on the data collected in Phase 2. As part of the collaborative design process, we presented the images of existing robot platforms to ground our discussion within current technologies, and to give participants the opportunity to discuss robot morphology. This process helped familiarize participants with currently available technologies. As a last step of this phase, we planned to ask the participants to visualize their ideal robots; however, they were not comfortable with sketching as a way to express their ideas. Thus, based on the results of this phase, we generated a design probe. As participants pointed out which robot design factors they liked or disliked, we were able to produce a flexible prototype based on the discussions. Our design probe helped the participants verbally express their ideas about how to redesign the robots while they physically interacted with it in Phase 3.

Fig. 7. Artifact analysis results from Phase 2. Left: Judith's robot categorization including a group of toy robots and a group of potentially useful robots for older adults; Middle: Judith collected toy-like robots and explained that they are cute but not very useful; Right: Barbara's group of toy-like robots.

Participants preferred similar robot design factors. Even when they had different opinions on one robot, we were able to identify patterns accounting for why they preferred (and did not prefer) certain robots. In summary, participants 1) rejected robot representations that they considered infantilizing in function, color scheme, and shape, 2) addressed the importance of downsizing in their lives, and 3) expected that their robots would reflect prosocial values. Among the robots that we shared, participants commonly selected Mabu and Relay as potentially useful (see Fig 6). Participants expected that they would be able to use the robots' tablet-based interfaces, and liked Relay's ability to carry objects.

4.2.1 Rejecting infantalizing robot representations. All participants tended to avoid the "toy-like features" of robots in terms of color scheme and function. All participants either made a group of robots called "toys" or described certain robots as toys. Participants disliked those toy robots because they thought the designs reflected the looking down on of older adults as children who have limited intelligence. Although participants sometimes had divergent opinions on which robots look particularly toy-like, they commonly pointed out that the vivid color schemes of robots represent toy-likeness. For example, Papero's combination of the vivid red and yellow [45], the yellow color of Keepon [16], or the combination of vivid red, yellow, green, and red of the CoCo - Parrot robot [50] were considered toy-like, see Fig. 6.

The participants disliked the social robots (including Kuri, Aibo, and Papero), which were designed primarily for entertainment and social interactions, calling them toy-like. This disfavor aligns with how participants see themselves as people with wisdom and maturity. In contrast, more than half of the participants (6/8) like tablets as a part of robots. Participants found that robots' tablets indicate programmable features that are easy to use (e.g., tablet screen of Mabu or Relay). Moreover, many said they are familiar with tablets from their everyday lives.

4.2.2 Importance of downsizing in the later stage of one's life. When the participants discussed their preferences for potential robot designs, all participants except two (6/8) were reluctant to accept robots because they conflicted with their lifestyle. Six participants described their lifestyle as people who do not buy new products unless they are absolutely necessary, similar to the minimalist lifestyle. Rather than adding new things into their daily lives, they wanted to scale down what they have and minimize their belongings. Downsizing was also important with regard to their financial planning. Half of our participants (4/8) wanted to save money for later in their lives, rather than spending it on unnecessary products. Specifically, they wanted to limit extraneous spending because they were unsure how long they would need to save.

When designing robots for older adults, it is important to consider lifestyles and living spaces in terms of size and functionality. For example, (4/8) participants preferred smaller-sized robots. Judith explains:

> *One other thing that people have trouble with is getting rid of things [although they want to]. Especially, people who have lived a long life... there are some apartments here that are such dumps in there [because they downsized their house but were not able to remove things]. I don't know even know whether a robot can get around there. Some residents... have so much big furniture. And they have something right in the doorway. And you can't even open the door because there is a piece of furniture. So the thing about body size [of robots] I don't know whether they can get [large robots] in there.*

These findings show the importance of understanding older adults' lifestyles and how they adopt new technologies and other products.

4.2.3 Older adults as critical citizens with their prosocial values. Older adult participants presented critical perspectives towards a role of robots in society. All participants except two explicitly expressed their concern about whether robots might negatively influence society. Among various robot designs, participants particularly worried about robots that have noticeable anthropomorphic features (e.g., the human-like face of Mabu) or robots that have high autonomy like a self-driving car. When reviewing Mabu's robot design, Barbara (90, retired social worker) explained why she was unconvinced about employing robots in healthcare settings. She said:

> *Technologies should not replace humans. And the money that you are going to spend on [robots] could give somebody a job. They want to cut Medicare because people have to spend extra money.*

Our discussion with Barbara started with how this technology could be useful for herself, then expanded to include broader social actors throughout our discussion. When we discussed how the robot might be employed as a part of a community center or other public health system, she argued that as a retired social worker she expected that employing robots would definitely influence job security for existing social workers. She also said the situations would be similar whether hospitals pay for robots or insurance companies pay for them. As HRI researchers focusing on robot designs for older adults, we have not considered the institutional changes or broader social stakeholders. Our discussion with Barbara highlighted how robots are placed within a broader social network.

Participants also maintained their critical views as they explored potential uses of robots in their homes. When discussing how existing robots can benefit them, they clearly avoided considering robots that would replace their existing helpers. All participants employed helpers who take care of housework and other errands, and it was important to them that their robots collaborate with the helpers, not replace them. For example, Sandra said her helpers are, "windows to the outside world out of my home," and would keep them regardless of employing robots. When reviewing the robots, she searched for robots that can perform tasks which her helpers find annoying (e.g., picking up the remote control over and over).

Based on our artifact analysis study, we found that the older adults are most positive about a robot that is controllable by a tablet, is capable of carrying things, and is mobile. As the participants were hesitant to sketch their ideal robots, we developed a design probe as a flexible prototype with modular parts that helps the participants to envision their ideal robots (see Fig 3).

4.3 Robots focusing on the wisdom of older adults

In Phase 3, we brought our design probe to the participants' homes and asked the participants to verbally explain and physically show how they would interact with this robot to tackle their health

Fig. 8. From left to right: Sandra's robotic drawer sketch; Sadra demonstrating how she interacts with her robot; Carol's list of significant others who she wanted to remember; Carol's embroidery work that she wants to reflect to her robot design

issues shared in Phase 1. We emphasized that this is a flexible prototype that they can redesign, and they do not need to limit their imagination to it. In this phase, rather than discussing how they can use the design probe, two participants shared why they do not want robots: they were satisfied with their lives. As a collaborative study, we respected the participants' opinion and accepted that robots cannot be the optimal solution for everyone. In this section, we focus on the remaining six participants. All six participants were generally content with the design probe's shape because of its minimally human-like morphology and its tablet interface. 4 of 6 participants assumed that the robot would be on the floor. They wanted it to be larger and more visible, and mobile so it could physically approach users. 2 of 6 participants wanted the robot to be on the table. They wanted to keep its original size, and remove its wheels.

During our discussions with the participants about how robots can support their health issues, they often disliked that robots focus on negative aspects of themselves (e.g., pointing out unhealthy habits through monitoring systems). Although they wanted to enhance how they manage their health issues, they preferred not to be criticized by robots. Rather, they wanted the robots to affirm their existing experiential knowledge so that they can be motivated to better handle the health issues. In other words, all participants expressed that their robots need to either explicitly or implicitly affirm their wisdom that was discussed in Phase 1.

For example, Dorothy (73, retired recreation therapist), gained new knowledge through her failures, and Judith (83, retired principal), shared her gender discrimination experience, initially wanted robot assistance for food and exercise management. However, upon explaining possible interactions with our design probe, they realized that such management functions can interfere in their autonomy. When discussing how a robot design probe can monitor Dorothy's eating habits to track her food choices, she explained that she disliked having a robot point out that she ate unhealthy foods. She explained that the robot is eventually going to interfere with her autonomy. To Dorothy, keeping her autonomy was more important than improving her eating habits. She said:

> *Food is an issue, but I don't want [the robot] to be [the] food police. I know what I should be doing. I should be doing it and when you tell me that means I am not doing it. That's criticism. That inhibits my ability to pursue it. And I am not a very "should"-oriented person. As soon as you say "should" as my mother [used to say], I would say "Screw you!" It's done. I don't care whether it's good for me. (laughs)*

To avoid this concern, we discussed what types of interactions with a robot could strengthen her autonomy. She explained that her robot should make her feel "able," which was a critical part of her wisdom as discussed in Section 4.1.3. To her, acknowledging her knowledge (wisdom) gained from previous experiences, and reminding herself how much she has survived, helps motivate behavioral changes. In other words, she wanted to have an affirmation of her wisdom as a reminder of her capabilities, which Judith also suggested in her interview. To let robots know about their wisdom, both Judith and Dorothy wanted to record how they encountered challenges and successfully dealt with them, in a few short sentences. After recording, they'd like to listen to the stories as "a repository of good" particularly when they need more motivation to change their behaviors. Dorothy explained:

> *Affirmation would be wonderful. It gets me away from being stuck in the negatives and re-affirming that the whole is a better view than the negative things that I did today. It would be nice to start with a day with it. Sometimes your day is crummy 'cause sometimes it is just crummy. Not very re-affirming but to have a recollection and start to have that.*

Dorothy and Judith liked to place their robots right next to their bed tables and get the affirmation every morning as they said:

> *It's like a good breakfast. I love affirmation. I think they are a friendly reminder of good and your own personal affirmation. That's very nice. All the good things and the struggles you had. Having a time of struggle is an affirmation. You know . . . Something heat my face but I smiled. I washed my face and moved on.*

Dorothy liked this interaction scenario particularly helpful because the robot does not teach her or interfere with her autonomy . She explained why she like this interaction as follows:

> *It's teamwork of me and myself. More than the sum of my parts. It's me, history, and a combination of those things. I think it's subsidiary that every robot is individual; that it's very personalized.*

These discussions helped us to understand that recommendations from robots could make older adults feel that they were being judged, watched, and examined. Similarly other participants also wanted their robots to support their capabilities accumulated through their life experiences.

Todd (85, retired high school teacher) and Carol (92, retired high school teacher) were partners, and they wanted a robot to assist with Carol's mild memory loss. Carol, who lost her parents before she was ten, wanted a robot to help her remember the names of the people she cares about. Due to her personal history, her relatives were an especially important part of her life, as they had helped her develop her laid-back attitude as discussed in Phase 1. They shared with us her photos that showed important memories which she does not want to lose (see Fig. 8 right). Because of her desire not to focus too seriously on her memory troubles, Carol wanted to interact with her robot rather infrequently (e.g., she wanted to interact with a robot about once a week, and wanted the ability to alter the interaction frequency to keep her from feeling forced to consider her imperfection). She did not want to spend the rest of her life trying to focus on memories that were not meaningful. Carol expected her robot to help her maintain memories of people which she cherishes rather than to problemitize (or fix) her memory loss in general. She also liked the idea of employing design themes of her embroidery work into her robot (see Fig. 8). Carol and Todd wanted the robot to be bigger so that they would not stumble over it. They wanted the robot to be placed in the living room, and to come to them when they are sitting on a couch. They can then use it in memory training activities. They liked the idea that the memory exercises could be a shared game on the tablet that they can play together.

As partners, James (81, retired civil service officer) and Sandra (83, retired childcare provider) wanted to have a robot to support Sandra's physical disabilities. Sandra, who has achondroplasia, learned that she does not need to hide the physical challenges caused by her condition, and instead actively shared them with people (see Phase 1 for more information about this experience). Since she had two part-time helpers and had enjoyed her social interactions with them, she wanted her robot to support her for painting activities. Because painting is an activity that allows her to focus on who she is, she preferred to be alone with a robot. The robot was expected to strengthen her identity not as a person with disability, but as to be a person who enjoyed painting, and expressing herself through the activity. She liked the basic shape of the robot, but wanted it to have more storage as a mobile drawer containing painting materials (see Fig. 8).

In this vein, it is crucial for the robot to know that older adults were people with their own wisdom, which represents who they are and who they had been. Understanding these experiences of older adults is as important as providing quantitative medical measurements and the meaning of the those measurements based on standardized metrics. The significance of personal history in technology design for older adults was also addressed in [69]. While measurements can provide objective information about older adults, this makes them passive actors who are examined and judged by robots. On the other hand, sharing wisdom with robots affirms older adults as engaged actors who have enough intelligence to change their behaviors regardless of their current status.

5 DISCUSSION

The most important concept to emerge from this collaboration with the older adults was wisdom. In this section, we will explain how wisdom lets us be reflexive about 1) the traditional definition of knowledge in HRI, as well as 2) the conventional understanding of older adults, which is not only present-centric but past-agnostic.

5.1 Wisdom as a critical lens to reveal the significance of experiential knowledge

To explore alternatives to the deficit model of aging, researchers should avoid representing older adults primarily as people with deteriorating health. However, when designing technologies to support health issue management, the question of health problems become a central one. In practice, avoiding the deficit model can be difficult. After identifying older adults' health issues, we inadvertently framed older adults as people with health problems rather than seeking their capabilities. In other words, we unintentionally followed the deficit model, which has long been predominant in assistive technology design studies.

Wisdom—a concept that emerged from our collaboration with older adults, rather than being intentionally chosen within our study design—provides the most helpful and practical frame for incorporating these ambivalent aspects of aging experiences. We had long discussions with our older adult participants regarding how their ideal robots could help them manage their health issues. They explained that they wanted us to focus more on their coping mechanisms for life issues. To the older adults, health issues were just one part of their lives, and they already knew suitable ways to manage them. They needed a way to better utilize their own experiential knowledge.

Experiential knowledge has largely been ignored within technology design communities and other academic fields. In particular, the experiential knowledge of people who have been misrepresented as having less knowledge (e.g., informal caregivers [60], production workers [12], people in developing countries [22], racial minorities [74]) is considered less credible—if it is even considered to be legitimate knowledge. For example, informal caregivers have long been presented as having limited medical knowledge, and thus technologies have been developed to compensate for the assumed lack of knowledge regarding caregiving practices and self-care [18, 27, 61]. However, researchers found that informal caregivers' own experience have already enabled themselves to develop their own coping mechanisms; moreover, these strategies can work better than those developed by healthcare professionals.[60].

A growing number of studies have argued the importance of incorporating the experiential knowledge of marginalized communities into technology design and other social interventions for positive social change [22, 60, 74]. These studies focus on visualizing previously invisible knowledge of underrepresented groups and designing their interventions for the communities' empowerment based on that existing knowledge. Researchers discovered that this approach generates solutions that are effective and sustainable because of their familiarity and suitability to research participants. Older adults' experiential knowledge is not particularly appreciated in HRI and other technology design communities. This could be because those fields have long considered technological knowledge as primary. The wisdom of older adults can be considered as an important asset, which could enable design researchers to be aware of older adults' capabilities and to utilize them in the design process.

5.2 Wisdom as a critical lens to rethink time boundaries when understanding older adults

When understanding older adults and their issues, HRI researchers and other technology design researchers have focused on older adults' lives through a past-agnostic lens. The researchers have looked at older adults' health issues as a result of aging. However, to identify who older adults actually are, their past experiences are as crucial as their present experiences.

In our map-making session, one of the three keywords that we presented was "myself." To explain who they are, all participants naturally explained their past experiences. It was surprising how unique our participants' past experiences were. We had initially perceived their pasts as largely superfluous background information that would not be directly relevant to our work. However, as we continued to negotiate with our participants regarding robot designs, we realized that those experiences are crucial for designing robots that fit in their users' identities and lives.

Wisdom includes older adults' coping strategies that they attained throughout life experiences: not just their presents but their pasts. Because researchers only have limited time to encounter participants, it is easier to identify older adults solely in currently-visible aspects (such as physical and mental decline). With wisdom as a design concept, researchers could pay more attention to how older adults went through their lives and how these experiences make their current identity. This could also let researchers understand older adults not just as people who are experiencing health problems now, but as people who have gone through multiple stages of their lives.

6 LIMITATION

Wisdom is a promising concept that helps researchers pay more attention to older adults' experiential knowledge. However, because everyone has their own personal history and aging experiences, it is difficult to generalize the design features of wisdom-focused robots, or to measure wisdom with standardized metrics. Self-affirmation was a promising design feature for our participants who had certain social, cultural, and historical experiences, but it is not the only one. We encourage HRI researchers to seek the unique wisdom of their participants through building close collaborations with them and investigating their sociocultural contexts throughout their lives. Regardless of these limitations, we hope wisdom can provide an opportunity to HRI researchers to be aware of their own unintentional bias towards older adults.

7 CONCLUSION

Older adults have been one of the most popular demographic groups in HRI since the field's inception [14, 65]. Recently, an increasing number of studies have recently begun acknowledging the stereotyped representations of older adults in assistive robot design and exploring alternatives. One of the solutions to avoid the deficit model of aging is incorporating older adults' voices in robot design processes as collaborators and co-designers. However, due to the long history of focusing on the decline of older adults, it is difficult to be self-aware of the overarching societal ageist viewpoints being reflected in robot design. In our collaborative study, we found that wisdom to be as a promising design concept that could help HRI researchers to be more reflexive about their biases. The wisdom-focused approach, like the asset-based approach, can aid in appreciating the pre-existing capabilities of socially marginalized populations (e.g., socio-economically disadvantaged communities), and in generating sustainable solutions for these groups. Assistive robots could not only provide new technological solutions for older adults but also mobilize their existing capabilities. We hope this study sheds light on wisdom that could provide a critical lens for HRI researchers to question how they define knowledge, how they understand older adults, and how they design robots for aging.

REFERENCES

[1] Care-o-bot promotion video link. https://youtu.be/lccHeEiOrBc.
[2] Social security database. https://www.ssa.gov/oact/babynames/.
[3] P. L. Ackerman. Adult intelligence: The construct and the criterion problem. *Perspectives on Psychological Science*, 12(6):987–998, 2017.
[4] M. Ardelt. Empirical assessment of a three-dimensional wisdom scale. *Research on aging*, 25(3):275–324, 2003.
[5] P. B. Baltes and U. M. Staudinger. Wisdom: A metaheuristic (pragmatic) to orchestrate mind and virtue toward excellence. *American psychologist*, 55(1):122, 2000.
[6] P. B. Baltes, U. M. Staudinger, A. Maercker, and J. Smith. People nominated as wise: A comparative study of wisdom-related knowledge. *Psychology and aging*, 10(2):155, 1995.
[7] K. J. Bangen, T. W. Meeks, and D. V. Jeste. Defining and assessing wisdom: A review of the literature. *The American Journal of Geriatric Psychiatry*, 21(12):1254–1266, 2013.
[8] N. Barker and C. Jewitt. Filtering touch: An ethnography of dirt, danger, and industrial robots. *Journal of Contemporary Ethnography*, 51(1):103–130, 2022.
[9] J. M. Beer, C.-A. Smarr, T. L. Chen, A. Prakash, T. L. Mitzner, C. C. Kemp, and W. A. Rogers. The domesticated robot: design guidelines for assisting older adults to age in place. In *Proceedings of the seventh annual ACM/IEEE international conference on Human-Robot Interaction*, pages 335–342. ACM, 2012.
[10] M. Blythe, J. Steane, J. Roe, and C. Oliver. Solutionism, the game: design fictions for positive aging. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 3849–3858. ACM, 2015.
[11] K. Boehner, J. Vertesi, P. Sengers, and P. Dourish. How hci interprets the probes. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 1077–1086. ACM, 2007.
[12] H. Braverman. *Labor and monopoly capital: The degradation of work in the twentieth century.* NYU Press, 1998.
[13] R. Brewer and A. M. Piper. Tell it like it really is: A case of online content creation and sharing among older adult bloggers. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 5529–5542. ACM, 2016.
[14] J. Broekens, M. Heerink, H. Rosendal, et al. Assistive social robots in elderly care: a review. *Gerontechnology*, 8(2):94–103, 2009.
[15] P. Caleb-Solly, S. Dogramadzi, D. Ellender, T. Fear, and H. v. d. Heuvel. A mixed-method approach to evoke creative and holistic thinking about robots in a home environment. In *Proceedings of the 2014 ACM/IEEE international conference on Human-robot interaction*, pages 374–381, 2014.
[16] H.-L. Cao, G. Van de Perre, R. Simut, C. Pop, A. Peca, D. Lefeber, and B. Vanderborght. Enhancing my keepon robot: A simple and low-cost solution for robot platform in human-robot interaction studies. In *Robot and Human Interactive Communication, 2014 RO-MAN: The 23rd IEEE International Symposium on*, pages 555–560. IEEE, 2014.
[17] K. Charmaz. *Constructing grounded theory: A practical guide through qualitative analysis.* Sage, 2006.
[18] Y. Chen, V. Ngo, and S. Y. Park. Caring for caregivers: designing for integrality. In *Proceedings of the 2013 conference on Computer supported cooperative work*, pages 91–102, 2013.
[19] A. E. Clarke, C. Friese, and R. Washburn. *Situational analysis in practice: Mapping research with grounded theory.* Routledge, 2016.
[20] V. Clayton. Wisdom and intelligence: The nature and function of knowledge in the later years. *The International Journal of Aging and Human Development*, 15(4):315–321, 1983.
[21] I. Deutsch, H. Erel, M. Paz, G. Hoffman, and O. Zuckerman. Home robotic devices for older adults: Opportunities and concerns. *Computers in Human Behavior*, 98:122–133, 2019.
[22] P. Dourish and S. D. Mainwaring. Ubicomp's colonial impulse. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*, pages 133–142. ACM, 2012.
[23] K. V. England. Getting personal: Reflexivity, positionality, and feminist research. *The professional geographer*, 46(1):80–89, 1994.

[24] J. Forlizzi, C. DiSalvo, and F. Gemperle. Assistive robotics and an ecology of elders living independently in their homes. *Human-Computer Interaction*, 19(1):25–59, 2004.
[25] D. Forsythe. *Studying those who study us: An anthropologist in the world of artificial intelligence.* Stanford University Press, 2001.
[26] C. Guan, A. Bouzida, R. Oncy-Avila, S. Moharana, and L. D. Riek. Taking an (embodied) cue from community health: Designing dementia caregiver support technology to advance health equity. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–24, 2021.
[27] M. K. Hong, U. Lakshmi, K. Do, S. Prahalad, T. Olson, R. I. Arriaga, and L. Wilcox. Using diaries to probe the illness experiences of adolescent patients and parental caregivers. In *Proceedings of the 2020 chi conference on human factors in computing systems*, pages 1–16, 2020.
[28] D. V. Jeste, M. Ardelt, D. Blazer, H. C. Kraemer, G. Vaillant, and T. W. Meeks. Expert consensus on characteristics of wisdom: A delphi method study. *The Gerontologist*, 50(5):668–680, 2010.
[29] C. D. Kidd, R. Orr, G. D. Abowd, C. G. Atkeson, I. A. Essa, B. MacIntyre, E. Mynatt, T. E. Starner, and W. Newstetter. The aware home: A living laboratory for ubiquitous computing research. In *International workshop on cooperative buildings*, pages 191–198. Springer, 1999.
[30] A. Kubota, E. I. Peterson, V. Rajendren, H. Kress-Gazit, and L. D. Riek. Jessie: Synthesizing social robot behaviors for personalized neurorehabilitation and beyond. In *Proceedings of the 2020 ACM/IEEE international conference on human-robot interaction*, pages 121–130, 2020.
[31] L. E. Lassiter. *The Chicago guide to collaborative ethnography.* University of Chicago Press, 2005.
[32] A. Lazar, C. Edasis, and A. M. Piper. A critical lens on dementia and design in hci. In *CHI*, pages 2175–2188, 2017.
[33] A. Lazar, H. J. Thompson, A. M. Piper, and G. Demiris. Rethinking the design of robotic pets for older adults. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*, pages 1034–1046. ACM, 2016.
[34] H. R. Lee, E. Cheon, C. Lim, and K. Fischer. Configuring humans: What roles humans play in hri research. In *Proceedings of the 2022 ACM/IEEE International Conference on Human-Robot Interaction*, pages 478–492, 2022.
[35] H. R. Lee and L. D. Riek. Reframing assistive robots to promote successful aging. *ACM Transactions on Human-Robot Interaction (THRI)*, 7(1):11, 2018.
[36] H. R. Lee, S. Šabanović, W.-L. Chang, S. Nagata, J. Piatt, C. Bennett, and D. Hakken. 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*, pages 244–253. ACM, 2017.
[37] H. R. Lee, S. Šabanović, and S. S. Kwak. Collaborative map making: A reflexive method for understanding matters of concern in design research. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 5678–5689. ACM, 2017.
[38] H. R. Lee, S. Šabanovic, and E. Stolterman. Stay on the boundary: artifact analysis exploring researcher and user framing of robot design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1471–1474. ACM, 2014.
[39] H. R. Lee, H. Tan, and S. Šabanović. That robot is not for me: Addressing stereotypes of aging assistive robot design. In *Robot and Human Interactive Communication (RO-MAN), 2016 25th IEEE International Symposium on*, pages 312–317. IEEE, 2016.
[40] G. E. Marcus and M. M. Fischer. *Anthropology as cultural critique: An experimental moment in the human sciences.* University of Chicago Press, 2014.
[41] MayoClinic. Percocious puberty. https://www.mayoclinic.org/diseases-conditions/precocious-puberty/symptoms-causes/syc-20351811.
[42] S. H. McFadden. Religion and meaning in late life. *Exploring existential meaning: Optimizing human development across the life span*, pages 171–183, 2000.
[43] S. Moharana, A. E. Panduro, H. R. Lee, and L. D. Riek. Robots for joy, robots for sorrow: community based robot design for dementia caregivers. In *2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, pages 458–467. IEEE, 2019.
[44] L. Neven. 'but obviously not for me': robots, laboratories and the defiant identity of elder test users. *Sociology of health & illness*, 32(2):335–347, 2010.
[45] J. Osada, S. Ohnaka, and M. Sato. The scenario and design process of childcare robot, papero. In *Proceedings of the 2006 ACM SIGCHI international conference on Advances in computer entertainment technology*, page 80. ACM, 2006.
[46] J. Parviainen and J. Pirhonen. Vulnerable bodies in human–robot interactions: embodiment as ethical issue in robot care for the elderly. 2017.
[47] S. Pihkala and H. Karasti. Reflexive engagement: enacting reflexivity in design and for'participation in plural'. In *Proceedings of the 14th Participatory Design Conference: Full papers-Volume 1*, pages 21–30. ACM, 2016.
[48] E. H. Porter. *Pollyanna.* Page Company, 1913.

[49] A. Prakash and W. A. Rogers. Younger and older adults' attitudes toward robot faces: effects of task and humanoid appearance. In *Proceedings of the human factors and ergonomics society annual meeting*, volume 57, pages 114–118. SAGE Publications Sage CA: Los Angeles, CA, 2013.
[50] T. Racky, F. Roth, I. Wegmann, M. Pilz, C. Busch, K. Horst, C. Söller-Eckert, et al. Coco: the therapy robot. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems*, pages 1089–1094. ACM, 2011.
[51] J. Reichstadt, G. Sengupta, C. A. Depp, L. A. Palinkas, and D. V. Jeste. Older adults' perspectives on successful aging: Qualitative interviews. *The American Journal of Geriatric Psychiatry*, 18(7):567–575, 2010.
[52] L. Riek. Robotics technology in mental health care. In *Artificial Intelligence in Behavioral and Mental Health Care*, 2016.
[53] L. Riek. Healthcare robotics. *Communications of the ACM*, 60(11), 2017.
[54] H. Robinson, B. MacDonald, and E. Broadbent. The role of healthcare robots for older people at home: A review. *International Journal of Social Robotics*, 6(4):575–591, 2014.
[55] J. A. Rode. Reflexivity in digital anthropology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 123–132. ACM, 2011.
[56] W. A. Rogers, T. Kadylak, and M. A. Bayles. Maximizing the benefits of participatory design for human–robot interaction research with older adults. *Human Factors*, page 00187208211037465, 2021.
[57] W. A. Rogers and T. L. Mitzner. Envisioning the future for older adults: Autonomy, health, well-being, and social connectedness with technology support. *Futures*, 87:133–139, 2017.
[58] G. Rose. Situating knowledges: positionality, reflexivities and other tactics. *Progress in human geography*, 21(3):305–320, 1997.
[59] S. Šabanović, W.-L. Chang, C. C. Bennett, J. A. Piatt, and D. Hakken. A robot of my own: participatory design of socially assistive robots for independently living older adults diagnosed with depression. In *International Conference on Human Aspects of IT for the Aged Population*, pages 104–114. Springer, 2015.
[60] J. Y. Shin, D. Chaar, C. Davis, S. W. Choi, and H. R. Lee. Every cloud has a silver lining: Exploring experiential knowledge and assets of family caregivers. *Proceedings of the ACM on Human-Computer Interaction*, 5(CSCW2):1–25, 2021.
[61] P. J. Slater, P. E. Fielden, and N. K. Bradford. The oncology family app: providing information and support for families caring for their child with cancer. *Journal of Pediatric Oncology Nursing*, 35(2):94–102, 2018.
[62] U. M. Staudinger. A psychology of wisdom: History and recent developments. *Research in Human Development*, 5(2):107–120, 2008.
[63] U. M. Staudinger and J. Glück. Psychological wisdom research: Commonalities and differences in a growing field. *Annual review of psychology*, 62:215–241, 2011.
[64] U. M. Staudinger, J. Smith, and P. B. Baltes. Wisdom-related knowledge in a life review task: age differences and the role of professional specialization. *Psychology and aging*, 7(2):271, 1992.
[65] A. Tapus, M. J. Mataric, and B. Scassellati. Socially assistive robotics [grand challenges of robotics]. *IEEE Robotics & Automation Magazine*, 14(1):35–42, 2007.
[66] S. Traweek. *Beamtimes and lifetimes.* Harvard University Press, 2009.
[67] R. Van Patten, A. V. Keller, J. E. Maye, D. V. Jeste, C. Depp, L. D. Riek, and E. W. Twamley. Home-based cognitively assistive robots: Maximizing cognitive functioning and maintaining independence in older adults without dementia. *Clinical Interventions in Aging*, 15:1129, 2020.
[68] J. Vines, G. Pritchard, P. Wright, P. Olivier, and K. Brittain. An age-old problem: Examining the discourses of ageing in hci and strategies for future research. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 22(1):2, 2015.
[69] J. Wallace, J. McCarthy, P. C. Wright, and P. Olivier. Making design probes work. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3441–3450. ACM, 2013.
[70] J. Waycott, F. Vetere, S. Pedell, L. Kulik, E. Ozanne, A. Gruner, and J. Downs. Older adults as digital content producers. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 39–48. ACM, 2013.
[71] N. M. Weststrate, M. Ferrari, and M. Ardelt. The many faces of wisdom: An investigation of cultural-historical wisdom exemplars reveals practical, philosophical, and benevolent prototypes. *Personality and Social Psychology Bulletin*, 42(5):662–676, 2016.
[72] B. Woodworth, F. Ferrari, T. E. Zosa, and L. D. Riek. Preference learning in assistive robotics: Observational repeated inverse reinforcement learning. In *Machine Learning for Healthcare Conference*, pages 420–439. PMLR, 2018.
[73] Y.-H. Wu, V. Cristancho-Lacroix, C. Fassert, V. Faucounau, J. de Rotrou, and A.-S. Rigaud. The attitudes and perceptions of older adults with mild cognitive impairment toward an assistive robot. *Journal of Applied Gerontology*, 35(1):3–17, 2016.
[74] T. J. Yosso. Whose culture has capital? a critical race theory discussion of community cultural wealth. In *Critical race theory in education*, pages 181–204. Routledge, 2014.
[75] H. Zacher and U. Staudinger. Wisdom and well-being. *Handbook of Well-Being. Salt Lake City, UT: DEF Publishers*, 2018.