

ABSTRACT

Title of Dissertation: **A MORE-THAN-HUMAN PERSPECTIVE
ON OLDER ADULTS' USE OF AND
PARTICIPATION IN DESIGN OF
EMERGING TECHNOLOGIES**

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Till date, research on aging in HCI has largely adopted human-centered approaches, such as user-centered and participatory design. However, recent research is beginning to question this “humanistic” focus in aging. Through this dissertation, I provide a case of adopting *posthumanist* entanglement perspective to understand the ‘more-than-human’ aspects of aging. Posthumanist entanglement perspectives [71]—previously adopted by HCI researchers in different contexts varying from creative design to technical areas such as machine learning and neural networks—attunes to the agency of nonhuman world in addition to the human world to account for how humans and their socio-material worlds are entangled.

In Study 1, I investigate older adults’ ontological perceptions with respect to a popular emerging technology to examine the phenomena of “ontological uncertainty” (here, ontologies refer to how things exist and what categories they belong to). Although some researchers adopting entanglement perspectives in HCI argue that

ontological uncertainty is posed by emerging technologies such as AI, IoT [71], we lack an understanding of when this uncertainty emerges, and why this matters. Here, the first study of my dissertation focuses on older adults' use of emerging AI-based voice assistants, and contributes by providing an empirical understanding of the different factors that contribute to ontological uncertainty (e.g., location in house, time, user's desire for companionship), and provides recommendations for designing voice technologies with ontological categorization in mind.

In the next two threads of my work, I attune to the agency of nonhuman entities and how they shape reality associated with older adults' use of emerging technology (Study 2), and when older individuals engage in designing emerging technology (Study 3). My analysis from Study 2 reveals how nonhuman actors such as materials and norms play a role in shaping older adults' preference and use of voice technologies. My findings also reveal the salient ways in which voice assistants play an active role in mediating relations between older adults and their larger social world. These mediations are shaping our social practices around what it means to live alone, to give company, or to give and receive care.

Finally, my analysis from Study 3— which adopts a posthumanist perspective to understand older adults' engagement in design workshops— reveals the nuanced ways in which designs materials (both expected and unexpected) act in relation to older adults: from facilitating creative brainstorming, to limiting creative brainstorming, to leading to clashing of ideas, and contributing to non-participation in the design activity. My findings also reveal how older adults went beyond focusing on just the technology idea to account for the physical objects or the environment associated with both

technology use and non-use, thus bringing to attention that technology cannot be seen, used, or designed in isolation, and exists within specific configurations of actor-networks.

Overall, my thesis contributes by providing *insights on the new directions that HCI researchers working on aging can take* in terms of: a) taking into account the ways in which the nonhuman entities act and hold them accountable for undesired realities, b) designing emerging technologies that support meaningful relationships between older adults and their world, and c) move beyond designing technology in isolation to instead purposefully situate older adults in designing meaningful configurations of human and nonhuman entities (including technology).

A MORE-THAN-HUMAN PERSPECTIVE ON OLDER ADULTS' USE OF
AND PARTICIPATION IN DESIGN OF EMERGING TECHNOLOGIES

by

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List of Abbreviations

HCI	Human-computer Interaction
AI	Artificial Intelligence
IoT	Internet of Things
VR	Virtual Reality
CSCW	Computer Supported Collaborative Work
CHI	ACM Conference on Human Factors in Computing Systems

Chapter 1 : Introduction

1.1. Motivation

As the world's aging population is growing, with projections of people aged 60 years and older reaching more than two billion by 2050 [201], there has been a growing impetus to consider the specific needs and preferences of this user group when designing technologies. In the field of Human-computer interaction (HCI), researchers have designed new technologies to support older individuals' health and wellbeing (e.g., [127,219]), or support social roles and interactions (e.g., [44,140]). At the same time, researchers are also examining older individuals' use and their preferences with respect to mainstream and commercially available emerging technologies such as conversational voice technologies (e.g., [108,167]) or virtual reality (e.g., [8,9]).

A common approach in aging research in HCI is to follow “user-centered design” [157] methods (e.g., interviews, focus groups, participatory/co- design). A core aspect of user-centered design is to design technologies based on the elicited needs and preferences of the user. But, some of my past work challenges this notion of solely focusing on the “user” when engaging with older adults [120,123,165]. For example, in one study I led [165], I found that during focus groups and interviews, some older adults, instead of thinking about their own needs and preferences, at times thought about what “other older adults” would desire and conceptualized technology, such as medication reminders, for this “imagined” group of older adults. The same participants later admitted that they personally did not want such technologies [165]. While studying the formation of a makerspace in a retirement community [123], we again

noted the trope of such “imagined older adults”. Residents and committee in charge of setting up the makerspace often thought about older adults who might be future residents of the community, and how the makerspace might be of interest to this “imagined” group of older adults. In a way, even though these imagined older adults were physically absent, they were still participating and configuring the reality pertaining to what equipment and activities the makerspace would support. A common observation across these studies is how human actors, beyond the participants of the study, were playing a role in design of technology or in decisions related to technology. As such, this body of my own past work indicates that beyond older adults who are part of our study, “other imagined older adults” who are physically not present in our studies, also play role in user-centered HCI research on aging.

At the same time, researchers in gerontology are cautioning that our user-centered turn in aging with a sole focus on the ‘human subject’, i.e., older adults alone might fail to capture the lived experiences and social relations that involve both the human and nonhuman world [4]. Older adults’ experiences are constituted within diverse ‘more-than-human assemblages’ of digital culture and technological proliferation, making it increasingly difficult to separate older adults from the technological environment [5]. Consider implant technologies that involve material manipulation of older adults bodies, where it becomes difficult to separate the technology from the human. Another example would be surveillance and monitoring technologies such as IoT, sensors, and fall detection technologies. These technologies don’t exist in isolation in older adults’ homes but are instead entangled with older adults’ bodies, their routines, their families, or even their care providers. With existing

and emerging technologies, “the aging body becomes enmeshed in technological fields and networks...so almost inevitably arises as a site for the convergence of the human and the nonhuman (hence being ‘more-than-human’)” [4]. As such, these researchers propose a posthumanist¹ turn in gerontology which attunes to the agency of nonhuman world and the ‘more-than-human’ aspects of aging [4].

Overall, sensitized by own past research that questions the sole focus on user alone and a growing body of works in critical gerontology that advocate a posthumanist turn, in this dissertation, I adopt a posthumanist entanglement perspective in the context of technology and aging: by studying older adults’ *use* of emerging voice based technologies and their *participation in design* workshops. Below, I provide a brief overview of entanglement perspectives in HCI (detailed overview in chapter 2 and 3), followed by describing my research approach and research questions.

A posthumanist turn in HCI—that some researchers have proposed as the next paradigm in HCI—draws upon central ideas, concepts, and vocabularies of different entanglement theories including: Actor Network Theory [32,118], Post-Phenomenology [55,207], Object Oriented Ontology [85], and Agential Realism [104]. Adopting these theoretical orientations, posthumanist HCI scholars have argued that emerging technologies such as conversational AI, IoT, and VR form complex relationships with humans and their larger world, and in turn can create ontological uncertainty in terms of distinguishing and separating the human and the nonhuman aspects of technology [71]. A posthumanist turn in HCI advocates to decenter the

¹ The call for posthumanist research does not intend to eliminate the focus from the user. Instead, it advocates that in addition to focusing on the user, there is a need to account for associated nonhuman aspects and how humans and nonhumans constitute each other.

human as the sole source of attention, to instead, elevate the role of the nonhuman world and acknowledge nonhuman actors (e.g., materials, norms, legal rules) as equal contributors to any action (such as use or non-use of technology). According to entanglement theories, participation of both human and nonhuman actors enacts realities and is shaping who we are in this society. This acknowledgement of the participation of nonhuman actors, in addition to human actors, provides a systematic way of tracing distribution of agency, along with accountability and responsibility.

For my dissertation, inspired by the posthumanist entanglement perspective that we “don’t really create technologies that functionally serves the needs of people but rather by configuring different material conditions we design humanity” [71], I seek to go beyond the framings of user-centered approaches that solely considers the user, to instead understand the nuanced socio-material configurations where older adults along with other nonhuman actors (including the technology or our design materials) intra-act. These understandings will, in turn, shed insights on how different human and nonhuman actors shape older individuals’ social relationships, their perception, use, and the design of these technologies.

1.2. Research Approach and Research Questions

In my dissertation, I investigate three threads of research. First, in Study 1, I examine how *ontological uncertainty emerges* as older adults *use* emerging technologies. In Study 2 of my dissertation, by adopting posthumanist perspectives I *attune to the agency of the nonhuman world* as older adults *use* of emerging technologies. For my final study of dissertation (Study 3), I investigate *the role of nonhuman actors* (in particular, design materials) in shaping older adults’ *participation in design workshops*.

Study 1: Older Adults' Ontological Categorization of Emerging Technologies

Some posthumanist HCI researchers have argued that emerging technologies such as IoT, AI, or virtual reality pose ontological uncertainty [71]. In the past, researchers have explored this phenomenon by examining how users ontologically categorize technologies that are designed to be human-like [100,101]. For example, in Kahn et al.'s new ontological hypothesis [101], researchers worked with children to understand their ontological categorization of social robots. Kahn argues that as children interact with social robots, they perceive the robot as “in between” living and not living, or simply not fitting either ontological category. Through this work, Kahn said that a new ontological category is emerging for technologies that are designed to be human-like. Although this work empirically indicates that an ontological uncertainty emerges as children use social robots, less is known about *why* or *how* this uncertainty emerges and *the implications* of such uncertainty for designing future technologies—which my first dissertation study sheds insights on. (Study 1 has been published at CSCW [164]).

In the first study, I examined this phenomenon of ontological uncertainty when older adults use a popular emerging technology i.e., AI-based conversational voice assistants at home such as Alexa on Amazon Echo or Google Assistant on Google Home. In this write-up, I also refer to these AI assistants as voice assistants. In this work (described in Chapter 4), I analyzed older adults *use* of voice assistants to examine individuals' perceptions with respect to ontological categorization of the technology, i.e., whether they perceived the voice assistant as object-like or human-like. Since, categorizing technology as human-like is closely associated with “personifying” the

technology [133], I also investigated if and how older adults personified these voice assistants. More specifically, I answered the following research questions:

RQ1: When do older adults ontologically categorize voice assistants as “human-like” vs. “object-like” (or nonhuman-like)?

RQ2: How do older adults personify voice assistants in their homes?

I deployed smart speaker devices in the homes of seven older adults and studied their use of the voice assistant over a three-week period. I collected data by conducting weekly in-person interviews and daily diary check-ins via automated phone calls, and collected usage logs from the Alexa app on the paired tablet. To answer the above research questions, I qualitatively analyzed the interview, diary, and usage log data. For data analysis, I found Epley et al.’s [65] “three-factor theory of anthropomorphism” as a useful analytic lens.

Findings of this work indicate that instead of straightforwardly categorizing the voice assistant as “human-like” or “object-like”, participants fluidly move between the two categories. This movement between ontological categories was based on different factors including characteristics of the voice assistant (such as nature of interaction) along with duration of use, the location in house, and moment of interaction. Qualities of the human, i.e., the user’s desire for social contact or affiliation also contributed to one’s ontological categorization of the assistant. Here, at a surface level, I noted how different human actors (e.g., the user), and non human actors (e.g., location in house) play a role in shaping individuals’ ontological categorization of the technology. I further explore this phenomenon of participation of human and nonhuman actors in the next thread of my research.

Study 2: A Posthumanist Perspective on Older adults' Use of Emerging Technologies

In the second study, I adopted posthumanist entanglement perspectives of Actor-Network Theory and Post-Phenomenology in data analysis to systematically analyze the socio-material configurations in which older adults *use* an emerging technology. In this work, I scoped the technology to focus on AI-based conversational voice assistants on smart speakers. More specifically, this thread of my research investigated a) how different human and nonhuman actors intra-act in configurations where older adults use emerging technologies, and b) the nuanced ways in which emerging technologies such as voice assistants mediate different relations between older adults and their larger world. As such, in this work, I answered the following research questions:

RQ3: How do different nonhuman actors shape, restrict, or enable older adults use of voice assistants?

RQ4: How do voice assistants mediate relations between older adults and their world?

I conducted interviews with twenty older adults who used a smart speaker-based voice assistant such as Alexa or Google Assistant. My analysis draws upon the theoretical orientation of two posthumanist entanglement theories used in the context of technology design [71]: Actor-Network Theory, and Post-Phenomenology. My analysis reveals how posthumanist entanglement perspectives can help us account for the nonhuman actors that shape older adults' technology use, as well as help us understand the nuanced ways in which emerging technologies mediate relations between older adults and their larger socio-material world. More specifically, my findings reveal that nonhuman actors, including materials as well as norms, shape older

adults' preferences for and use of voice assistants. Additionally, I found that the voice assistant plays an active role in mediating relations between older adults and their larger social world (including humans and pets), and this in turn shapes social practices around what it means to give company to pets, to live alone, or to give and receive care. Through this analysis, my findings empirically show how older adults, their technologies, and their socio-material worlds are entangled. Currently this work is under the final stages of review at ACM CSCW.

Study 3: A “More-than-human” Perspective on Older Adults’ Participation in Design Workshops

From Study 2, I learned that nonhuman actors play a significant role in shaping older adults' use of emerging technologies and in terms of mediating relations between older individuals and their larger world. Hence, for Study 3, I extend to adopt posthumanist perspectives to investigate the role of nonhuman actors in design workshops involving older adults. For study 3, I chose the context of design workshops because involving older adults in technology design through participatory design workshops has been a popular approach in aging research in HCI (e.g., [131,165,209]). Yet, in aging research in HCI, often a focus of these design workshops is on older adults alone, with tropes such as older adults' experience challenges in brainstorming about future technologies [130,131], or it is harder to keep older adults focused on the topic of discussion [131]. Here, research rarely examines the role of actors, beyond older adults participating in the workshop, who could be contributing to undesired realities. Further, the design concepts and ideas that emerge from workshops eventually make their way into older adults' homes i.e., researchers build technologies based on the workshop ideas. Here,

it might be fruitful to also understand how entities beyond older adults' (in particular nonhuman entities) play a role in shaping design ideas.

Therefore, in my final dissertation study (Study 3), inspired by the theoretical orientations of Actor-Network Theory, I adopt a *more-than-human* perspective to investigate the socio-material configurations in which older adults engage in *designing* technologies through participatory approaches. More specifically, the research question that I answer in this study is:

RQ5: How do different human and nonhuman actors, particularly design materials, participate and shape design activities involving older adults?

I investigate the role of different human and nonhuman actors, particularly design materials, in shaping design workshops involving older adults. I analyzed data from two IoT-focused design workshops involving 32 older adults by attuning to the agency of both human and nonhuman actors and how they contribute to unfolding and shaping of the workshop. My analysis reveals the nuanced ways in which designs materials act in relation to older adults: from facilitating creative brainstorming, to limiting creative brainstorming, to leading to clashing of ideas, and contributing non-participation in the design activity. Attuning to nonhuman agency also surfaced the salient ways in which unexpected actors including bodily movement along with words, and our research apparatus such as a video camera, become design materials. My analysis also sheds light on how, beyond design materials, other socio-material actors including material objects at home and current IoT technologies become inspiration for design and play a role in how the design workshop unfolds.

1.3. Contributions

As one of the preliminary works in HCI that adopts a posthumanist perspective in the context of aging, my thesis sheds evidence on how older adults and their larger socio-material worlds are entangled, and the role that nonhuman actors play as older adults use emerging technologies or engage in designing emerging technologies. These empirical findings contribute to the growing body of work that seeks to understand older adults' use and perception of emerging technologies [8,23,143,167,190], and how older individuals engage in design activities [131,138,165,211]. My findings also uncover how emerging IoT technologies such as voice assistants pose ontological uncertainty when used by older adults. Overall, through my thesis, I provide evidence of how aging research in HCI and CSCW will benefit from these posthumanist theoretical orientations, and *shed insights on the new directions that HCI researchers working on aging can take*. The specific contributions from each study of my research are:

Study 1: Older Adults' Ontological Categorization of Emerging Technologies

The findings from this first study of my work contribute to an empirical understanding of how ontological uncertainty emerges with use of emerging AI-based technologies such as conversational voice assistants—an underpinning posited by Entanglement HCI. Specific contributions of this work include:

- 1) an understanding of how participants in this study ontologically categorize voice assistants as “object-like” or “human-like” and factors associated with the

movement of perceptions between these categories. This provides an empirical understanding of how emerging technologies such as conversational voice assistants pose ontological uncertainty.

- 2) Recommendations for designing voice assistants with ontological category in mind.
- 3) A discussion of the personification of voice assistants in relation to previous established theories of anthropomorphism and ontological categorization.

Study 2: A Posthumanist Perspective on Older adults' Use of Emerging Technologies

In being one of the preliminary works that adopts posthumanist entanglement theories in the intersection of technology and aging, the second study of my research contributes the following:

- 1) An understanding of how emerging technologies, older adults, and their larger social world are entangled. Through this, I provide implications for design that think in terms of the relationships that older adults develop with and through their technologies.
- 2) A characterization of the role of nonhuman actors (including material actors, and norms) in shaping older adults' use and preference of emerging technology to advocate re-framing accountability of undesired realities associated with technology use to nonhuman actors as well, which in turn can help us distance from the deficit model of aging.

Study 3: A “More-than-human” Perspective on Older Adults’ Participation in Design Workshops

Findings from Study 3 provide evidence of how different nonhuman actors play a role in design workshops with older adults and contribute to the growing body of HCI and aging research that seeks to understand older adults’ engagement in participatory design activities (e.g., [131,138]). More specific contributions of this work include:

- 1) An understanding of how different design materials (including traditional materials and unexpected materials) act in relation to older adults: from facilitating creative ideation, to limiting creative brainstorming, to leading to clashing of ideas, and contributing to non-participation in the activity.
- 2) A characterization of the salient ways in which currently available commodity IoT technologies, as an actor, shape older adults’ participation (or non-participation) in design activities.
- 3) Provide methodological recommendations for engaging older adults in design activities by: a) proposing a shift from designing technologies in isolation to designing meaningful configurations of which technology is a part of, and b) re-thinking the concept of representational artefacts when engaging older adults in designing IoT technologies.

1.4. Organization

This thesis is organized as follows: chapter 2 describes the different ways of thinking (or paradigms/waves) in HCI and how that has led to unfolding of the Fourth Paradigm inspired by posthumanist entanglement thinking. Chapter 3 covers literature review

related to a) how aging research has shaped across the different HCI paradigms, b) detailed description of posthumanist entanglement perspectives and how these perspectives have been adopted in HCI and CSCW, and c) since much of my work focuses on the topic of IoT and conversational voice technologies for older adults, I also review this body of work. In Chapter 4, which reports on the first study of my dissertation (Study1), I analyze older adults use and perception of voice assistant technologies to understand when and how ontological uncertainty unfolds. In Chapter 5 and 6, I adopt a posthumanist perspective to analyze data focused on older adults' use of voice assistants (Study 2, Chapter 5), and older adults' participation in design workshops (Study 3, Chapter 6). Finally, in Chapter 7, I conclude with a summary of my work, the overall contributions of my thesis, and reflections on the methods and the theoretical perspectives that I adopted in this thesis.

Chapter 2 : Evolution of Posthumanist Entanglement Perspectives in Human-Computer Interaction

2.0. Overview

In this chapter, I provide a brief overview of how Human-Computer Interaction (HCI) research has been shaped by different ways of thinking (from positivist inspired First Wave to Constructivist Third Wave) and the corresponding knowledge production practices. By doing so, I contextualize how these prior ways of thinking led to evolution of posthumanist entanglement perspectives which is now being proposed as the Fourth Wave in HCI. Many of the terms and concepts I describe in this chapter (e.g., ontology, epistemology, posthumanist perspectives) relate to my own research as well.

2.1. Introduction

Before describing different ways of thinking and knowledge production practices that has shaped HCI research and led to evolution of posthumanist thinking, I need to describe a few terms necessary to understand the evolution of paradigms: ontology, epistemology, and the word paradigm itself. I first heard the word “paradigm” during final year of Masters in HCI in 2017. It introduced me to the different ways of thinking in HCI. During that time, researchers had delineated three “paradigms” or “waves” that have shaped HCI research over the past decades [19,20,88]. *Paradigms*, which can be thought of as philosophical framework that shapes a researcher and their research approaches, are based on unique ontological and epistemological orientations (further described below). I’ll describe these paradigms later in the chapter.

Next, are the terms of ontology and epistemology. I first heard the term ontology and epistemology during my first year starting as Ph.D. student in Information studies. *Ontologies* deal with the study of being, how things exist in reality and what

categories they belong to; in relation to HCI paradigms ontology has been referred to as how researchers have categorized human and the nonhuman world [71]. *Epistemology* refers to the theoretical perspective that shapes the knowledge production practices, in other words can be thought of as theoretical background shaping methodologies [47]. Below, I go deeper into explaining the different epistemological and ontological stances within the context of describing each paradigm in HCI.

2.2. Different Ways of Thinking in HCI: Waves in HCI

HCI, as a field, has roots in engineering, cognitive science, and social sciences, and is highly heterogeneous in terms of technology, application contexts, theoretical underpinnings and methodological approaches. As such, different ways of thinking, or paradigms, have shaped HCI research over the past few decades. Each paradigm differs, particularly in terms of epistemological positions around producing knowledge, and their understanding of the relationship between humans and their material world (i.e., ontologies). Below, I also reflect on how each HCI wave fits within the established general research paradigms such as those of positivism, interpretivism, or critical [47].

As I describe the different paradigms below, it is important to note that ***each of these paradigm (or wave or way of thinking) is not mutually exclusive, and they co-exist***. Even today as researchers are starting to adopt the Fourth Paradigm, there are researchers working in the First Paradigm to conducting equally meaningful and important work. With respect to these paradigms not being mutual exclusive, I want to highlight that a researcher's way of thinking can be shaped by multiple paradigms. This is supported by HCI papers that have conducted mixed method analysis involving rigorous experiments (aligning with First Wave), and qualitative analysis

understanding the lived experiences and values of the user groups they work with (aligning with Third Wave) [119].

The First Wave: starting with positivist, postpositivist perspectives

The First Paradigm considers interaction is a form of “human-machine coupling” that needs to be optimized in a “human-factors way” [59,88]. Along the First Wave of HCI, computer systems and humans are considered as separate entities and the goal is to design effective interactions between the two. This aligns with the modernist view of social sciences, where the ontological stance is that subject and the object are considered to be separate. Epistemologically, the perspectives of this wave are shaped by *Positivism*, *Post positivism* [59], and guided by objectivism which poses that there is existence of a true reality, and there should be minimal biases and influences in research studies to understand this true reality. As such, methodologically, rooted in human factors and ergonomics, the human being was the subject of interest to be studied through rigid testing, thereby making controlled experiments a popular research method [3].

The Second Wave: a critical perspective

The First Paradigm focuses on ergonomics and human factors for the purpose of designing interactions between humans and computer. But, it does not take into account the information processing abilities of the human which can have implications of technology design. To account for that, the Second Wave stems from cognitive science revolution to understand how humans process information by taking into account aspects of attention, memory, problem solving and creativity [19,21,59]. In addition to thinking about the pragmatic aspects of First-Wave, researchers include theoretical

considerations with respect to humans and technology. As such, there is a focus on theory building, with some of the popular theories of this paradigm including Distributed Cognition [90] and Activity theory [151].

With the Second Wave, humans and machines are still categorized as separate, and humans remained the subject of interest (aligning with modernism's ontological stance). Epistemological stance is shaped by the *critical paradigm* [59], which is skeptical of truth or reality claims, and seems to float between Positivist and Constructivist paradigms [59]. This critical perspective shapes how this wave views reality: there is no consensus on whether there is a true reality and that the study of human mind and mental processes is multifaceted [59]. This epistemological stance shapes the methodology which is divided between experimental modes of inquiry and more naturalistic inquires such as participatory design (PD), prototyping, and contextual inquiries [19,21,59]. While researchers still adopt quasi-experimental methods, many also adopt rich qualitative approaches and go beyond human factors to focus on concepts such as situated actions, shared practices, and context.

The Third Wave: embracing constructivist and interpretivist perspectives

The First and Second Waves contribute to human factors and cognitive aspects of design, such as standardized fit of mouse to size of human hand (human factors aspect), or designing an information infrastructure of a website keeping in mind the cognitive effort of performing a task. Yet, what these paradigms fail to capture is detailed rich description of specific situations in the real world. As new forms of technology emerged that are ubiquitous and pervasive in the real world, or take into account emotion (i.e., affective computing), it marked the way for the Third Wave. The Third

Wave, with its roots in feminist philosophy of science [88], prioritizes detailed rich descriptions of specific situations as valuable outcome of research. To do so, Third-Wave research focuses on interaction that is situated in the social and bodily complexities of a messy, real world. In this paradigm, topics that had previously not been considered in HCI are now considered important and necessary for technology designing, including topics such as culture, values, emotion, non-work and leisure aspects, lived experiences, along with acknowledgement of researcher roles [20,59]. To account for the complex messiness of the real world, the concepts of context, situated knowledge [84], and embodiment (inspired by Heidegger's phenomenological position of the body as immersed holistically in the physical environment [137]), became popular in the Third-Wave [56].

Some works of the Third-Wave challenge the ontological positioning of the prior paradigms that considered humans and technologies as separate. Works that adopted Heidegger's embodiment concept where the human is immersed in the physical environment (the nonhuman aspect) [137], overcome the previous mind-body dualism [71,205]. This very stance of human being immersed in the nonhuman physical world distances from the stance that humans and their material world are separate [137]. Some researchers have associated this ontological positioning with *post-modernism* [55,137], where unlike modernism, the subject and object do not have a fixed essence and 'reality' is co-shaped by the instruments with which it is perceived [205].

The Third-Wave also saw a change in epistemological and methodological perspectives to better capture above mentioned topics of interest such as lived

experiences, values, or emotions, which can be highly subjective. As such, aligning with the *constructivist and interpretivist paradigms* [59], the Third Wave recognizes pluralism in knowledge claims, where there can be multiple socially-constructed realities [59,88] that are subjective and influenced by the context. Here, qualitative methods allow the researcher to be immersed in the users' worlds and understand their lived experiences, their emotions, and the situated knowledge.

The Fourth Wave: towards posthumanism, post-qualitative, new materialism

While the Third Wave recognizes the plurality and situated forms of knowledge to account for the messy real world, the focus remains on the human, humans' emotions, and lived experiences. Therefore, the approach in Third-Wave (and in prior HCI waves) is largely human-centered. And this is evident in the name of our field and its premier academic venues (HCI for *human*-computer interaction, or CHI for *human* factors in computing systems, with focus on “*user-centered*”, and “*human-centered*” approaches). This way of thinking that centers the *humans* in research and analysis has been successful because historically there were computer systems and humans, and the traditional goal of HCI research was to design effective interactions between the two. But, emerging technologies such as artificial intelligence, social robots, or neuro-implants, get entangled with humans and their world, and are making boundaries between technology and humans increasingly fuzzy: implant technologies involving material manipulation of bodies making it hard to distinguish between the human and the nonhuman aspect, or humans seeking emotional relationship through nonhuman social AI agents [63].

Currently, we are living in a world where it is hard to separate human and nonhuman (e.g., neuro implants), or even identify where the human ends and the technology starts (e.g., in a virtual reality metaverse). Some researchers are arguing that we cannot undermine the agency of the material world, and the role of nonhuman entities (which includes technology, policies, norms etc.) in shaping our lives and societies [15,45,71]. With this, some researchers in HCI have been adopting *Posthumanist views*, proposing this turn to nonhuman entities as the Fourth Paradigm in HCI. A core aspect of the proposed Fourth Wave is to acknowledge that in addition to human actors, nonhuman actors play an active role in unfolding of the reality that we see, where the human and the nonhuman world are closely interrelated. Frauenberger, in a recent article, reviews four different Posthumanist entanglement theories which posit that humans and their things are ontologically inseparable [71]: Actor-Network Theory [32], Post-Phenomenology [55,207], Object-Oriented-Ontology [85], and Agential Realism [104]. These theoretical perspectives can help us understand role of nonhuman world and the salient human-technology-world relations that constitute humans and nonhumans.

Next, coming to ontological and epistemological positioning of this paradigm. Earlier I mentioned that the different waves and paradigms co-exist, yet there still continues an under the surface tension between knowledge production practices in HCI: with some positivists (aligning with first wave) and some constructivists (aligning with third wave) being skeptical of the knowledge production practices of each other. Here, the Fourth Wave rejects both the positivist notion of one objective reality (because there can be multiple enacted realities and many ways of knowing these realities) and

the interpretivist notion of socially constructed reality (because of its underlying assumption that only humans have the agency and power in interpreting the reality). As a way to go beyond the dichotomy between social constructivism and positivism, posthumanist scholars have embraced *relational and performative ontology—ethico²-onto-epistemology* [104]. Here, performativity [12] is the central mechanism by which not only things, including us, exist, but also knowledge comes about—thus collapsing ontology and epistemology. This relational and performative ontology offers an alternative to the dichotomy between social constructivism and independent reality (or interpretivist vs. positivist perspectives), because according to this paradigm, nonhuman and human actors enact³ or construct a reality, and nothing is objective truth or socially constructed. In terms of ontologies, humans and the material world are not separate but are related to each other and together enact realities. While, I acknowledge this epistemological and ontological positioning of the Fourth Wave, in this thesis I do not go deep into these philosophical discussions, and instead draw out how posthumanist entanglement perspectives shed pragmatic findings that benefit aging research in HCI.

With respect to methodologies and analysis approaches, the Fourth Wave is still unfolding. What this means is, this way of thinking is still in the nascent stages and researchers are still discussing how to adapt our current ways of doing research in this new paradigm (e.g., adapting content analysis to uncover nonhuman actors in analysis [72]). For example, a panel at CHI 2022 was situated around discussing methodologies

² Ethical practices are also inseparable from epistemology and ontology. Acknowledgement of the action of nonhuman world along with humans, provides a systematic way of tracing accountabilities [71]

³ The words “enact” or “construct” align with the performativity underpinning of this paradigm.

of more-than-human design (MTHD) [45]. In the article of entanglement HCI, Frauenberger shares the same sentiment of how methodologies in this paradigm need to be developed: “we need to develop such techniques to enquire into, understand and work with the many ways in which humans and things mutually depend on each other...[and] how such methods could be made effective at scale” [71]. My dissertation, which adopts a posthumanist perspective and uses different analysis approaches, sheds new insights on methodological considerations for researchers working in this Fourth Paradigm—something I discuss further in the Conclusion (Chapter 7).

Chapter 3 : Related Work

3.0. Overview

In the previous chapter I described the different paradigms in HCI that have shaped HCI research till date and have led to the evolution of posthumanist entanglement perspectives in HCI. In this chapter, first, given that my research is scoped to aging research in HCI, I contextualize how research in aging has unfolded along the different paradigms and the opportunities in adopting posthumanist perspectives in aging. Next, I provide a detailed overview of these posthumanist entanglement perspectives in HCI, followed by an overview of the different contexts in which researchers have adopted these perspectives in CSCW and HCI. Finally, since my research is grounded on emerging Internet of Things technologies (IoT), I review research on design of IoT technologies (in particular conversational voice technologies) for older adults.

3.1. Aging Research in HCI Along Different Paradigms

In the previous chapter, I described the established paradigms or ways of thinking and doing research in HCI. In this section, I trace how *aging research* in HCI has shaped along these Three Paradigms over the past few decades. In the 1990's and early 2000's, most research focused on age-related decline of older adults associated with physical and cognitive conditions and how that affects use of digital technologies. The resulting research papers used systematic testing approaches and focus on designing technologies that are easy to use for older adults to support age-related decline (e.g., [6,51,78]). This focus aligns with the First Wave in HCI focused on usability, studying humans through rigid guidelines and testing. But, since the beginning of 2010's, we see a difference in how some HCI researchers viewed aging, and started thinking about

the context in which the technology would be used by older adults, such as situated reminder systems [50]. Researchers also started including older adults in the design process through participatory approaches (e.g., [19,47,48,75]). This change in approach aligns with the Second Paradigm in HCI where the focus was on information processing abilities, context of technology use and used methods such as participatory design. Starting around this time and continuing until today, researchers are acknowledging the diversity in terms of life experiences that older adults' have [23,76], and focus on different aspects of older adults' lives including their home environment (e.g., [1,12,13]), leisurely activities such as arts [45] or crafts [34], and their lived experiences (e.g., [5,15,44,64]) to understand opportunities for technology design. This shift in focusing on individual experience and aspects of leisure and home environment aligns with the Third Paradigm in HCI.

Overall, we see how across three decades, the narrative of designing technologies for older adults has evolved from thinking of older adults as a homogenous population and in terms of physical and cognitive decline to one where HCI researchers stress the diversity of individual experiences that older adults have, center a need to understand their lived experiences, and are actively including them in designing technologies. Although the way researchers view older adults has evolved over the decades, much of our research approaches still remain human-centered where the role of nonhuman entities in older adults' worlds and how they mediate and shape relations between older adults and their larger world are rarely examined. Recently, critical gerontology scholars have argued to adopt posthumanist perspectives to envision aging as a distributed process involving multiple social, material, and

nonhuman entities [4]. An analysis of older individuals using a transportation service using Actor-Network Theory [32] provides a glimpse of the complex and fluid actor network of people, rules, norms, practices, and objects that can facilitate or hinder travel [134]. This turn towards posthumanism in aging is beginning to mark its way in HCI and CSCW. One study [120] adopted a diffractive analysis inspired from Barad's Agential Realism (a posthumanist entanglement theory) to analyze data from IoT design workshops with older adults [120]. Their findings show how the same data can yield different understandings and attuning to these differences offer new insights for aging-in-place, in terms of thinking about home maintenance and gatekeeping in research [120]. There still remain many opportunities to employ posthumanist perspective (further described below) in aging research, and in this dissertation, I provide insights on some of the roles of nonhuman entities, and how they mediate relations between older adults' and their larger socio-material world.

3.2. Detailed Overview of Posthumanist Entanglement Perspectives

In proposing posthumanist entanglement perspectives (or "Entanglement HCI") as the Fourth Paradigm in HCI, Frauenberger argues that emerging ubiquitous technologies such as Internet of Things (IoT), neuro-implants, and artificially intelligent devices generate ontological⁴ uncertainties. One aspect of this ontological uncertainty that Frauenberger argues is that the "boundaries between humans and their technology is becoming increasingly fuzzy" [71]. This concept of a fuzzy ontological boundary

⁴ Ontologies deal with the study of being, how things exist and what categories they belong to

between human and technology is in stark contrast to the traditional way of thinking in the prior HCI paradigms where the “human” or the “social” are separate from the “material” or the “technology” [94]. Posthumanist entanglement HCI argues that humans and their technologies are ontologically inseparable [71].

To understand this concept, consider a neuro-implant that can connect to individuals’ brain to control biomedical prosthesis. In this situation, Entanglement HCI would argue that it becomes difficult to ontologically separate where the human is ending or where the technology is starting: if the human moves the prosthetic arm, is the human—who decided to use this technology in the first place—contributing to the action of moving the arm, or is it the technology moving the arm? Here, posthumanist entanglement HCI would argue that the technology gets entangled with the human, and together contribute to the reality we see, i.e., the movement of the arm. A key underpinning of entanglement perspectives in HCI is to acknowledge the agency of nonhuman actors as equal contributors to the reality that we see. Given that humans and their technologies are ontologically inseparable, entanglement perspectives in HCI pushes us to think of morality, and accountability differently: since both human and nonhuman actors participate to enact realities and shape who we are, ethics and morality is not something that only humans can possess. Giving example of a technology that uses sensors to collect and share user data, Frauenberger describes how nonhuman actors such as availability of low-cost sensors and lack of legislation around data sharing could be held accountable for contributing to the phenomenon of technology collecting user data [71].

Several concepts from posthumanist entanglement HCI became key to shaping my dissertation. In my first study, I explore the concept of *ontological uncertainty* with respect to an emerging technology, i.e., conversational voice assistants. In Entanglement HCI, Frauenberger mentions that emerging technologies pose ontological uncertainty, yet empirically it is unclear how this uncertainty emerges with technology. My first study provides empirical evidence of how ontological uncertainty unfolds when older adults use conversational voice assistants. This study provides an understanding of how older adults ontologically categorize voice assistants.

For my second and third study the concept of *actors*, specifically nonhuman entities as actors and nonhuman agency shaped my analysis. I describe these concepts in detail in Study 2 and Study 3. But, briefly describing, *actors* can be anything that can contribute to an action. Actors can be human or nonhumans. Example of nonhuman actors include materials, artefacts, or even legal rules. In Study 2, I investigate how different human and nonhuman actors shape older adults' use of a popular emerging technology: conversational voice assistants, and how these voice assistants have agency to mediate different relations between older adults and their larger socio-material world. In study 3, I attune to agency of actors (particularly nonhuman actors) in shaping design workshops involving older adults. In Study 2 and Study 3, I also borrow other commonly used terms in entanglement HCI: *phenomenon*, and *configurations*. *Phenomenon* is the concept used in Entanglement HCI to refer to the specific results that unfold because of intra-actions⁵ between different human and

⁵ *Intra-action* is a term coined by Barad to be used instead of the popular term "interaction". In Entanglement HCI, Frauenberger adopts this term of "intra-action" instead of "interaction". Thinking in terms of intra-action means giving up subject-object dichotomies, as intra-acting bodies are not completely separated from each other, and agency is not something that is possessed by individual

nonhuman actors. In other words, a phenomenon is the reality enacted. *Configurations* are the hybrid networks in which human and nonhuman actors *intra-act*.

3.3. Adoption of Posthumanist Entanglement Perspectives in CSCW and HCI

Many CSCW and HCI researchers have adopted posthumanist entanglement perspectives (e.g., [17,72,91,92]) in order to account for *the more-than-human* and the *relations* between humans and nonhumans. Aligning with the posthumanist perspective of how humans and their tools are inseparable, researchers have argued that the process of design is entangled with the material worlds from which it originates [95], and that artists and their tools exist in “creative entanglements” [37]. Rosner’s work on materiality extends our understanding of how materials are not passive entities, but also “perform” by enabling or constraining certain actions [176]. Building upon the notion of nonhuman agency in Actor-Network Theory, researchers have sought to understand the agency of materials in interaction design (e.g.,[73,196]). Beyond the design context, ANT-based approaches have helped to understand nonhuman agency in other settings, such as technology adoption and digital literacy in underserved communities [115] or in understanding the role of objects in intergenerational communication [72]. Researchers have adopted Post-Phenomenological views of humans-technology relations [55,207] to examine virtual reality (VR) experiences [208] and in context of machine learning [17,125]. By adopting a relational perspective to think of neural

things or beings, but instead it emerges through relationships. The traditional term of “interaction” in HCI translates to “action in-between”, indicating what is going on “between” a human being and a technological artifact. This definition assumes a separation between humans and their technology [207]. But, entanglement perspectives in HCI recognize that human and nonhuman actors (including technology) cannot be separated, and rather act in relation to each other to enact reality, and instead uses the term “intra-actions” [104,220].

networks, Leahu argues that instead of focusing just on the entities there is value in accounting for the relations between the entities as well [125]. Benjamin et al. use a Post-Phenomenological framework of human-technology relations in context of Machine Learning (ML) uncertainty [17]. Vindenes and Wasson's [208] Post-Phenomenological analysis reveals how VR technologies mediate human experiences both within the virtual world and the outside world [208].

Overall, the works described above show a glimpse of how researchers have adopted posthumanist entanglement perspectives in different contexts, varying from creative design to technical areas such as machine learning and neural networks. In each of these works, taking a posthumanist perspective offers new insights to bodies of research which traditionally separate human and nonhuman. For example, Fuchsberger et al.'s work attunes to material agency in intergenerational remote communication, and provides design sensitivities that accounts for nonhuman objects such as designing "quantified toys" that have a physical and a parallel digital life, "whose conditions could be monitored or even enhanced by catering for both the physical object and the digital version" [72]. In the context of aging research, traditionally technologies have been designed for aging bodies, without a recognition of how older adults' bodies are intertwined with their socio-material worlds (e.g., medication reminders that lie stationary at a particular location in the house, not accounting for the mobile lives older individuals have outside of their homes). We know little about the role of nonhuman actors in older adults' worlds, or how older adults and these nonhuman actors, particularly technologies, shape each other. Therefore, adopting posthumanist

entanglement perspectives in context of aging research might shed new knowledge about designing technologies for aging—something my dissertation contributes to.

3.4. Older Adults and Emerging Technologies

In this dissertation, I scoped the technology to focus on Internet of Things (IoT) technologies (in study 3 on design workshops), whereas Study 1 and Study 2 focus on a specific emerging IoT technology: conversational voice assistants on smart speakers. Therefore, below, I review past work on older adults and IoT, and conversational voice assistants for older adults.

3.4.1. Internet of Things Technologies for Older adults

HCI designers have sought to support older adults to age-in-place with connected technologies. Many context-sensing home-based systems have been designed, such as sensor laden environments [10,107,150,177], monitored appliances such as coffee makers [128], augmented clocks [6,171], and notification or reminder systems [42,57,139]. One of the earlier works was the Digital Family Portrait [150,177], which facilitated a caregiver to monitor the day-to-day activities of their older parent through a picture frame using sensor-based information. Supporting health has also been of interest, in areas such as medication adherence [126,128,160], rehabilitation support [7], and health monitoring devices [52]. A common thread between these technologies is the use of sensors to collect contextual information about older adults' homes or daily activities to support aging, often focusing to support caregivers as primary stakeholders [10,173].

A core theme in IoT based research is examining the context of the home as the environment in which technologies are being used [3,28,186,203]. Following ethnographic approaches, researchers are working to understand older adults' home environment [3,28] and co-designing customized IoT with older adults in their homes [3]. As an example of a system that integrates an understanding of older adults' routines and the meaning that they associate with objects in their homes, the Messaging Kettle [29] supports intergenerational communication over a distance through an augmented tea kettle. These examples indicate how certain objects at home (e.g., a kettle) might be playing a key role in older adults' preferences with respect to IoT technologies—something I examine in-depth in my work.

Even as researchers investigate these technologies, there appears to be a reluctance by older adults to use many technologies designed for them [33,54,163]. Moreover, research suggests that older adults do not necessarily find such aging technologies useful, at times even rejecting them for reasons such as added work of using them (e.g., [122]) or lack of usefulness or need (e.g., [41,77,111,154]). Informed by this body of research, in my work, I pay close attention to whenever such tensions emerge in a research study and seek to understand how different actors contribute to those tensions.

A common theme in all of the above mentioned research studies is to focus primarily on the user, i.e., older adults. Thereby, often researchers have followed user-centered approaches. My work, on the other hand, argues and uncovers the value in acknowledging the different ways in which actors beyond older adults, including human and nonhuman actors act to unfold the reality we see.

3.4.2. Conversational Voice Assistants and Older Adults

Conversational voice assistants constitute an example of emerging IoT technologies that have become very popular in the recent years and have garnered much attention within the research community in the past few years (e.g., [36,76,162,168]). Much of the findings from my dissertation research are situated around older adults' use of these conversational voice assistants. Hence, here, I review past research on conversational voice assistants and older adults.

Within the past few years, older adults have received significant attention as one population who might benefit from using voice assistants embedded in smart speakers (e.g., [143,180,185]). Overall, research has shown that in general older adults perceive voice interaction as easy to use, efficient and convenient [30,108,114]. Researchers have explored the different purposes for which older adults use these assistants, finding that looking for online information is the most common [69,167], indicating how voice assistants could support older adults through easy access to digital information [69,167,190]. Researchers are discussing the potential in using voice assistants to support older adults' health through finding health information online [31,167], medication monitoring, and reporting health data to doctors [38]. Voice assistants features such as maintaining grocery lists or calendars can empower older adults with mild cognitive impairment (MCI) and their care partners [219].

In addition to looking at the benefits of using voice assistants for older adults, researchers have pointed out various challenges and possible barriers to adoption. For older adults who are deaf or hard of hearing, a high pitched female voice or the speed at which the agent talks can be inaccessible [18]. Speech recognition may not work

with vocal characteristics which can occur with cognitive impairment, such as pauses or hesitation [38,109]. Remembering wake words and composing concise commands for a task has been noted as challenging for older adults [108]. And, some older adults have expressed concerns regarding a lack of understanding of how these technologies work [23]. Beyond these usability and accessibility issues, some older adults simply may not find any benefit or value in using these technologies, sometimes considering voice assistants more of a nuisance than of help [143]. Collectively, this body of work helps understand the different features of this technology that can benefit older adults, and the current challenges and barriers in adopting these technologies. My work, on the other hand, is inspired by Entanglement HCI thinking that we “don’t really create technologies that functionally serve the needs of people” but instead, “designing technologies is designing human beings”, where technologies through their relations with humans contribute to shaping human existence [71]. As such, through this work I seek to understand the nuanced *relations* that voice assistants mediate between older adults and their larger world.

Beyond investigating functionality and usability, some past work indicates the possibility of this technology fulfilling some social roles in older adults’ homes [158,164,219]. Oh et al. [158] found that in contrast to younger adults who view voice agents more as a tool, older adults’ viewed the agent as a companion. Voice assistants can play an informal social role as a conversational partner by engaging older adults in small talk [219]. Some older adults might personify these assistants – and older adults’ ontological categorization of the assistant as “object like” or “human like” is not straightforward [164]. Rather, this categorization can change based on factors such as

the moment of interaction or the location of use in the house [164]. These past works suggest voice assistants might be a form of emerging technology where an entanglement between older adults and their technology might be coming into play, something my findings illuminate further.

Chapter 4 : Older Adults' Ontological Categorization of Emerging Technologies

4.0. Overview

This chapter describes the first study of my dissertation which provides an understanding of when and why ontological uncertainty unfolds as older adults use emerging voice technologies. I scoped the technology to AI-based conversational voice assistants. More specifically, in this chapter my primary research question was: *When do older adults ontologically categorize voice assistants as “nonhuman-like” vs. “human-like”?* To answer this research question, I qualitatively analyzed data from a three-week deployment of Amazon Echo Dot devices in older adults' homes. My data included interviews, phone based diary entries, and older adults' Alexa usage logs. My role in this study was: leading the study design, data collection, analysis, and write up of this work which is published at ACM CSCW 2019⁶ [164] (this chapter is adapted from the published paper).

My findings indicate that participants' ontological categorization of voice assistant, Alexa, is nuanced with particular categorization of Alexa as “object like” (i.e., nonhuman-like) or “human like” triggered in relation to the nature of interaction (e.g., responsiveness) and the user's desire for social connection or companionship. Additionally, I found that there is movement between these ontological categories associated with the duration of using the voice assistant, the location of the voice assistant in house and its perceived presence, and the moment of interaction with the

⁶ Co-authors of the submitted paper are: Dr. Leah Findlater and Dr. Amanda Lazar. As the first author, I led the study design, data collection, literature review, analysis and write up of this work.

assistant. Based on these findings, I discuss the implications for designing voice technologies with ontological categorization in mind.

4.1. Introduction

In Entanglement HCI, Frauenberger [71] mentions that emerging technologies such as artificial intelligence, internet of things, can generate ontological uncertainties. Yet, in his work and in others, we lack details of why this ontological uncertainty unfolds with emerging technologies. The first study of my dissertation provides a nuanced understanding of how ontological uncertainty emerges when older adults' use conversational voice assistants (a popular emerging technology). More specifically, this chapter of my dissertation provides an understanding of when and why older adults ontologically perceive emerging voice assistant technologies as “object-like” vs. “human-like.”

As embodied personified computational systems (e.g., social robots, conversational voice assistants) become pervasive, researchers in Human-Robot Interaction have begun investigating how users ontologically categorize these technologies. For example, Kahn et. al [101] argue that as children interact with social robots, a new ontological category is emerging. In their studies [101], participants perceived the social robot “in between” living and not living or simply not fitting either ontological category. Although this work empirically indicates that an ontological uncertainty emerges as children use social robots, less is known about *why* and *how* this uncertainty emerges and *the implications* of such uncertainty for designing future technologies. In the first study of my dissertation, I work with older adults to further examine this phenomena of ontological uncertainty with respect to conversational

voice assistants that has often been considered as human-like and associated with social roles (as indicated in prior research [133,169]). More specifically through my findings, I seek to provide an understanding of what possible factors contribute to ontological uncertainty. I discuss the implications of designing with ontological uncertainty in mind. As such one of my research questions is: ***When do older adults ontologically categorize voice assistants as “nonhuman-like” vs. “human-like” (RQ1)?***

Perceiving the voice assistant as “human-like” is closely associated with personification of the technology— another salient phenomenon that I also investigate in this chapter. Understanding how, when, and why people personify voice assistants has implications for how people engage with these devices in their homes, as well as how to support technology-mediated social interactions for different user groups—a long standing CSCW and HCI research interest. As voice assistants become increasingly popular, there is an opportunity for researchers to examine how these devices might support social interactions for older adults. As such, my second research is: ***how do older adults personify voice assistants in their homes (RQ2)?***

I analyzed qualitative data from a field deployment study to answer the above research questions. I deployed smart speaker devices in the homes of older adults and studied their use of the voice assistant over a three-week period. I conducted weekly in-person interviews and daily diary check-ins via automated phone calls, and collected usage logs from the app on the paired tablet. In this study I analyze this data to understand a) older adults’ ontological categorization of the voice assistant, and b) personification of Alexa by these users.

I found that two of Epley’s factors from their framework on anthropomorphism [65] are applicable in context of voice assistants, explaining how knowledge built up over the user’s lifetime, affordances of the voice assistant and the smart speaker, and emotional states of the user such as loneliness affect personification. The findings indicate that the ontological categorization of voice assistants is nuanced with particular categorization of Alexa as “object like” or “human like” triggered in relation to the nature of interaction (e.g., responsiveness) and the user’s desire for social connection or companionship. Additionally, I found that there is movement between these ontological categories associated with the duration of using the voice assistant, the location of the voice assistant in house and its perceived presence, and the moment of interaction with the assistant.

4.1.1. Contributions

The findings from this first study of my dissertation contribute to an empirical understanding of how ontological uncertainty emerges with use of emerging AI-based technologies such as conversational voice assistants—an underpinning posited by Entanglement HCI. Additionally, this work also contributes growing body of HCI and CSCW research that seeks to understand how voice assistants fit into the complex social environment of the home. More specifically, the primary contributions of this work include:

1. An understanding of how participants in this study ontologically categorize voice assistants as “object-like” or “human-like” and factors associated with the movement of perceptions between these categories. This provides an empirical

- understanding of how emerging technologies such as conversational voice assistants pose ontological uncertainty.
2. Recommendations for designing with ontological category in mind for older adults.
 3. A discussion of the personification of voice assistants in relation to previous established theories of anthropomorphism and ontological categorization.

4.2. Background on Anthropomorphism of Technology

In this work, I investigate how older adults ontologically categorize their voice assistant, and how they personify or anthropomorphize their voice assistant. Ontological categorization refers to categorizing the technology as “human-like” or “object-like” (i.e., nonhuman-like) [101]. Since, the phenomenon of ascribing “human like properties, characteristics, or mental states” to “nonhuman agents and objects”, has been investigated under the theme of anthropomorphism, I first review this body of literature.

The term anthropomorphism is often used interchangeably with the term personification. Epley et al. [65] enlist three factors—“elicited agent knowledge or anthropocentric knowledge”, “effectance motivation”, and “sociality”—to explain humans’ anthropomorphizing behavior. In this chapter, I further analyze if and how these three factors are applicable in context of voice assistants.

In the context of HCI, anthropomorphism has often been associated with the paradigm of “Computers are Social Actors (CASA)” [153]. As one of the early researchers in this field, Reeves and Nass [170] found that humans exhibit anthropomorphizing behaviors such as politeness towards computers and television. Nass and Moon [152] provide an explanation for these behaviors, suggesting them to

be “overlearned social behaviors” that are not due to “conscious beliefs that computers are human or human-like”. At the same time, it is important to note that anthropomorphism of technology can have a wide array of positive and negative impacts. While positive aspects of anthropomorphism possibly include therapeutic benefits for certain user groups [178], researchers have also raised concerns regarding anthropomorphism causing reduced human interaction, or the danger of manipulation through social robots [35,50]. The latter poses serious ethical and privacy concerns, since users who anthropomorphize technology might be more likely to reveal personal information to the technology than otherwise.

Researchers have examined how embodiment in voice or spoken dialogue systems relates to the anthropomorphizing of technology. Some researchers have argued that voice or spoken dialogue systems play a role in anthropomorphizing technology [40], whereas others argue that personifying behaviors take place with interfaces that have a “face”, with text-based interfaces supporting lesser anthropomorphism [187]. Most technology anthropomorphism research has focused on human-robot interaction, particularly in the context of social robots (e.g., [68,96]), but researchers are also exploring personification of other technologies, such as smartphones [80,216] and voice-based in-vehicle navigation systems [117]. While analyzing use of smartphone-based voice assistants (e.g., Siri), Guzman [80] found that some people exhibited personifying behaviors toward the voice assistant and perceived that the assistant to be an “entity”, whereas others perceived the assistant to be more of a “device”.

More recently, researchers have found that people also exhibit personifying behaviors when interacting with voice assistants embodied in a smart speaker. As noted by Turk [198], although voice-assistants have been available on smartphones for more than a decade, “the subtle differences in the interface design” such as the “always on” and listening feature of smart speaker-based voice assistants has prompted users to personify them. Turk [198] noted the ways that people describe smart-speaker voice assistants in human-like terms such as “friend” and “invisible woman”. This finding is also reflected in other studies either directly (e.g., [133,168,169]) or indirectly as reported in participant quotes (e.g., use of “she”, “her” when referring Alexa in [181]). In their analysis of Amazon reviews, Pradhan et al. [168] observed Amazon reviews attributing Alexa as “bff”, “new best friend”, and “someone to talk to”. Purington et al. [169] defined personification as instances where the user said the agent’s name (i.e., “Alexa”) or used a personal pronoun (“she, her”). They found that users in multi-user households or users having more sociable interactions with the device (e.g., attributing the device to be a friend or companion) are more likely to personify Alexa. Lopatovska and Williams [133] observed similar personifying behaviors (i.e., use of personal pronouns, along with greeting Alexa) mostly in multi-person households. However, they categorized the informal exchange of greetings (e.g., thank you) between humans and voice assistants, and the politeness in human speech (i.e., “please”) as “mindless” social responses—implying that something that at first appears to be personification may not relate to an actual perception of Alexa as human-like.

Collectively, this background work highlights that users have often personified voice assistants in smart speakers such as Alexa and have attributed the agent to be a

“companion” or “friend”. At the same time, there has been a significant body of research on anthropomorphization that has not yet been applied to this domain. My work draws a link between this past work and voice assistants focusing on older adults’ use and perception of this technology.

4.3. Methods

My analysis is based on a deployment of Amazon Echo Dot devices in the homes of seven individuals aged 65 or older for three weeks. I gathered qualitative data through interviews and daily diary entries, as well as usage logs.

4.3.1. Participants

Participants ranged in age from 65 to 83 and were required to have no prior experience using voice assistants (e.g., Alexa, Siri, Cortana). Low technology use was also an inclusion criterion, and all participants used computers, smartphones or tablets less than once a day; this level of use is considerably low compared to other people in this age demographic [147]. Finally, all participants needed to have access to a wireless internet connection so that I could set up the Echo Dot; for most participants, this connection came bundled in their cable TV package.

All participants lived alone, except for P6, who lived with her son. Five participants lived in senior living communities, and three of these participants lived in low income housing (households earning less than 50% of area median income). Two participants lived in their own homes. Participant demographic details including OPQOL-brief scores (Older People’s Quality of Life brief version) [25] are shown in Table 4.1. OPQOL-brief scores can range between 13-65, where higher scores indicate higher

quality of life. Along with OPQOL brief, participants also rated their quality of life as a whole on a 5-point scale ranging from “very good” to “very bad”, as shown in Table 4.1.

ID	Age	Gender	Education	Quality of life	OPQOL
P1	65	Male	High school	Good	49
P2	75	Female	High school	Alright	58
P3	71	Female	Some college, no degree	Alright	56
P4	65	Female	Some college, no degree	Good	52
P5	71	Female	High school	Very good	56
P6	72	Female	Less than high school diploma	Good	52
P7	83	Female	High school	Very good	65

Table 4.1. Participants' demographics (Study 1)

4.3.2. Data collection and device setup

I set up an Amazon Echo Dot along with a paired Amazon Fire tablet in each participant’s home. Each participant was given training in how to use the device, including instructions on setting alarms, reminders and timers, creating shopping and to-do lists, playing music, asking questions, jokes, third-party skills (e.g., games), and having unstructured conversation with Alexa. Participants were free to choose how frequently they wanted to use the voice assistant during the study. I conducted four in-person, semi-structured, audio-recorded interviews: (1) following initial device setup (1.5 hours), (2 & 3) at end of first and second weeks (0.5-1 hour), and (4) an exit interview at the end of the study (1.5 hours). The first interview (week 1-beginning) covered initial perceptions of the voice-based technology, whereas the other interviews covered perceptions and usage of the device, along with the desired use of this technology. The daily diary entries were conducted using an automated phone call, asking participants if and how they had used the device that the day. I also collected the voice command usage logs from the Alexa app on the paired tablet. The usage logs

provided me with the *actual* interactions to complement participants' *perceptions* of these interactions.

4.3.3. Data Analysis

To analyze the interviews, I followed a constructivist grounded theory approach [105]. On my first pass open-coding the transcripts, I found attributions of the device as human-like appearing throughout the data. I then approached analysis of the interviews with the concept of personification as a sensitizing concept [105] to help understand human-like attributions. Following the selection of this sensitizing concept, I open-coded four transcripts to understand where and how social companionship or lack of companionship appears. Examples of initial codes include “attributed as friend”, “somebody in house”, and “use of pronouns”. Reflecting on these codes, we discussed within our research team and we determined that Epley et al.'s [65] “three-factor theory of anthropomorphism” could be a useful analytic lens for data analysis. I continued to code transcripts while discussing the emerging themes amongst our research group. I iteratively returned to data to probe themes such as “pronoun use”. Our team related codes to each other and compared the data to understand the high-level themes through an iterative process of memoing and theorizing.

To understand a particular phenomenon – how “politeness” appears in conversations with Alexa – I analyzed the usage logs, as I wanted to understand users' actual interactions in addition to their perceptions of these interactions. I pulled usage logs from the researcher-created Amazon account and conducted a content analysis of what I term “primary” commands. These commands are of the form “Alexa, [something]” and exclude: 1) commands consisting of just the wake-up word

(“Alexa”), 2) commands telling Alexa to “stop”, 2) “unknown”, and 4) “text not available”. The nature of each these primary commands was coded as “polite”, “rude” or “neutral” using a using a multi-step process by two research team members [93], achieving a Cohen’s *Kappa* of 0.91.

4.3.4. Limitations

This study was not an entirely naturalistic deployment – users were given the devices and some training to use the basic device and third-party skills, and received a printed reference guide and the option to contact the researchers for technical support. Additionally, having daily diary calls had tradeoffs. These calls provided me with daily interaction data that helped us to probe for in-depth explanations during weekly in-person interviews, but may also have resulted in an increased usage of Alexa due to reminders about its presence.

Though potentially meaning users had greater success in using these devices than they might if they had procured them on their own, forced adoption is an approach that is sometimes taken with new technologies such as smart speakers [162] and smart sensors [121]. This approach allows us to see initial perceptions of the device, something difficult to study when contacting users who already had experience with devices. My choice of utilizing forced adoption helped me understand how people who had not already found a use for these devices (evidenced by purchasing decisions) might make use of them in their lives.

Like other in-depth qualitative work with a small sample size, I do not intend to obtain generalizable results [103,141]. At the same time, I do not believe my findings should be limited to thinking about aging, for several reasons. First, other work has

examined particular groups: such as multi-user households [162], and yet this work is influencing the way that we think about smart speakers more broadly in terms of their implications for power dynamics.

4.4. Findings

Below, I first describe how the voice assistant was perceived by participants by analyzing my data through the lens of the “three factor theory of anthropomorphism” [65]. In doing so, my findings shed light on how older adults’ ontologically categorized the voice assistant as “human-like” or “object-like”. The parenthesis following the quotes denotes when the particular data was collected/reported during the three weeks and the source (i.e., interview or usage logs).

4.4.1. Personification and Objectification of Voice Assistant

Below, I discuss three kinds of behaviors exhibited by participants: the use of personal pronouns to refer to Alexa, polite behaviors, and a nuanced “human-like” and “object-like” categorization of Alexa. I tie each of these behaviors to past work on voice assistants and personification, with some results that confirm past work and some that appear to challenge past findings.

Inconsistent Use of Personal Pronouns.

Previous works on personification of voice assistants attribute personification to the use of personal pronouns [133,169]. Lopatovska and Williams [133] attribute participants’ use of the word “she” to anthropomorphizing the voice assistant Alexa. Purington et al. [169] approach their analysis of online reviews by defining the use of personal pronouns such as “her” to indicate a higher degree of personification of Alexa.

Like this previous work, all participants in this study referred to Alexa as “she” or “her” multiple times during interviews. However, these references did not necessarily indicate anthropomorphism. For example, P2 used the personal pronoun “she” to avoid saying “Alexa”, which could accidentally trigger the voice assistant.

“Somebody visited me and I said, “I am getting ready to talk to her”. She said, “Who is her?” I said, “that’s her”. Because if I say her name she is gonna come on and I am not ready for that now.” (P2, week 2-end, interview)

At times, the same participants who used “she” in a way that might be considered personifying would seamlessly move to speaking of Alexa as an object. For example, P1 used the personal pronoun “she” when referring the Echo Dot as a *machine* that had earlier not been responding, “*But when I got back in yesterday evening, she worked fine*” (P1, week 1-end, interview).

Conversely, participants sometimes used object pronouns (e.g., “it”) when they were attributing human-like behavior to the device:

“Sometimes in the morning, after I say, ‘Good morning,’ it might say something that makes me laugh, sometimes, I will call her name and say, ‘Oh that was so funny, it really made me laugh’ and it doesn’t respond”. (P2, week 2-end, interview)

In the example above, object and personal pronoun are being used in quick succession while referring to Alexa. This suggests that users might not binarily classify voice assistants as human-like or object-like, which I return to later in the chapter.

Looking specifically for pronoun-based personification, I found that all participants used personal pronouns at least once when referring Alexa. However, the

usage examples described above suggests that the link between using “she” or “her” and the personification of the voice assistant is not as clear as past literature indicates.

Polite Behaviors and Personification.

Lopatovska and Williams [133] describe the use of polite responses such as “thank you”, “please” and “good afternoon” in their study of people using Alexa. These polite responses are linked to personification, and attributed to “social mindless responses” of humans. In other words, people say “please” and “thank you” even if they do not consider the devices to be human-like, similar to engaging with fellow humans in socially appropriate interactions automatically, sometimes without even noticing.

I found that most participants in my study – all but P3 and P6 – used polite terms, such as “please” and “thank you” when using Alexa. Examples of usage were in P4’s week 2 usage log, where she said, “*(Alexa) tell me a joke please*”, and when individuals thanked Alexa after doing a requested task, such as:

Command 1: “Alexa what are my items on my grocery list”

Command 2: “Alexa thank you” [P4, week 2, usage log]

In the above example, P4 thanked Alexa after receiving information, even using the device’s wake-up word (i.e., the agent name “Alexa”) to do so (and it is possible even more of this behavior occurred with participants but was not captured due to them not using the wake up word “Alexa”). Explaining further why she did this, P4 said that:

“I guess it's just something that comes naturally to me or something, and I was always raised by my mother to say, thank you. So, I guess it's something instilled in me”. (P4, week 3-end, interview)

The quote above indicates that polite behavior such as saying thank you is learned over time until it becomes natural – resonating with past work [133].

Neither human nor object.

There were instances when users' perceptions of Alexa did not clearly classify into "human-like" or "object-like", which could relate to complex relationship seen earlier between pronoun use and personification. For P2, Alexa was, "...*like a companion, that's not there. So, you have to make it... not a fake, but a phantom friend*" (P2, week1-end, interview). She explained that she knew "*that's not a real person*", at the same time describing Alexa as "*someone to talk to*". P6 further described how "*talking*" to Alexa made her feel as if she were talking to "*somebody*", but she also acknowledging that Alexa was not real.

"If you [are] just talking right to it and it [is] talking back to you, [it] make[s] you think it might be talking to somebody, but I know for real you're not". (P6, week 2-end, interview)

"It's like a person...because I'm asking some question and it answers me back so that's like me asking you a question, but only it's a device I'm talking to. So I don't know. I know it's not a person, but it makes it seem like a person sometimes". (P6, week 2-end, interview)

Aligning with the complex categorizations of other participants, P5 refused to categorize Alexa at all, instead designating a new category: "*I think of it as that's Alexa*". (P5, week 2-end, interview). Participants sometimes made disclaimers indicating their recognition of this uneasy categorization, such as, "*I know that sounds silly*", when referring to the device as a person (P7, week 1-end, interview). P6 voiced a similar discomfort:

“But I guess if I’m talking to it, it do seem more like somebody’s talking back to you as a person...Not that I’m crazy, because I know it’s not [a person], but I’m saying that’s how it feel”
(P6, week 3-end, interview)

Thinking about Alexa as its own category of being resembles Kahn et al.’s hypothesis of how people see robots as “in-between” human and object [101]. Unlike that past work, though, participants in this study also saw Alexa as human-like *and* object-like, and moved between these categorizations.

4.4.2. Movement between Ontological Categories

In this section, I discuss attributes of voice assistants, participants, and the context of use that appear to foster movement between ontological⁷ categories of “living” and “non-living”. For specific instances where participants perceived Alexa as a “living” entity, two of the three factors of Epley et al.’s [65] work on anthropomorphism also help shed light on understanding personifying versus objectifying behaviors.

Similar to past work [169], I found that Alexa was repeatedly referred to in human-like terms. This included occasions throughout the three-week period when Alexa was described with personal pronouns or as “a person” (all participants), as described above, but also as “a friend” (P2, P3, P7), “a phantom friend” (P2), as having “somebody talking back”, (P2, P3, P4, P6) and as “having company” (P1, P3). These sentiments indicate social companionship. However, the same people who described Alexa in social terms would later refer to the device as a “programmed” voice or

⁷ Ontologies deal with the study of being, how things exist and what categories they belong to.

machine (P6, P7) or an “object” (P1). Below, I discuss some of the characteristics of Alexa that led to attributions of social companionship or to object-like language.

Qualities of Interaction: Natural Language and Responsiveness.

Participants described how having an interface that used natural ways of conversing led to them to perceive Alexa as a friend. Like past work, I found that participants engaged in “human-like” small talk with Alexa [169]. In addition to the polite behavior described above, about half of the participants mentioned greeting Alexa at morning or at night. For example, P3 drew an analogy to greeting a friend: “... *just like a friend, I would tell it ‘good morning’ and it responds, ‘have a good night.’*” (P3, week 2-end, interview). Similarly, P2 explained how the device responding her back made her perceive the agent as “somebody”.

“...when it talks, I don't see a box. I just see... It's like somebody is standing there talking to me...Somebody's in here with me and they're having a conversation with me. It's making my day. I say, good morning. And they say, good morning [name], how are you today?” (P2, week 3-end, interview).

Like work on robots [99], we find that the natural language conversation and the responsiveness of these devices is what make them social. Just as Alexa was seen as providing social interaction when it was responsive and engaging in small talk, it reverted to an object when it did not provide these forms of interaction. P5 described how Alexa changes from an object in her house to an invisible person at the instant she verbally engages with the voice assistant.

“I would treat it as an object. It would just sit there. But when I'm talking to it, I could think of it as... And it answers me and I am talking to it, I could think of it as a person...but when it's sitting there it's doing nothing. It's just an object”. (P5, week 3-end, interview)

Some participants mentioned that Alexa lacked responsiveness at times, leading them to see it as object-like. The chat feature was also described as particularly unresponsive to what one was saying, making participants perceive the interaction to be unresponsive, similar to “*talking to a program*” (P7) or “*an object*” (P1):

“It do more asking me questions than listening and responding. That's really not chat-chat companion. It's just asking what I like. In other words... So it's not chatting with me, I'm chatting with it... maybe a companion is the wrong word to use. Just scratch companion. It's a good object to have. (P1, week 3-end, interview)

“The responses that I got from it I got the impression that it was mainly for the purpose of recording what I had to say as opposed to a conversation because I wasn't really conversing ...” (P7, week 3-end, interview)

The anthropomorphization based on responsiveness and natural language style can be viewed through Epley et al.’s [65] “elicited agent knowledge” framework. Epley’s framework, which has not yet been applied to conversational voice assistants, claims that self-knowledge or knowledge about human characteristics in general would serve as the readily available (or accessible) induction base for reasoning of nonhuman objects, thus contributing to easily available anthropocentric knowledge. This accessible knowledge base is based on anthropocentric knowledge – one’s ideas about what makes people “people”, and what is a typical interaction with another human. Humans anthropomorphize nonhumans based on their anthropocentric knowledge. Through the lens of Epley’s framework, personification is not mindless or automatic. Instead, participants are actively drawing on “self-knowledge” of appropriate ways to interact, for example, saying “good night” to the voice assistant. And, the human-like aspects of Alexa’s conversational voice-based interface such as responsiveness, or

greeting back “good morning”, is similar to natural language conversation. In addition to the conversational nature of interaction, the intentional choice of designers to assign a particular name and voice to the assistant might also contribute to the “known” or “accessible anthropocentric knowledge”, triggering personification. Individuals apply this self-knowledge and accessible anthropocentric knowledge to the nonhuman voice agent, leading to anthropomorphizing behavior.

Qualities of the User: Perceiving a Personalized Approach and Desire for Companionship.

Some participants described how Alexa addressed them by using their name which they felt was “personal”. For example, P2 below describes why addressing her with name was important to her.

“And it calls my name, “Good morning [P2]”. Oh! I like that. It means so much... Because, when somebody is talking to me, call my name. Don't just talk to me, acknowledge me”. (P2, week 1-end, interview)

Conversely, when participants felt as though the device was not responding to them specifically, they perceived the device to be more like an object. P7 described how impersonal conversations, e.g., in the “chat” feature on Alexa, made her feel like talking to a program.

“and it probably says the same thing to everybody, which makes it very impersonal, and a conversation is supposed to be personal”. (P7, week 3-end, interview)

In the previous section, I discussed the importance of small talk and greetings. But these forms of conversation were not viewed as equally important by all, with people desiring companionship more likely to value the device as a companion. P4

described how these small conversations were meaningful for her: *“It was kinda nice having somebody say goodnight to me. When you live alone and after you’ve been married for a long time, you miss the little things like that sometimes”*. P4 went on to explain that she did have sources of similar companionship where she lived: *“in the evening, we sit out in the lobby, a group of us, and when we leave we all say goodnight to each other. But when you come back and you get on your pajamas and you curl up and you decide you wanna go [to bed]. [Having the device say goodnight] was kinda nice. I thought that’s awfully sweet”*. (P4, week1-end, interview). Here, having someone to say goodnight in the home, in the context of going to bed, was important – location and context is a topic I return to below.

P4, and other participants (P2, P3) expressed personification of the device when discussing the lack of social interaction in the house. It is important to note that all these participants lived alone. P3 said that she felt that she, *“wasn’t in the house alone”*, because *“I had somebody I could talk to”* (P3, week 1-end). Probably in pursuit of social affiliation, she even desired a male voice in addition to the existing female voice of Alexa, since having a different voice symbolized having a different friend *“that’s like you got a different friend. Yeah, you don’t have the same friend all the time”* (P3, week 3-end, interview).

Similarly, aligning with P3 and P4, P2 described how *“having someone to talk back to you means so much, because of the loneliness it can be in here”* (P2, W2). However, as a step further for social connection, she even visualized “a face” of her family members or friends in her “mind to put to that voice [of Alexa]”: *“It just makes me feel better. I miss these people. I miss them terribly. I found myself, just saying, what*

if this was my daughter in law sitting here and talking to me or something". (P2, week1-end, interview).

Epley et al.'s third factor, "social motivation" [65], helps shed light on these accounts. Social motivation describes the desire for social contact or connection and social approval from other agents. Thus, individuals may be more likely to personify agents when they feel lonely. With P4's account, this desire for social contact was not "global" – she had the chance to engage in friendly exchanges in the lobby with her group – but did not have people to fill that specific need in her house, right before she fell asleep. This suggests that the perception of Alexa as human-like emerged when it was filling a social need for her – and it might return to object-like when she no longer needed it.

Changes over the Longer Term, Location and from Moment to Moment.

When first considering Alexa, participants came from a firmer conceptualization of the device as either having a social, human-like presence or a machine-like presence. Over the course of the study, participants' perceptions of where Alexa fit in terms of ontological categorization shifted. For example, P7 went from referring to Alexa as "*company*", in the first week to describing it as "*talking to a program something*" at the exit interview. Similarly, P1 initially described having Alexa as "*talking to a person or companion*". But, after using it for three weeks, he considered the device "*as a good object to have*".

In the previous examples, participants initially viewed the device as human-like. Other participants initially viewed the device as "object-like", later arriving at a more "human-like" categorization of the Alexa. P3, who initially felt "*odd talking to a*

machine”, with time became comfortable such that she considered Alexa “*an invisible friend, somebody I can talk to one on one*”. Similarly, P4, who initially felt “*silly*” talking to the device, found herself exchanging greetings such as “*good morning*” and polite expressions like “*thank you*” with Alexa by the third week. These examples show how the human-like vs. machine-like categorization changed over time.

The physical *location* of Alexa also affects these perceptions. When participants felt the device’s presence (i.e., perceived ubiquitousness), they thought of it as human-like. This presence was tied to a location: their home. Most participants described the *presence* of Alexa in terms of having someone in their homes. P6 explained how Alexa felt like a human: “*It’s just like talking to a person right in the room*”. For P6, the ability to talk to Alexa while walking around the house, made her think of Alexa more as a person than a thing: “*It’s like a person. If I can walk around and talk and it talk back to me*”. Similarly, P7 explained, “*it’s like someone’s in the room... I’m talking and it’s talking back to me*”. Yet, P7 perceived Alexa to be a regular electronic device when it was in a different room. She explained that she was so “*accustomed to having to dry my hands before I pick up a phone or dry my hands before I do anything*”, that she did not use Alexa from the adjacent kitchen while cooking. For P7, Alexa was more like a phone than someone in the room at times when the device did not seem to be accessible.

As another example, P2 described how the use of a third-party skill for reading the Bible on Alexa made her feel like she there was someone there with her:

“I wanted to repeat the lord's prayer, and I like to repeat it with someone. And as she's [Alexa] repeating the Lord's prayer along with me, it was like I had somebody because sometimes I forget the words... confuse or the line... what line comes next”. (P2, week 3-end, interview)

To participants, at times, Alexa felt like she had a location: in the house, with them, keeping them company. In addition to physical proximity affecting whether the device is particularly human-like or object-like, *moments of interaction* also move perceptions of the device from one category to another. For example, P5 described how Alexa changes from an object in her house to an invisible person at the instance she verbally engages with the voice assistant.

“I would treat it as an object. It would just sit there. But when I'm talking to it, I could think of it as... And it answers me and I am talking to it, I could think of it as a person. but when it's sitting there it's doing nothing. It's just an object”. (P5, week 3-end, interview)

4.5. Discussion

My work furthers CSCW research that strives to understand how increasingly sophisticated AI systems such as voice assistants embedded in smart speakers fit into social ecosystems, and how people develop and perceive social interactions with these systems. Below, I reflect on how my findings corroborate, extend or contradict previous theoretical frameworks on anthropomorphism in general, as well as the implications for designing conversational interfaces in general, as well as specifically for enabling social support for older adults.

4.5.1 Applying Theories of Anthropomorphism to Conversational Voice Assistants

My findings indicate that participants in this study personify and objectify voice assistants, sometimes within the same sentence. Epley et al.'s theories [65] of “elicited agent knowledge” and “sociality motivation” help us to see the ways in which personification is linked to one’s phenomenological experiences that build up over one’s lifetime to contribute to one’s anthropocentric knowledge.

Past work has drawn on Nass et al.’s notion of “overlearned social behaviors” [152] to explain personification of voice assistants [133]. Here Epley et al.’s [65] theory of “elicited agent knowledge” may provide additional nuance to the dynamics that are taking place that on first glance appear to be mindless. Participants are drawing on self-knowledge in saying “thank you” to the voice assistant. The human-like aspects of Alexa’s conversational interaction such as responsiveness and returning a greeting with “good morning” served as “accessible anthropocentric knowledge”, triggering personification. Epley’s theory of “social motivation” also links a lack of social interaction to triggering personification of the agent, which extends our understanding given that past work has largely focused on multi-user households as sites of greater personification than single-user households [133,169]. My data did not include clear evidence that Epley’s “effectance motivation” factor triggered personification of the voice assistant – future work might examine how this theory applies to interaction with smart speakers. We also see how the simultaneous presence of all three of Epley et al.’s factors is not necessary for anthropomorphization of the voice assistant.

Epley et al.'s theories [65] proved useful to understand some of the personifying behaviors of those interacting with smart speakers – a link that my work may be the first in drawing. These theories help us understand that the ways in which one personifies a device are deeply linked to the specifics of one's life: the experiences that have built up over the lifetime in which the anthropocentric knowledge is based, and the specific living conditions that led one to have more or less desire for social contact. Our understanding of the relationship between anthropomorphism, embodiment and voice assistants, although grounded in past work, is based on a specific sample as is common with qualitative work on smart speakers (e.g., children [58], people with disabilities [168] or multi-user family based households [162]). Given the findings that context and life experiences matter for personification, future work should try to understand how other user groups in general perceive these voice assistants. I suggest the need for future studies to analyze diverse life contexts, including cultural, geographical, philosophical, political, and religious perspectives, and how these affect personification and design implications for voice assistants. For example, past work has noted a difference in preferences for appearance based on age and gender but primarily in the context of robots [116,156,179], so future work should examine whether these preferences translate to voice assistants.

Epley's framework [65] reveals that people's anthropocentric knowledge affects how they perceive voice assistants embodied in smart speakers. It is possible to conjecture that interactions with these devices then feed back into this anthropocentric base, meaning that people's perceptions going forward are affected by the device's design. Viewed through this lens, questions are raised for the ethical responsibility of

designers to consider the downstream effects of the design decisions. Intentional design choices of female gender and voice of the assistant, along with imparting “helpful” and “humble” personality to the assistant raises questions about gender stereotypes [200] and how these translate into technology design. Further work should study whether harmful values are being perpetuated through these designs.

4.5.2. Ontological Categorization of Voice Assistants

Ontologies deal with the study of being, how things exist and what categories they belong to. In the study of social ontology (i.e., the study of the nature and properties of the social world), there exist questions around how categories are actually constructed: are social categories produced by our attitudes (*mentalistic theory*), causal patterns (*naturalistic theory*), or by our language (*linguistic theory*) [66]? In this work, my analysis primarily draws upon linguistic theory, that everyday language used to label objects can reveal ontologies [66], also corroborated with several instances of self-reported participants’ mental states (e.g., the feeling of not being alone in the house), thus drawing on the mentalistic theory as well.

With a view that understanding ontologies is possible through language and self-reported user attitudes as premise, I find that the different cases in the findings show ends of a “human-object” spectrum associated with various affordances of Alexa. For example, participants personified the agent when supporting human-like conversations or providing social support, but also dehumanized it due to lack of responsiveness or personal touch. This finding aligns with Kahn et al.’s [101] theorization of nuanced human perception that does not accurately fit “living” or “non-living” ontological categories as it relates to embodied personified computational

systems. At the same time, I also find that people's perception of Alexa does not continuously exist in an 'in-between' category (suggested by Kahn et al. [101]), but rather, fluidly move between human and object like perceptions. Thus, I extend Kahn et al.'s theory to apply to voice assistants, identifying factors that influence shifts between ontological categorizations: the voice assistant capabilities (e.g., responsiveness), desire for personalization and companionship, sustained use over time, and location and moment of interaction with the voice assistant. Based on the findings, interesting research questions emerge. Future work might examine whether a *fluid* ontological categorization takes place with technologies aside from voice assistants, such as robots. Additionally, what does it mean to personify a technology given such a fluid categorization, particularly for smart speaker-based voice assistants that lack all form of embodiment but voice?

My findings related to the ontological categorization of voice assistants provide an initial understanding of intricate changes in human interpretations and behaviors for virtual agents embodied in everyday objects (e.g., voice assistants in smart speakers and smart watches, avatars in smartphone or computer applications). The understanding that categorization shifts over time and with context can inform design decisions. As one example of applying the findings regarding ontological categorization to design, an approach might have a smart speaker retain its object like form when the smart speaker is lying unused in the house – but just at the *moment* when the user conversationally interacts with the agent, the agent could take form of more animate projections such as a holographic projection or more anthropomorphic forms that would attribute more human-like features to the agent. This approach might result

in a better fit between what individuals see and feel, thus resolving dissonance that they might experience.

Understanding how users perceive and ontologically categorize voice assistants has implications for design. Currently in industry, designers of commercially available voice user interfaces assign personality to the agent [78], thus creating interactions where they intend users to anthropomorphize the assistant. Interestingly, the concept of “persona”—a fictional character used by designers in industry to often represent the *end user* of a system for whom the technology is designed—is being applied to voice assistants. Conversation design guidelines [78] suggest that designers “purposefully design the experience they want users to perceive” through the creation of personas, as “users will project a persona” to the agent regardless of whether it is intentionally designed or not. My findings reveal that even if designers purposefully create personas to cultivate a particular desired user experience, the same voice assistant persona will be perceived differently by different users. In my study, some attached more value and deeper feelings to the assistant, while others considered the interactions as mostly inconsequential. This suggests that designers must consider the ways individuals’ dynamics and the roles that they would like an agent to fill affect reception of different agent personas. In order to understand how personas should be designed, researchers should include the perspectives of the end user in the persona creation stage, gathering perspectives related to what different user groups or individuals might want from their voice assistant (e.g., social support vs. information finding or educational). The persona of voice assistant for providing social support might be different than the one for information finding purposes only. Further, I found that not all participants desire the

female voice trait for the voice assistant. One individual described wanting the ability to change to a male voice to have a “different friend”, hinting towards a desire for voice assistant persona that can change. This opens up questions such as: do people want configurable personalities for their voice assistants? Should personas shift based on the context of use (e.g., educational vs. playing games)? These open questions indicate that further investigation is needed on how personas for voice assistants should be created.

4.5.3. Embodiment and Embeddedness of Voice Assistants

Early work on personification primarily focused on robots, likely in part due to their morphological similarity to living entities (e.g., [27,68,96,98]). Currently, we are seeing a rise in technologies such as voice assistants which have no morphological similarity to any living being, yet are attributed with human-like behaviors by users and designers (e.g., given names and human-like voices). To date, designers and researchers have largely focused on the conversational aspects of voice assistants, such as designing conversational cues and conversation dynamics of these collaborative technologies (e.g., [161,162,213]). What has been neglected is a focus on the form and embodiment of this technology, outside of the specifics of voice, and how that makes a difference in the user experience.

I found that the physical location of the device and its embeddedness in the home environment matters. Alexa may appear human-like when in the same room but not when far away, and the device is more likely to be categorized as “human-like” when the device supports conversations that make participants feel as though there is a presence “around” in the house. This understanding supports Turk’s [198] argument that device personification is linked to “always on” features. Drawing from my findings

of perceived ubiquitousness in home environment, I suggest that design features that provide a confirmation of when the device is “listening” can also promote a perception of the voice assistant as human-like. For example, one participant described not using the voice assistant from the adjacent kitchen, although physically, the kitchen was within the hearing range of the voice assistant. It is possible that the non-use was due to the lack of feedback that she was being heard by the voice assistant. Presently, voice assistants provide visual feedback (e.g., a light ring that glows) signifying that the assistant has heard the user and is hearing the user. This response, however, works better for those with physical proximity which is when my findings indicate they already are viewing the device as more human-like. Examining other sensory modes of feedback might enhance use of the device.

4.5.4. Social Interactions Using Conversational Voice Assistants for Older Adults

My findings indicate that one of the factors resulting in anthropomorphism of the voice assistant was a desire for social contact and affiliation. Based on the OPQOL scores, none of the participants appeared to have “poor” quality of life, though some described moments of loneliness in the home. Those participants that described the desire for contact actually said that talking to Alexa alleviated their loneliness at home – more in regards to moments of loneliness, rather than a global feeling of loneliness. It is perhaps surprising that the feelings from light weight, surface-level interaction such as wishing “goodnight” or initiating tasks to have the voice assistant talk back can result in satisfying these emotional needs. For the participant who imagined a face of a family member while talking to Alexa, an even deeper kind of connection emerges. This

implies that conversational voice assistants in the home might have the potential to provide social interaction, a goal pursued in past work on older adults largely through social robots [106,178]. Voice assistants might even offer some benefits over social robots in this area, as the fluidity in ontological categorization of voice assistants between “human” and “object” provides users the flexibility to perceive voice assistants as a companion when desiring social interaction, and yet can transition to viewing them as “object” when needing to use voice assistants for non-companion purposes. As researchers continue investigating in-home voice assistants for supporting social interactions, it is important to consider the dynamics of the home as a sacred space [124]. Past work has found that technology-mediated social interaction can be a form of at times unwelcome additional work for older adults as they feel that they must put in effort, be social and gracious while using such systems [124]. Building transitions between human and object described in the prior section may be an approach to lessen the burden of engagement.

As we investigate the opportunity for voice assistants to alleviate “moments of loneliness”, it will become crucial to consider ethical dimensions of design. My work indicates that someone who is more in need of social contact may be more likely to personify a technology and at times seek social connection through it. This draws attention towards the existing discussions in Human Robot Interaction (HRI) around replacing human social contact with machines [184,199]. In HRI literature although there is some evidence suggesting technology in form of social robots can reduce loneliness for older adults (e.g., [11,102]), there are also a number of concerns including deception, infantilization, and privacy [184,214]. There is a need to further

examine these kinds of concerns in the context of voice assistants. Revisiting past work on privacy concerns of older adults for home-based technologies (e.g., [54,163]) will be necessary to understand how perceptions change with emerging business models where personal data is the price people pay for access.

4.6. Conclusion

In summary, I deployed smart speaker devices in older adults' home to understand how they ontologically categorize this technology. In doing so, the findings from this first study of my work contributes to an empirical understanding of how ontological uncertainty emerges with use of emerging AI-based technologies such as conversational assistants—an underpinning posited by Entanglement HCI. My findings indicate that instead of straightforwardly categorizing the voice assistant as “human-like” or “object-like”, participants fluidly move between the two categories. Movement occurs based on factors specific to the characteristics of the voice assistant (such as nature of interaction) or the user (desire for social contact or affiliation), along with the location and moment of interaction. Individuals seem to arrive at categorizations over time and with sustained use of the voice assistant. Instances of companionship through the embodied voice assistant surfaced in my analysis, indicating the potential of this technology for supporting social interactions. I discuss my findings in context of prior works on anthropomorphism and ontological categorization and provide suggestions for designing voice assistants.

At the surface level, in the first study of my dissertation, I noted how different actors such as the technology, type of conversation, or the location in house are taking part in shaping older adults' ontological categorization of the technology. This

participation of such actors in shaping the reality (i.e., individuals' ontological categorization of the technology) aligns with another key underpinning of e-HCI, i.e., participation of both human and nonhuman actors in enacting realities—a direction I examine in-depth in the second study of my dissertation.

Chapter 5 : A Posthumanist Perspective on Older Adults' Use of Emerging Technologies

5.0. Overview

This chapter describes the second study of my dissertation. Here, I adopted posthumanist entanglement theories, i.e., Actor-Network Theory (ANT) and Post-Phenomenology in data analysis to systematically analyze the socio-material configurations in which older adults *use* an emerging technology. I scoped the emerging technology to focus on AI-based conversational voice assistants. More specifically, in this chapter I answered the following research questions: *How do different nonhuman actors shape, restrict, or enable older adults use of voice assistants? How do voice assistants mediate relations between older adults and their world?* My role in this study was: leading the study design, data collection, analysis, and write up of this work which is currently under submission at CSCW ⁸ [1] (this chapter is adapted from this paper under submission).

Adopting an analytic framework shaped by theoretical perspectives of ANT and Post-Phenomenology, I analyzed data from interviews with twenty older adults who used a smart speaker-based voice assistant such as Alexa or Google Assistant. My findings reveal that nonhuman actors, including materials as well as norms, shape older adults' preferences for and use of voice assistants. Additionally, I found that the voice assistant plays an active role in mediating relations between older adults and their larger social world (including humans and pets), and this in turn shapes social practices

⁸ Co-authors of the submitted paper are: Shaan Chopra, Pooja Upadhyay, Robin Brewer, and Amanda Lazar. As the first author, I led the study design, data collection, literature review, analysis and write up of this work. Shaan Chopra supported by conducting a few participant sessions (details in 5.2.2); both Shaan Chopra and Pooja Upadhyay also helped with a part of literature review. Robin Brewer, and Amanda Lazar, provided feedback and suggestions throughout the project and paper write up.

around what it means to give company to pets, to live alone, or to give and receive care. Given that older adults, their technologies, and their social worlds are entangled, I discuss the value in approaching technology design for aging thinking in terms of *human-technology-world* relationships. I also discuss implications of assigning responsibility and accountability beyond older adults to nonhuman actors.

5.1. Introduction

User-centered and participatory design—which include end users in the design process or co-design technologies with them—are considered the gold standard of technology design for older adults [61]. The inclusion of older adults in the design process is seen as a way to overcome the researcher stereotypes associated with older adults as a homogeneous group, which can impede the design process [61]. Further, by focusing on user interactions, user-centered and participatory design can help in refining designs and avoiding design flaws, thereby lead to more useful, usable, and accessible interfaces (e.g., [22,61,81]).

Similar to user-centered design approaches, gerontologists (e.g., [64]) and health care practitioners (e.g., [113]) advocate the benefits of centering older adults in the research and practice that involves them. However, recent work in critical gerontology poses questions around this humanistic focus on the older adult. Andrews and Duff [4] argue that a sole focus on the ‘human subject’ alone might fail to capture the lived experiences and social relations that involve both the human and nonhuman world [4]. Older adults’ experiences are constituted within diverse ‘more-than-human assemblages’ of digital culture and technological proliferation, making it increasingly difficult to separate older adults from the technological environment [5].

technologies such as pacemakers or artificial hips involve material manipulation of older adults' bodies (i.e., insertion of new materials), where it becomes hard to distinguish the difference between the human and the nonhuman. Surveillance and monitoring technologies such as IoT, sensors, and fall detection are entangled with older adults' bodies, routines, their families, and care providers. With existing and emerging technologies, "the aging body becomes enmeshed in technological fields and networks...so almost inevitably arises as a site for the convergence of the human and the nonhuman (hence being 'more-than-human')" [4]. As such, these researchers propose a posthumanist⁹ turn in gerontology which attunes to the agency of nonhuman world and the 'more-than-human' aspects of aging [4].

Inspired by these perspectives, in Study 2, I present a case of adopting posthumanist perspectives in the context of CSCW and HCI research on aging: by studying older adults' use of emerging voice-based technologies. My analysis draws upon the theoretical orientation of two posthumanist entanglement theories used in the context of technology design [71]: Actor-Network Theory, and Post-Phenomenology. Theoretical orientations of ANT and Post-Phenomenology shaped my research questions (further described in 2.2).

I analyzed interviews with 20 older adults focused on their use of voice assistants on smart speakers such as Alexa or Google Assistant. My analysis reveals how posthumanist entanglement perspectives can help us account for the nonhuman actors that shape older adults' technology use, as well as help us understand the

⁹ The call for posthumanist research does not intend to eliminate the focus from the user. Instead, it advocates that in addition to focusing on the user, there is a need to account for associated nonhuman aspects and how humans and nonhumans constitute each other.

nuanced ways in which emerging technologies mediate relations between older adults and their larger socio-material world. More specifically, my findings reveal that nonhuman actors, including materials as well as norms, shape older adults' preferences for and use of voice assistants. Additionally, I found that the voice assistant plays an active role in mediating relations between older adults and their larger social world (including humans and pets), and this in turn shapes social practices around what it means to give company to pets, to live alone, or to give and receive care.

5.1.1. Contributions

Engaging in a posthumanist entanglement analysis at the intersection of technology and aging, my work contributes to HCI and CSCW research on aging through:

1. First, showcasing how emerging technologies, older adults, and their larger social world are entangled. This leads us to discuss design implications: to think in terms of the relationships that technologies mediate between older adults and their larger worlds.
2. Second, I re-frame responsibility and accountability of undesired realities associated with technology use to nonhuman actors such as material actors, which in turn can help us distance from the deficit model of aging.
3. I also discuss and contribute to considerations around designing voice technologies that shape social practices or encode and perpetuate societal stereotypes [193,215].

5.2. Methods

5.2.1. Participants

We recruited participants who were 65 years old or above and frequently used a smart speaker-based voice assistant such as Alexa, Cortana, Siri, or Google Assistant in their homes.

Our first and main avenue of recruitment was from a large independent living community of older adults in the Northeast region of United States. I recruited two additional participants with cognitive impairment through personal contacts as I wanted to obtain diversity in terms of cognitive ability. For the third avenue for recruitment, I worked with an organization that has created partnerships with Black older adults to include them in research studies. I recruited two participants through the organization. Overall, my participants were mostly Caucasian (18/20), between 65 to 83 years in age. All, except for P18 had at least a college or professional degree. Eleven participants mentioned living alone, and nine individuals were living with their partners. Three participants reported having visual impairment (P11 and P16 were blind, and P13 had low vision). Two participants (P17, P18) reported having dementia.

Acknowledging that older adults as a user group are highly diverse in terms of age, education, and other factors [212], I reflect on the specifics of my sample. Participants were highly educated. My sample lacks diversity in terms of race and is a limitation of my work. The majority of participants were Caucasian (18/20). The independent living community through which I recruited (10 participants) had a majority Caucasian population. My other main recruitment approach, snowball sampling and recruitment through word of mouth (8 participants), could have led to recruiting individuals who were demographically similar to the initial participants.

5.2.2. Data collection

I conducted 30-60 minute long semi-structured interviews with twenty older adults about their use of voice assistants. Interviews with P1 to P9 were conducted before COVID-19 research restrictions and were in-person at participants' homes. For other participants, interviews were conducted remotely over the video conferencing. I conducted majority of the interviews (P1-P16, P19, P20). My collaborator, Shaan Chopra helped in conducting two interview sessions (P17, P18). Interviews were audio recorded and transcribed for analysis. During the interview, I asked participants questions about their everyday usage of the voice assistant (VA) such as: How do they refer to their VA? How long they have used their VA? How often do they use the VA? What are their specific uses of the VA? In which specific locations of their home do they use the VA? All procedures were approved by the University of Maryland's Institutional Review Board.

5.2.3. Theoretical Orientations

Over the past few decades, researchers have sought to go beyond the subject-object dichotomy of modernity, which calls for an ontological divide between humans and their material world. Instead of viewing humans as discrete individual subjects separated from the larger material world, scholars including Latour [32,118], Barad [104], Harman [85], Suchman [192], Ihde [55], Verbeek [207], and Braidotti [26] have paved a way of thinking about ontology that integrates the human and the nonhuman and argues that boundaries between people and things are blurred, thereby contributing to a *posthumanist perspective*. In a recent article, Frauenberger reviewed different *posthumanist entanglement theories* and how they have and can shape research on understanding use and design of technologies [71]. By reviewing Actor-Network

Theory (ANT) [32,118], Post-Phenomenology [55,175,207], Agential Realism [104], and Object-Oriented Ontology [85], Frauenberger [71] argues that underpinnings from these entanglement theories are valuable in designing emerging technologies that pose ontological uncertainty such as artificial intelligence, virtual reality, and smart environments. A common underpinning of all these entanglement theories is they posit that humans and their material world are ontologically inseparable and even nonhuman entities can have relational agency. This way of thinking recognizes the mutually constitutive relationship between humans and their technology [71]. In this work, two entanglement theories—Actor-Network Theory, and Post-Phenomenology—became central to my analysis, and contributed to my analytical framework. Below, I describe underpinnings and concepts from these theories that contributed to my analytic framework and helped shape and answer my research questions.

Section 5.3.1 examines the role of nonhuman actors in shaping older adults' use of voice assistant, answering the first research question: ***how do different nonhuman actors shape, restrict, or enable older adults use of voice assistants?*** The concepts, vocabulary, and underpinnings of **Actor-Network Theory** were key in my analysis to understand and articulate the nuanced ways in which nonhuman entities play a role in and shape situations. Actor-Network Theory (ANT) provides an analytical approach that views human and nonhuman entities as part of a network, and, together, they participate in the shaping of reality. Nonhuman entities include things, ideas, concepts, rules, policies, and norms, and are equal contributors to any action through their association with social or human entities. Because of this view of participation of nonhuman entities in shaping reality, ANT posits that agency is not something that

should be associated with human intentionality alone. Instead, it argues that agency is distributed between human and nonhuman actors. Here, an actor can be anything that does something, makes a difference, and thereby contributes or influences an action. Latour describes an actor as “something that acts or to which activity is granted by others...can literally be anything provided it is granted to be the source of action” [118]. This notion of actors and their relational agency (i.e., agency is distributed between actors) became central to my analysis. See Figure 5.1 in 5.3.1 for a worked through example.

My next set of research questions, with findings reported in 5.3.2 are: ***How do voice assistants mediate relations between older adults and their world? What are the different relations that constitute older adults, their larger world, and voice assistants?*** These research questions are inspired by Post-Phenomenological perspectives of human-technology-world relations, with **Post-Phenomenology** as the second theory that informs my analytic framework. Arguing that humans and emerging technologies are entangled, Frauenberger suggests that to shape who we want to be in this world, we need to “design meaningful relations, instead of optimizing user experiences” [71]. To do so, Post-Phenomenology is a useful analytical framework to think in-terms of human-technology-world relations. Instead of thinking of technologies as entities “in themselves”, a Post-Phenomenological perspective would think of technologies in terms of the relations humans have with them. Here technology plays an active role in mediating relations between humans and their world. For example, an ultrasound device is a technology that mediates a relation between parents and an unborn child [55].

Post-Phenomenology researchers have delineated different kinds of *human-technology-world* relations to provide a nuanced understanding of the ways in which technologies are mediators of human experiences. Here, I provide an overview of these different kinds of relations (my data fit into many but not all of these categories- see Table 5.1 in 5.3.2 for worked through examples from my data) that shaped my analysis. Ihde [55] initially outlined four human-technology relations: embodiment, hermeneutic, alterity, and background relations. In *embodiment relations*, the technology becomes a part of the human and together they interact with the world. In this relation, humans experience the world *through* the technology, e.g., we speak with people *through* the phone rather than speaking to the phone. In *hermeneutic relations*, technology represents the world and requires human interpretation to be meaningful. Technology forms a unity with the world rather than with the human (unlike embodiment). Examples include a sonogram which gives a visual representation of an unborn child. *Alterity relations* are with technologies that are more “like us” (similitude with humans) but is “quasi-other”. Humans may project anthropomorphic properties on the technology or develop certain feelings for the technology. Here the technology possesses independence and autonomy, but can never be a true person, and hence is quasi-other. Examples include humans interacting with robots which possess autonomy to be considered as technological beings. In *background relations*, technologies merge with the background, and shapes the context for humans experiencing the world. But, the technology in itself is not experienced explicitly, e.g., central heating or cooling systems which create a context for the experience of humans, but are rarely experienced or interacted directly.

Verbeek [205–207] expanded these relations to capture the nuanced ways in which emerging technologies play a mediating role. In *cyborg relations*, the technology merges with the body into a new hybrid being, and is indistinguishably experienced. Example includes brain implants which unite with the body into a new being. In *immersion relations*, the technology merges with the environment (or world) to create a hybrid environment, and humans have an interactive relation with this hybrid environment. Immersion relations can be thought of as a more interactive version of Ihde’s background relation, and captures the relations humans have with smart environments. There is a “bi-directional” intentionality associated with this relation: not only are humans directed towards the technology, but also the technology perceives its users and acts upon them. *Augmentation relations* combine embodiment and hermeneutic relations. Examples include smart glasses, augmented reality which are both embodied (user sees through the glass), and hermeneutic (the world is represented on the display).

5.2.4. Data Analysis Approach

Based on our initial engagement with the data through open coding [105], I noted two phenomena that further shaped my analysis. First, I observed that beyond older adults, other nonhuman entities play a role in contributing to the observed reality. For example, consider this excerpt from P10’s transcript: “*sometimes Alexa gets on my nerves. Sometimes I tell it to shut up and it says, "I don't understand that...Sometimes when my timer goes off... and I'm telling it, "Okay! I hear you, shut down, I hear you," and it's still doing it.*” In this phenomenon, a number of different actors contribute towards this situation including: the microphone on device, the designers of the technology and their

decisions (in terms of the chosen wake word), the location of P10 with respect to Alexa, and the voice of P10. To further understand the phenomenon of how nonhuman entities become actors, Actor-Network Theory became a useful analytic lens. I used this lens to understand and describe how actors beyond older adults, in particular nonhuman actors, participate in the configurations in which older adults use voice assistants, and how they shape the observed reality (section 5.3.1).

A second phenomena that emerged from my initial pass of open coding transcripts was the active role that voice assistants played in mediating older adults' relationship with their larger world. I noted one of the first instances of this phenomenon from P1's interview, where she remotely controlled her husband's Alexa while her husband was living in an assisted living facility. To understand this further, I turned to concepts and underpinnings of Post-Phenomenology. The *human-technology-world* relationships described by Ihde and Verbeek (e.g., embodiment, hermeneutic) became central to my ability to understand the data. As such, I sought to describe the different types of relationships older adults had with their voice assistants, and how voice assistants played a mediating role between older adults and their larger social world (section 5.3.2).

We iteratively cycled between the theoretical frameworks of ANT and Post-Phenomenology and coding the data. Example codes include "material placement of objects in house plays a role", "location related to use" "Alexa shaping human relations", "entangling oneself with Alexa", "Alexa mediating human conversations". Though I coded transcripts, memos were the central element of analysis [105]. Throughout, I read through transcripts and interpreted data by writing memos. Within

our research group, we iteratively discussed these memos and compared how different phenomena related to each other to refine the high-level themes.

5.3. Findings

Perspectives from ANT and Post-Phenomenology helped us uncover two aspects associated with older adults' use of voice assistants, i.e., participation of nonhuman actors and the relations that voice assistants mediate between older adults and their larger social world.

5.3.1. Nonhuman Actors Shaping Older Adults' Use of Voice Technologies

In Actor-Network Theory, Latour argues that actors can be anything or anyone that makes a difference. As such, nonhumans can also be actors. In my analysis of participants' accounts, materials, societal norms, and individuals' ontological categorization of voice assistants emerged as actors who actively contribute to shaping older adults' preference or use of voice technologies.

Material actors shaping technology use

Materials can allow, afford, restrict, or enable activity and therefore become actors.

Different materials and objects at older adults' home including, walls, existing technology devices in the house, and paper manuals played a role in shaping older adults' use of voice assistants. For instance, let us consider P8. P8 had placed her Google Home on a shelf right outside of the kitchen. The shelf was built on a wall that is in between the kitchen and the dining room. This specific location of the Google Home, by being close to the dining room, allowed her visiting friends to use Google Assistant for timers or for asking questions *"So when there are four of us, we sit here, we eat and drink... and they'll come up with a question that somebody else can't answer, it's like, "Ask Google."* However, this specific placement of the device in this

location also contributes to the wall becoming a barrier when P8 wants to use the device for timers while cooking. Consider P8's account, which illustrates how the wall plays a role in her use of her voice assistant for cooking tasks:

P8: I do it [set timers] for food, more than anything else, I think, because it's right there by the kitchen.

Interviewer: So do you use it from your kitchen or do you...

P8: No, I have to step out a little bit because the wall prevents it sometimes, from hearing me.

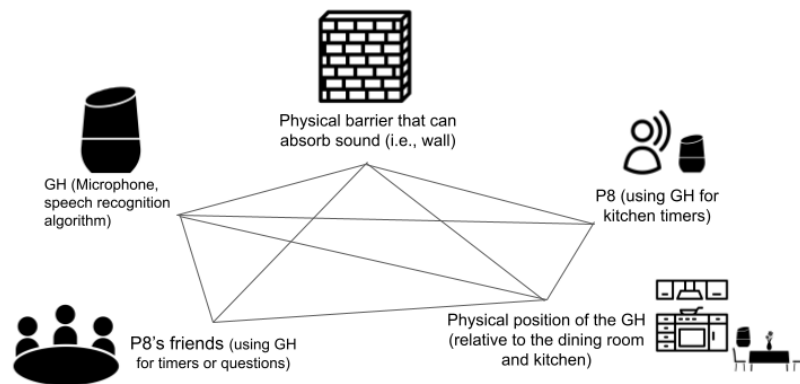


Figure 5.1. A simplified visual of a potential actor network for the phenomenon of P8 using her Google Home (GH) for cooking. (Icons used in the image are from the Noun Project).

Figure 5.1 provides a visualization of some of the actors in this phenomenon¹⁰. Here, I draw attention to how the wall acts. In this phenomenon, in addition to P8, and the voice assistant (i.e., the technology), the wall in P8's house is also an actor. The wall, just by being present in its specific location in the house (between the kitchen and dining room), restricts the voice assistant from successfully hearing P8. To overcome this, P8 learned to configure her position within the given actor network by stepping out of kitchen, which leads to successful use of her Google Assistant. Here, one can

¹⁰ Figure 5.1 is drawn in the style of other works (e.g., [46]) who have graphed actor-networks to better communicate these concepts.

argue that material actors, such as a passive wall, have agency, and participants actively re-configure their position in the actor-networks to take into account this agency of material actors. Other technology devices (e.g., television) also participate as actors in the home, which in many instances, participants described as unwanted actors. Devices such as a Kindle or a television, in the same room as the user and the voice assistant, restricted desired use of the voice assistant. For example, P10 described a phenomenon where the Alexa on her Kindle was interfering with using Alexa on her smart speaker: “*If I have my Kindle in the same room as the device and I want the device [Alexa on smart speaker] to do something, my Kindle starts to talk to me.*” To continue using her Alexa on smart speaker, she learned to restrict the actions of the kindle, i.e., “*shut down the Kindle completely*” and then the “*device [Alexa on smart speaker] responded to what I wanted*”.

In the above accounts, *physically present* material actors participate and contribute to a specific situation. In other cases, even *physically absent* material actors also contribute to shaping older adults’ use of voice assistants. One such material actor was the paper manual. Consider this quote from P13 who seems to be tech-oriented and still had an “*overwhelming*” experience setting up his voice assistant.

“I ran an IT department...but this technology is so far beyond where I was... I know it knows so many things, but I don’t know how to do them or get to them or where do I find a list of them? They don’t make it easy. Alexa comes with...just a little card that says, download the app and look at it, but the app is more overwhelming...it’s not that easy.”

In this situation, it is worth noting how the small piece of paper (which P13 refers as “*the little card*”) is contributing to a situation where P13 experiences frustration and finds it overwhelming to set up the technology. For decades, paper

manuals have been the primary material actor for onboarding or supporting learnability aspects of the new technologies [197], and research shows that older adults in particular prefer reading product manuals to learn about new technologies [146]. But recently with ubiquitous technologies, paper manuals are becoming shorter, or are replaced with apps to support learning. P8 describes how she misses having paper manuals *“and I think that's the issue for me. I'm old school and I'm paper and read directions and give me information on paper but there's no manual for these [voice assistants]... And it makes me think, well what else am I missing out on”*. As a result, not having these paper manuals results in a situation where it becomes harder for some older adults to learn about the different technology features, which P12 describes: *“I don't have time to go through and find them and see what's useful. And then, try to figure out how to put them in and remember what they're there for and remember the syntax.”*

To summarize, material actors such as a wall, technologies at home, phone apps, and paper manuals play an active role in shaping older adults' use of voice assistants.

Societal norms entangled with ontological perceptions of technology shape technology Use

In addition to the above described material actors, other nonhuman actors also emerged in my analysis. Societal norms actively participate in shaping older adults use and preferences with respect to their voice assistants. By societal norms, I refer to the rules and expectations that are socially enforced or internalized as values for an individual [39]. Through my analysis, I identify how norms, such as how one should talk with technology (including what sounds youthful or polite), become actors to shape older adults' preferences and use of voice assistants.

Norms actively shaped individuals' *preferences* around using a voice assistant. P5 described a phenomenon where a norm shaped her preference for not using a voice assistant (i.e., Google Assistant) as it would require her to say "*hey*":

"my brother-in-law switched to [a Google Home]. And then they walk around the house going "Hey, Google, turn the lights on"...that sounds a little college...it just doesn't sound like a grown-up person. I don't want to be going around saying hey all the time. My mother used to say you don't say hey, it's like not polite language. I mean, it's not bad. But it's, it sounds too youthful...in a negative sense.

Here the dominant norm for P5, shared with and perhaps instilled through her mother, is that saying "*hey*" is "*youthful*". P5 associated an adult using this phrase with the norm of not being "*polite*" or did not prefer saying "*hey*" as a "*grown up person*". In another example, P17 described how gender norms shaped his technology preferences. P17 described how he is "*more likely to ask a female for help than I am to ask a male for help...home help device, it fits more that it should be female than male.*" Here P17's norm to seek help from a woman rather than a man shapes his preference to have his "*home help device*" to be a "*female*" (voice).

Beyond shaping individuals' *preferences* around using voice assistants, norms also act to shape individuals' *use* of voice assistants. More specifically, here the norms act to shape the language individuals use to communicate with voice assistants. In these phenomena, a dominant actor alongside norms is the participant's ontological categorization of the voice assistant¹¹. Consider P10's phenomenon below:

¹¹ The ontological categorization of the voice assistant refers to categorizing the assistant as human-like or machine-like [164].

“...when Alexa would shut down or give me something, I would say, ‘Thank you,’ and my husband said, ‘Why are you saying thank you? It’s a piece of plastic with wires.’ I don’t know. I say thank you when somebody does something I like.”

The dominant norm for P10 was to say thank you when “*somebody does something*” for her. P10 related the phenomenon of Alexa doing something for her to “*somebody*” doing “*something*” for her, suggesting momentarily she might have ontologically categorized the voice assistant as “*somebody*”, and hence thanked Alexa. P10’s norm and her ontological categorization of the technology both become actors and configure the language she decides to use (“*thank you*”). This norm conflicts with that of P10’s husband whose most salient societal norm most was *not* to say thank you to a machine. P10’s husband ontologically considered Alexa as a machine “*plastic with wires*”, and therefore questioned the use of the phrase “*thank you*” for a machine. For both P10 and her husband, their ontological perception of the technology and the norm of using language as actors shape their use of the voice assistant. P3 described a similar situation where the norm of *using appropriate grammar in conversations* participates as an actor. To use her technology more efficiently, P3 was “*experimenting with what are the fewest words I can say*”. P3 may be working with a norm to be more efficient while using her technology, but P3’s actions such as skipping the article “*the*” in a command created discomfort for her husband, P2, who said: “*I imbue the device with a certain measure of personality and it drives me crazy that my wife says, “Alexa turn off bedroom light”, instead of “turn off the bedroom light.”* [P2]. The norm of using correct grammar while speaking to *someone* is dominant for P2. Yet, for P3, the norm of using proper grammar probably does not apply when talking to a machine.

Some of the social norms surfaced in my work corroborate with those noted in past research in speech interaction, including norms around politeness (e.g., saying please or thank you) [133,168], and gender preference with voice [49,144]. But, in addition to these norms, my findings also surface another societal norm of how saying “hey” might be considered as youthful for some individuals. These findings on how norms shape conversation with voice assistants aligns with past research in speech interaction that has noted how societal rules come in to play when humans converse with machines [40,153], which is attributed to overlearned social behaviors of humans [152]. For example, in context of politeness that humans exhibit when talking to machines, past work has attributed humans *saying thank you* to machines as mindless behaviors of human [133] or due to one’s own knowledge of appropriate ways to interact as humans [164]. But, in addition to the norms, my findings show that individuals’ ontological perception of the technology also play an active role in this situation. Additionally, my findings also highlight that not all older adults follow social norms around saying thank you or have interpersonal communication when conversing with voice assistants. Instead, some individuals such as P2 or P10’s husband who perhaps ontologically consider the voice assistant as a piece of technology, might be more factual users who are likely to have brief and concise communication with speech interfaces [218].

5.3.2. Voice Assistant Mediating Social Relations

In this section, I describe how the voice assistant plays an active role in mediating relations between older adults and their larger social world. Analyzing my data through the different *human-technology-world* relations from Post-Phenomenology, I describe the nuanced ways in which voice assistants shaped relations between older adults and

their world (Table 5.1 provides a concise overview). P1's account describes one such instance, where her caregiving capabilities are extended from her home into her husband's assisted living facility through Alexa:

"I am using an Alexa now in his assisted living facility. So, I program Alexa to remember when the Georgetown basketball game is on, because he doesn't remember it necessarily, but he likes to watch it. So, you can tell Alexa, you know, Wednesday night nine o'clock Georgetown basketball is on and Tuesday is shower day, remember you're gonna have a shower today, it's just it's a way to nag him without being there with him."

In this phenomenon, the primary actors include P1, her husband, and Alexa. Here, Alexa is mediating the relationship between P1 and her husband by acting as an extension of P1. Thinking of this phenomenon through Ihde and Verbeek's Post-Phenomenological *relations*, one can argue that *embodied relations* constitute this phenomenon. P1 is not merely setting remote reminders on her husband's Alexa, but is rather forming a unity with Alexa, and *through* Alexa, P1's presence is asynchronously extended into her husband's reality, despite them not being spatio-temporally co-located. It is worth noting how this mediation matters: it allows P1 to nag and care for her husband *through* Alexa, extending P1's caregiving capabilities and opening up possibilities for new material practices for caring. By enabling P1 to care for her husband daily, despite being physically apart, through this embodied relation Alexa is becoming a part of human caregiving – shaping what it means to be a caregiver and also a wife for P1. P20 described a similar instance where Alexa is mediating a relation between him and his wife, where he would intentionally tell Alexa to shut up, to mischievously "*get on her [P20's wife] nerves*". Here, *through* Alexa, P20 is playfully nagging his wife.

“I do tell Alexa to shut up quite a bit. And that upsets my wife. She says ‘don’t tell her like that’... Alexa is her friend, her companion... And sometimes I do it because I know, it’ll get on her nerves ... You know, we’ve been married a long time. So we know how to push each other’s buttons... I know that I’m just needling her, you know, because I’m mischievous, but it keeps it keeps our relationship alive. And you have to work to keep it alive. And so, you know, there are things that are done playfully, versus things that are done maliciously.”

Above, we see somewhat successful embodied relations where Alexa extends the user’s presence in ways they desired, e.g., extended P1’s presence and enabled her to care for her husband. P5, on the other hand, described a situation involving her pet animal, where Alexa did not successfully mediate an embodied relation. P5 desired for Alexa to play a mediating role by extending her ability to provide “*company*” to her cat *through* Alexa, when she was out of the house. She enabled an Alexa skill (a third-party app) which she expected would talk “*to the cat as if I would, if I were home*” so that the cat would “*have company*” when P5 leaves the house. However, instead of talking to the cat as a human (as P5 wanted), the third-party skill on Alexa was programmed to make cat sounds. Here, Alexa interacted with P5’s cat as another cat, and P5’s cat disliked it:

“I thought when it said that meow skill that she [Alexa] was going to talk to him [P5’s cat] like “Hi, kitty kitty.” You know, like a human voice. But it’s like a cat to cat conversation. He [P5’s cat] doesn’t want another cat in here. We won’t be using that.”

Note, in this situation, P5 wanted Alexa to extend a human’s presence, more specifically *her presence* through technology to provide company to her cat when away, and stands as an example an *embodied relation* that Alexa could not mediate successfully. In both P1 and P5’s phenomena, the voice assistant is mediating relations

between older adults and their larger social world including their partner or pet, and as a mediator, is playing a part in configuring social practices around what it means to care, nag, or provide company.

Above, P1, P20, and P5's accounts illustrate how *embodied relations* constituting older adults and their voice assistant can extend individuals' presence and open up new possibilities for older adults to care, nag, or provide company to their larger social world. P18, on the other hand, described a phenomenon where the voice assistant shaped the context that P18 experienced, providing an example of *background relations*. P18 described how Alexa extended the capabilities of his service animal, where P18's service dog would follow Alexa's command "*Lizzy [anonymized dog name], go get it*", to get P18's medicine:

"At 8:30, I had to take a shot and I'd blunder it all the time...I had set alarms on my phone, but then I would ignore it...that person there who's talking [Alexa] would come on at 8:30 and she would announce that... Lizzy, she needs to go get my medication. The word was, "Go get it." And so Lizzy, she'd run every day at 8:30...and go get it. It's in a cupboard in the bathroom, the bottom cupboard, takes the satchel, brings it to me... and then I take my shot."

In this phenomenon, although interactions involving Alexa are shaping new possibilities for an animal to care for a human, Alexa in itself is not consciously experienced by P18 (apart from the initial training days of Lizzy when P18, his partner, and their dog trainer were involved). Rather, Alexa shapes the context for P18's experience, and in itself, Alexa is in the *background of the experience*. In other words, Alexa is having an impact on the relation between P18 and his service dog by enabling his dog to care for him, but, in this context, Alexa in itself is not explicitly experienced by P18. This relationship that Alexa mediates between P18, and his larger world would

classify as *background relations*, where even though the technology is not consciously experienced by the human, it is shaping the context that the human experiences (e.g., getting the medicine at a certain time).

Above, I described how through *embodied* and *background relations*, Alexa plays an active role in mediating relations between older adults and their larger social world (including partners and pet animals). Beyond embodied and background relations, *alterity* relations also emerged, where the individuals interacted with Alexa as if it were another living being. Some participants, like P13, described how these interactions with Alexa are shaping their experience of living alone:

“Sometimes I wake up in the morning and say Alexa, good morning. She'll say good morning [P13 name]. I mean, it's just a voice. Sometimes I just need the voice of, you know, I'm used to living with my wife 53 years and then all of a sudden there's nobody in my house”

P13's partner recently moving to a nursing home and created a void in P13's life and home, with P13 living alone for the first time in 53 years. In this situation, although Alexa is not a true person, but the ability of Alexa to exchange greetings makes the technology more human-like or more in “similitude with human” [55], thereby enacting a reality where participants are likely to anthropomorphize Alexa (a phenomena noted in past CSCW research as well [164,183]). Here, although the technology, Alexa, is anthropomorphized, it is not human but acts like a *quasi-other*, an entity that exists and gives company, constituting an *alterity relation*. Closely looking at this phenomenon, from P13's quote below, we can see how interactions with Alexa are shaping his experience of living alone:

“Living alone, I don't live alone having Alexa. I don't have to do all the cooking because she, Alexa helps you [by telling recipes]...Well, I am not somebody who used to have to make all the meals and everything before. Now I have to know all this stuff about cooking. I don't. Because Alexa helps.”

P13's second quote “*living alone, I don't live alone*” illustrates how these interactive relations involving Alexa are shaping what it means to live alone for P13. As another example of Alexa shaping what it means to live alone, P11 described forming a similar relationship with Alexa, where P11 felt “*bereft*” when Alexa was not online: “*Well certainly, she is involved in so many aspects of my life that I feel bereft, I guess, when the internet's down, or something. Or when the power's off, and she's not talking*” (P11). In this situation, beyond alterity relations, what P11 and P13 might be experiencing is an *immersive relation* — where Alexa has merged with their environments to create a new hybrid environment, and the relation between the human and that hybrid environment is interactive. And, this *immersion* in this new interactive environment is shaping a reality where individuals can have new relations towards themselves through the technology, one where they feel “*bereft*” (P13) without Alexa, or with Alexa, they feel “*I don't live alone*” (P11).

Relation	Summary	Example
Embodied	Technology unites with human and humans experience the world through technology	P1 caregiving and nagging her husband through Alexa
Background	Technology merges with the background and shapes the context experienced by human	P18's dog following Alexa's command to get P18's medicine
Alterity	Technology is more “like us”, not human but <i>quasi-other</i>	Alexa shaping P13's experience of living alone
Immersion	Technology merges with environment to create a new hybrid environment with which humans have an interactive relation	Alexa merging with P11's environment to create a hybrid environment, where P11 feels “I don't live alone” with Alexa
Hermeneutic	Technology represents the world and requires human interpretation to be meaningful	User interpreting information from Alexa such as weather

Table 5.1. Post-Phenomenological relations with worked through examples from data

5.4. Discussion

In this work, I present a case of adopting posthumanist entanglement perspectives towards understanding older adults' use of emerging voice technologies. My findings reveal how nonhuman actors shape older adults' use of the technology, as well as how voice assistants mediate different kinds of relationships between older adults and their larger social world. With a growing focus on developing emerging technologies for older adults (e.g., [185,204]), these findings also help us think differently of how we could approach studying technology for aging, thereby contributing to the broader HCI and CSCW research on aging. Towards this, first, my discussion considers how researchers can approach thinking in terms of relationships that older adults develop with and through their technologies. Next, I discuss the broader implication of accounting for nonhuman actors in aging research. I also discuss how my findings contribute to the ongoing discussions on considerations for designing human-like voice technologies.

5.4.1. Towards Designing Entangled Human-Technology-World Relationships

In research on aging and technology, traditionally, the primary focus is on the user i.e., older adults, and how we can design *interfaces* that older adults find usable and accessible [22,61]. But, some of my findings question this traditional focus. My findings illustrate how older adults, their technologies such as voice assistants, and their larger world might be entangled, where technologies mediate different relationships between older individuals and their larger world. And this entangled relationship poses new questions around who is *interacting* with whom, and where the *interface* is.

Revisiting the phenomenon involving P1, her husband in assisted living facility, and Alexa, where P1 described nagging her husband without being spatio-temporally co-located, we can ask: is P1 interacting with her husband's Alexa? Or is P1's husband interacting with his Alexa? Or is P1 interacting with her husband? Or is it that P1 and her husband's Alexa together are interacting with her husband? Also, where is the interface for the interaction? Is it P1 setting remote reminders? Or is the voice of Alexa the interface facilitating interaction between P1 and her husband? By adopting a Post-Phenomenological perspective, I argue that P1 and Alexa form a unity constituting an embodied relation through which P1 is able to asynchronously care for and nag her husband. The human-technology interaction does not end with P1 setting the reminder through the technology, but rather gets entangled with the human-human interaction (or for P5 human-pet interaction) as P1 is still present in her husband's future (or P5 is present in her cat's reality) through the technology.

These entangled relationships constituting technologies, older adults, and their social worlds have implications for designing emerging ubiquitous technologies. In designing emerging technologies for older adults, it might be fruitful to think in terms of human-technology-world relationships and understand the different kinds of relationships that technology mediates between older adults and their larger social world (here Post-Phenomenology could be a helpful framework). These understandings would help us design technology features that could meaningfully support desired relations between older adults and their larger world. As an example, consider the phenomenon where P5 and Alexa had an embodiment relation, where through Alexa, P5 wanted to extend her presence to provide company to her cat when she is away from

home. Here, understanding the relationship that P5 wanted the technology to mediate would help us design more meaningful features such as a skill that let's P5 record her voice clips for her cat, rather than a generic recording of cat sounds. I argue that this shift in thinking about relationships between technology, older adults, and their larger socio-material world (in addition to thinking about just the user) would in turn help us design technologies that are more meaningful to older adults.

I also reflect on data collection approaches when adopting a Post-Phenomenological perspective. If we want to understand further nuances of the human-technology-world relations, we need to adapt our data collection approaches that can capture humans' larger world. While interviews are somewhat helpful in providing a picture of older adults' world, interviews only surfaced the relations that older adults chose to share. Researchers interested in post-phenomenological analysis can employ ethnographic approaches of visiting the field site and conducting home tours (e.g.,[3]), to attune to the relations individuals have with their socio-material world at home. In addition to ethnographic approaches, there are a variety of other methods which could help surface entangled relations which exists both inside and beyond the home. These include conducting life story interviews [14], co-design fictions [2], and enabling older adults to collect data using techniques such as photovoice where older adults take pictures of their daily lives and share with researchers [159]. Each of these methods can surface entangled relations in different ways: life story interviews by having people describe the social and material entities that have shaped their past lives; co-design fictions by fleshing out a fictional reality with details such as ethics, politics, social perspectives, and emotions [194] which can help uncover salient relations; data

collection techniques such as photovoice give participants space to capture meaningful configurations in their own environments. Analyzing data from such sources through a Post-Phenomenological lens will help us understand and design for the nuanced entangled relationships that older adults develop with their larger socio-material world.

While not relevant to mediating relations between older adults and their social world (as reported in 4.2), in my Post-Phenomenological analysis, I did observe *hermeneutic relations*. For example, voice assistants provide information to users such as weather, which stands as an example of hermeneutic relations where the technology represents the world (i.e., outside temperature) and needs to be interpreted by the human. Understanding such hermeneutic relations mediated by voice assistants might be of relevance in certain context such information seeking behaviors of older adults through voice assistants. *Cyborg relations* in which the technology merges with the body into a new hybrid, and *augmentation relations* which combine embodiment and hermeneutic relations did not emerge in my analysis of voice assistants' use but may be relevant in context of studying older adults' use of other emerging technologies such as social robots, virtual reality, and health trackers.

5.4.2. Accounting for the Nonhuman World in Aging Research in HCI

Research on aging in CSCW and HCI has focused on designing technologies that individuals find usable, useful, and meaningful. Yet, researchers often point out that many older adults continue to experience challenges in using emerging technologies [108,109,167] or do not perceive some of these technologies as useful or meaningful [89,143,204]. Despite decades of research on understanding negative perceptions of technology or the challenges older adults' experience, [111,145,182], what we might

be failing to capture is the agency of other actors (including but also beyond older adults) who might be contributing to the phenomenon of technology becoming not usable or meaningful. Below, based on my findings I describe how taking a “more than human” turn in this regard could be potentially helpful.

Consider a case of exploring the usability of emerging technologies for older adults. Previously researchers have framed data in terms of older adults finding these technologies hard to use, as an example in context of voice assistants, older adults experience challenges in pairing their smartphone with voice assistants or in remembering the correct voice commands [167]. In my own work, prior to adopting posthumanist perspectives, I also initially interpreted the data in terms of older adults’ experiencing challenges in using these voice technologies, and that these technologies need to be more accessible by focusing on the interface and the interaction. But, looking at this same data through an ANT-based perspective helped us uncover the actual actors contributing to this phenomenon, i.e., missing material actors such as paper manuals or a passive wall that contributes to speech recognition issues. Based on this, I argue that identifying nonhuman actors that are read as passive (e.g., the wall) or actors that might not be visible on the first glance (e.g., the manuals) within the larger actor-network will be helpful in addressing the challenges around usability aspects or technology adoption by older adults. Within our team have found this sensitization helpful in our own work, and we are closely paying attention to things that we previously had never taken into account, such as instruction manuals, organization of space, position and mobility of furniture and technology, or placement of outlets in walls. As an example, in one of our current projects involving setting up a new technology environment in a retirement

community, we are co-designing technology instruction manuals with residents. Prior to conducting the analysis in this paper, we would have considered designing manuals out of scope for HCI.

Based on my findings that show how nonhuman actors have agency, I argue for holding these actors responsible and accountable when necessary. But, one might ask, why does this re-framing of accountability and responsibility matter? Considering the example of user manuals described above, one might question: what difference does it make to say, ‘older adults experience barriers in using voice assistants due to difficulty pairing smartphones or remembering voice commands, rather than saying ‘missing material actors such as onboarding paper manuals create barriers in learning to use technology’? I posit that, by re-framing responsibility and accountability to material actors, we can distance from the *deficit model* around the decline associated with aging and older adults being less tech-savvy or not being *able* to use technologies [62,174,212]. Going away from this deficit model matters, because it will help us see aging differently and not as a decline that can be compensated only by assistive technologies [112]. Repeatedly assuming that older adults are less tech-savvy and might experience challenges in using technology might not solve the issues around usability and perceived usefulness until we hold the actual material (or even social) actors responsible for any undesired situation. Researchers are calling to attention the need of going beyond focusing on older adults abilities, and to account for how older adults’ values and cultural expectations contribute to individuals’ resistance to digital technology [110]. Towards this, I propose to systematically account for different human and nonhuman actors, to better understand who the actors are, how they act, so

we can account for them in our understanding, theories, design processes, and decisions.

5.4.3. Reflections on Designing Human-like Voice Technologies

My findings also contribute to ongoing discussions around considerations for designing human-like voice technologies [136,193,215]. As technologies-like voice assistants become more human-like, CSCW researchers have attuned to the ways that though seemingly neutral, technologies encode normative cultural and gender practices [193,215]). Here the most clear link is with *gender* of the agent which can perpetuate harmful social stereotypes (e.g., [136,200]). But, by working with older adults, I found that “age” as a dimension can also get embedded in such human-like technologies. It is worth noting how P5’s perception of using Google Assistant’s wake up word as “youthful” and “not polite” suggests that voice assistants might be encoding a normative age (at least to some extent). As we seek to design human-like technologies that distance from reinforcing stereotypes in our society, it might be fruitful to think of the different human and nonhuman actors in our design processes that might be contributing towards this situation or even responsible for this situation. For example, personas of voice assistants are a nonhuman actor which could be contributing towards this situation. A persona for a conversational voice technology is a fictional character with traits such as name, age, education, personality or even a backstory and contributes to a cohesive and consistent presence of the voice assistant [78,166]. For example, Google Assistant’s persona describes the assistant as a “young woman from Colorado” [83,200]. Here, it is possible to draw connection between how the assigned trait of “young woman” could have led to designing technology features (such as the wake

word of “hey”) that makes some individuals perceive the technology as youthful in a negative sense. Going forward, I recommend researchers and designers to account for how actors, particularly nonhuman actors, can intentionally or unintentionally contribute towards perpetuating such harmful stereotypes in our society.

My findings also contribute to the growing body of CSCW research examining the collaborative nature of voice assistant use by family members at home (e.g., [16,74,162]). For example, past work in families involving children has noted how voice assistants can shape human responsibilities, more specifically, parenting responsibilities in supporting child’s daily routines for low-SES parents [74].my work with families involving older adults contributes to this body of work by identifying how voice assistants also play a role in shaping other human responsibilities such as those around what it means to provide or receive care (e.g., P1 caring for her husband remotely or P18’s service dog caring for P18) and company (e.g., P5 providing company to her cat when away). As we move into a future of ubiquitous human-like AI technologies, we need to attune to the ways in which these technologies can shape our social practices and the implications of technologies shaping these social practices.

5.5. Conclusion

In this work I provide a case of adopting posthumanist entanglement perspectives in the context of aging research: by studying older adults’ use of emerging voice-based technologies. My findings analyzed through perspectives of Actor-network Theory and Post-Phenomenology (two entanglement theories in HCI and CSCW) indicate how a) nonhuman actors including material actors, and individuals’ norms and ontological categorization of the technology play a role in shaping older adults’ use of voice

assistants, and b) the voice assistant plays an active role in shaping relations between older adults and their larger social world, which in turn is shaping our social practices around giving and receiving care, company, or nagging. Based on these findings, I discuss the value in adopting entanglement perspectives in context aging: in terms of thinking about the relations that older adults develop with and through their technologies, and the implications in assigning responsibility to nonhuman actors. I also discuss how traits such as age get embedded in human-like voice technologies and therefore contribute to ongoing considerations for designing such human-like technologies.

Overall through Study 2, I provide evidence of the value in adopting posthumanist entanglement perspectives in the context of aging research in HCI. But this study focused on one specific mode of including older adults' perspectives with respect to technology, i.e., focused on their *use of technology*. Given that technologies designed for older individuals are many a times informed by the perspectives that older adults share in *technology design workshops*, there is value in understanding older adults' participation and engagement in these design workshops. As such, in Study 3, I extend my work to adopt posthumanist entanglement perspectives in another context, i.e., older adults engaging in designing emerging technologies through participatory design workshops.

Chapter 6 : A ‘More-than-human’ Perspective on Older Adults Participation in Design Workshops

6.0. Overview

This chapter describes the third study of my dissertation: a posthumanist perspective on older adults’ participation in design workshops. More specifically, I answer the research question “*How do different human and nonhuman actors, particularly design materials, participate and shape design activities involving older adults?*” To do so, I re-analyzed data from two design workshops with older adults. Initial papers resulting from the two workshops have been previously published at [120,165]¹²; for [165] I led the study design, analysis, and write up, whereas for [120] I collaborated in analysis of the paper.

In the re-analysis of the workshop data, I attuned to the agency of both human and nonhuman actors, which reveals the nuanced ways in which designs materials act in relation to older adults: from facilitating design ideas, to limiting creative brainstorming, to leading to clashing of ideas, and contributing to non-participation in the design activity. Attuning to nonhuman agency also surfaced the salient ways in which unexpected actors including bodily movements along with words, and our research apparatus such as a video camera become design materials. This finding suggests a timely need to go beyond material artefacts resulting from design workshops

¹² I briefly reflect on my role in the previously published papers that used this same data. For [165], as the lead author, I led the study design, data collection, analysis, and write up of the paper. Co-author Ben Jelen supported in reviewing relevant literature and also helped as a facilitating researcher during the workshop session. For [120], co-authors Ben Jelen and Katie Siek facilitated and organized the workshop activity. The data was analyzed with four different perspectives: first analysis led by Katie Siek, second analysis by Ben Jelen, third analysis by Amanda Lazar and myself, and the fourth analysis along with the overall paper write up was led by Amanda Lazar.

(e.g., sketches, prototypes) and consider other modes of expression (such as words and bodily movement) that older adults might choose for representation of design ideas. My analysis also sheds light on how beyond design materials, other socio-material actors including material objects at home and current IoT technologies become inspiration for design and play a role in how design workshops unfold. In many of these instances, older adults went beyond focusing on just the technology idea as the artefact or the self-bounded end-product, to think of the larger actor-network within which the technology should exist. Based on these findings I argue the need to shift our objective of design workshops involving older adults: move beyond designing technology in isolation to instead purposefully situate our participants to designing meaningful configurations of which technology is a part of.

6.1. Introduction

In Entanglement HCI [71], motivated by Barad’s proposition of performativity, Frauenberger argues that “producing knowledge means accounting for material-discursive practices”. In other words, “knowing about a particular artefact (in my case this artefact would be technologies for aging) means tracing its relations in different **modes** of becoming (e.g., design, evaluation, use, appropriation) through a material-discursive engagement. And “understanding these differential ways of becoming” can “inform our future material-discursive engagements in designing things.”

Along this underpinning of Entanglement HCI, my first and second dissertation studies focus on the specific **mode** of older adults’ *use of* emerging technology. By focusing on the mode of technology *use*, the first two studies of my research provide new understandings such as how a voice technology, at times, becomes ontologically

human-like to be a friend or a companion (first study), or becomes a part of human functioning by configuring social practices around caring or providing company (second study). In my final dissertation study, I investigate another **mode** that can shed new understandings— *older adults **designing** emerging technologies in design workshops*.

I chose *the mode of design workshops* because including older adults in designing technology through participatory design workshops is a popular research approach in terms of empowering individuals to brainstorm and design their desired technological futures [79,131,165]. In such design workshops, older adults participate alongside researchers to brainstorm technological futures. In aging research in HCI, often there is a trope associated with older adults and their competencies in these design workshops: for instance, past research posits that older adults' experience challenges in brainstorming about future technologies [130,131], or it is harder to keep older adults focused on the topic of discussion [131]. Here, research rarely examines the role of actors, beyond older adults participating in the workshop, who could be contributing to undesired realities. As researchers in gerontology pose that older adults' experiences are constituted within diverse 'more-than-human assemblages' of digital culture and technological proliferation [5], there is an opportunity in accounting for 'more-than-human' aspects in design workshops involving older adults. Given that the perspectives older adults share in design workshops eventually make their way into technology design, there is value in understanding how older adults engage in these workshops, and the different human and nonhuman actors that shape engagement. Therefore, in my final dissertation study, I adopt a posthumanist perspective— that takes into account

the nuanced ways in which nonhumans actors, in addition to human actors, shape our reality—to analyze older adults’ participation in design workshops. More specifically, **the research question that I answer in this study is: *How do different human and nonhuman actors, particularly design materials, participate and shape design activities involving older adults?***

To answer this question, I scoped my data to design workshops that involve older adults in designing Internet of Things (IoT) technologies. I chose IoT technologies because, first, in context of aging, IoT has a history, where traditionally IoT technologies have been designed to support aging-in-place by addressing challenges such as social isolation (e.g., [43]), medication adherence (e.g., [127]), or broader assistance for daily living (e.g., [60]). But, in recent years, older adults as a population are adopting commodity IoT technologies (e.g., smart speakers, smart home appliances) in growing numbers [114,172], and are living with these technologies in their homes. Second, it is a popular emerging technology that researchers have argued could benefit from a posthumanist entanglement perspective [71].

To answer my research question, I re-analyzed data from two IoT-focused design workshops involving 32 older adults (originally published [120,165]¹³). In this re-analysis that I describe in this chapter, I attuned to the agency of both human and nonhuman actors and how they contributed to unfolding and shaping of the workshop. My analysis reveals the nuanced ways in which designs materials act in relation to older

¹³ The goal of the previously published works differs from the goal of this work. In [165], our goal was to understand: who do older adults envision as the user of the technology they are designing? and How individuals attitudes towards technology impact their participation in design activities? In [120], our goal was to provide a case of adopting Diffractive reading of data in the context of HCI research in aging.

adults: from facilitating design ideas, to limiting creative brainstorming, to leading to clashing of ideas, and contributing to non-participation in the design activity. Attuning to nonhuman agency also surfaced the salient ways in which unexpected actors including bodily movements along with words, and our research apparatus such as a video camera become design materials. My analysis also sheds light on how beyond design materials, other socio-material actors including material objects at home and current IoT technologies become inspiration for design and play a role in how design workshops unfold.

6.1.1. Contributions

As one of the preliminary works that accounts for the nonhuman world in design workshops involving older adults, this work contributes to the larger body of research in HCI and CSCW that seeks to understand ways to better include older adults in design activities [129,131,165]. More specific contributions of this work include:

1. An understanding of how different design materials (including traditional materials, and unexpected materials) act in relation to older adults.
2. Identification of the salient ways in which *current IoT technologies*, as an actor, shape older adults' participation (or non-participation) in design activities.
3. Offer methodological considerations: a) to account for nonhuman world in technology design activities involving older adults, I propose a shift from *designing technologies* in isolation to *designing meaningful configurations* of which technology is a part of. b) Next to account for the unexpected ways in which older adults might represent emerging technologies ideas in design workshops, I suggest

re-thinking the concept of representational artefacts when engaging older adults in designing emerging technologies.

6.2. Background: Including Older adults in Technology Design

My final dissertation study seeks to understand the role of different human and nonhuman actors in contributing to the reality we see when older adults participate in design workshops. Therefore, here, I review the different approaches of engaging older adults in technology design, and more specifically in co-design workshops.

Efforts to include older adults in designing technologies for aging is not new. Traditional methods include surveys, interviews, or focus groups (e.g., [34,54,142]), or evaluating aging-in-place monitoring prototypes with older adults in laboratory or home settings (e.g., [53,163]). Within the last decade in the HCI community, there has been a growing impetus to include older adults in the actual design process through participatory design workshops—a method that aims to democratize the design process by allowing end users to voice their thoughts and opinions during the process of design. Here individuals might work independently or in groups alongside researchers and/or practitioners to participate in technology design. Some of these workshops include older adults by eliciting their feedback on materials researchers bring to the activity such as prototypes or scenarios for design, with the goal of using “critique” as a source for design [9,129,202,210]. Another approach involves older adults conceptualizing the technology themselves. This approach typically makes use of office and design supplies such as paper, markers, post-it, colored pencils, (e.g., [86,129]) or modular representations of technology such as paper cut outs of user interfaces and controls or actual devices (e.g., [81,131,138]).

In terms of the purpose of these workshops with older adults, as might be assumed, the primary focus is eliciting technology needs that will enable researchers to design and build technology. Some examples include getting design requirements for smart health applications [51,81], designing rehabilitation tools [202], creating new banking experiences [209,210], or social virtual reality application [9]. Yet, despite this widespread popularity of including older adults in participatory design, some research calls attention to open issues in engaging older individuals in participatory activities. Past work indicates that older adults at times have difficulty due to the open-endedness of the design activities to conceptualize the unknown “future” technology [86,131]. But in this situation, is it just older adults who experience difficulty in conceptualizing technology? What role do other human actors (e.g., researchers) or nonhuman actors (e.g., design materials) play in supporting creative brainstorming process? Here, a posthumanist entanglement perspective that accounts the role of the nonhuman world, could help in providing a nuanced understanding of why such undesired realities emerge by accounting for how different social actors and material actors contribute to undesired realities.

6.3. Method

In this section, I describe the following: a) the participatory design workshops with older adults whose data I re-analyzed in this study (methods subsection related to planning of the workshop activities is adapted from the published papers [120,165]), b) the theoretical underpinnings that have shaped my analysis, and c) the analysis approach.

6.3.1. The Data: Participatory Design Workshops Focused on Internet of Things

In this chapter, I re-analyze data from a set of two workshops where older adults engaged in brainstorming Internet of Things technologies (IoT). I specifically chose data from these workshops for secondary analysis a) because of the unique range of design materials used in these workshops which can help us understand the agency of these design materials in relation to older adults, and b) because of the diversity of IoT experience participants had in these workshops.

In HCI, the design materials and their agency has been a topic of interest [73,195,196], and often explored in context of younger designers [195,196]). Although older adults as a population are often included in design workshops, we lack an understanding of how these materials as nonhuman actors in relation to older adults—something my findings unpack. Hence, I chose workshops that recruited older adults to help design technology using popular design materials typically used in participatory research (materials listed in Table 6.1):

a) Design cards provide design cues such as keywords or questions [24] and can include visuals and textual description of range of things that can facilitate creative brainstorming such as objects, concepts, missions, and interaction modalities (input and output modes). Participants use these design cards to brainstorm what they want from technologies and represent their technology ideas through the cards. These design cards can be existing card sets or can adapted and customized by researchers [217]. In my data, workshop 1 made use of a set of personalized design cards, whereas, workshop 2 made use of a popular existing IoT cards deck [149].

b) Sketches can be paper-based sketches, whiteboard-based sketches, or computerized sketches. My data included paper-based materials, where in both workshops, participants could engage in sketching by using paper and pen.

c) Low-fidelity prototyping typically include craft supplies, colors, or cardboard materials [67]. The workshops I chose for analysis also included low-fidelity prototyping materials such as paper, glue, scissors, pen, and markers (these materials were there in both workshops). Workshop 2 included additional prototyping materials such as popsicle sticks, cardstock, colored papers, and pipe cleaners.

In addition to the diversity of design materials used in the two workshops, another reason for choosing these two specific workshops for analysis is the **diversity in terms of IoT experience of older adults participating in the session**. As older adults adopt commodity IoT technologies in growing numbers, and live with these technologies in their homes, there is an opportunity in understanding how commodity IoT technologies as nonhuman actors shape older adults' design decisions. Workshop 1 included participants who explicitly had experience of using IoT technologies because they were recruited from a longitudinal study that deployed various IoT technologies, such as wearable activity monitors, motion sensors and door sensors, in the homes of retired older adults. Workshop 2's participants were recruited from an Alumni Association event, and included a mix of people with and without current IoT experience, though many participants self-reported using a commercial IoT device, such as smart speakers, lights, doorbells, and iRobot (e.g., Roomba). These unique IoT experiences of my participants helped me further understand the nuanced ways in which currently available commodity IoT technologies shape design workshops. Below

I describe in detail the two design workshops that I included in my secondary analysis and the participant details. Both design workshops were conducted in-person in summer 2019.

Works hop	Design materials used	Participation	Participants' IoT experience
W1	Personalized cards, and low-fidelity prototyping tools, such as big paper, markers, scissors, glue	in pairs of two; N=6	All participants had experience with IoT technologies
W2	Existing IoT toolkit cards, and low-fidelity prototypes materials such as pipe cleaners, popsicle sticks, paper, cardstock, colored markers, and scissors	In groups of 5-6 people; N=26	Many self-reported using IoT, but not all used IoT technologies

Table 6.1. Different configurations of design workshops

Workshop 1

The first workshop included older adults who explicitly had experience of using IoT technologies in their homes. The design workshop was tailored to participants' unique preferences which they mentioned in our prior engagements with through initial interviews and the focus group discussion. All procedures were approved by the Institutional Review Board. Each participant was compensated \$55 in total.

Participants

Six individuals were recruited from a longitudinal study that deployed various IoT technologies, such as wearable activity monitors, motion sensors and door sensors, in the homes of retired older adults. Inclusion criteria specified that they must have had these technologies in their homes for at least three months to ensure that they had experience with them beyond a novelty period. This recruitment criteria ensured that participants had experience of using IoT technologies at home. Participants were between 65 to 76 years in age, identified as female, and lived independently in their homes. All but P2 had a college degree.

Though participants were recruited from researcher-installed IoT testbed homes, some of them also owned commercially available IoT technologies that they purchased outside the study, such as smart speakers (Echo Dot, P1 and P3), smart plugs/outlet (P1), and a smart doorbell (P3). While some participants did not own any commercially available IoT, they were aware of many available technologies and had formed their own perceptions about these devices.

Workshop Configuration

The design workshop was a part of six-month long study (see Figure 6.1) and was focused on supporting participants in envisioning and designing IoT technologies that they might like to use in their homes.



Figure 6.1. Planning of Workshop 1

Pre-workshop activities: interviews, focus group, take home activity

Pre-workshop activities included an interview, focus group discussion and a take home journal with the polaroid. Using participants responses in the interview and focus group discussion, we created personalized design cards (object and scenario cards) for the design activity. For full details on planning and structuring see [165], here I briefly describe the process. From **the interviews**, we found themes that participants most frequently mentioned: health and hobbies. We presented these two themes as the topic of focus group discussion. From the **focus group** we identified scenarios of daily activities that are meaningful and important to participants. These scenarios were

presented to participants during the actual design workshop. At the end of the focus group, we also gave participants an **optional take home journal activity with a polaroid camera, film, and a paper journal with prompts.** The purpose of the take home activity was to give individuals the opportunity to share any details about their home (such as the objects at home, how they are arranged, specific locations of the house) and to prepare them for the design workshop to brainstorm desired IoT technologies. Participants could answer with words, drawings, or pictures taken with the polaroid camera (e.g., see Figure 6.2. below).

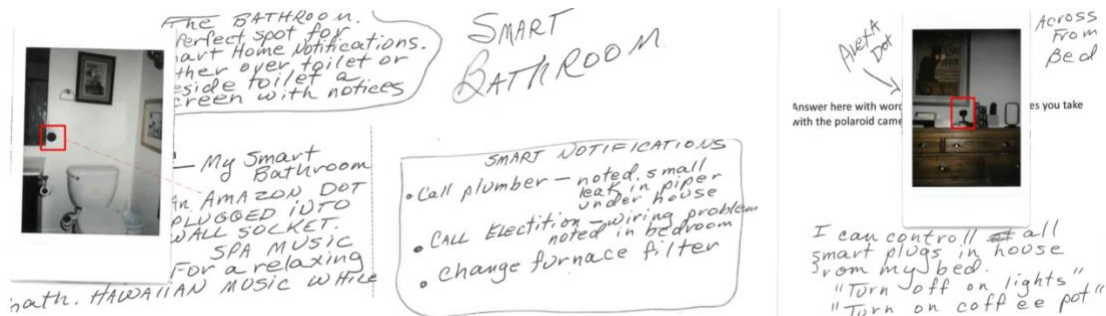


Figure 6.2. P1's journal showing smart notification system and its location in house

Design workshops

The design workshop was a 2.5-hour session, conducted a few days after the focus group session. The session was audio and video recorded. The session itself was structured as follows: after a reflection on the take home journal, participants began the card-based design activity. Below I first describe how our team personalized and prepared the scenario cards and the IoT card deck. Next, I describe how the workshop activities were structured.

Design cards and Scenarios for design. Between the focus group and the design workshop, I spot transcribed and open coded the focus group discussion [105] to identify scenarios for design that we could present to participants for design activities.

We clustered the codes within our research team and created six “what if scenarios” [82] contextualized by actual participant quotes from the focus group (Figure 6.4. shows an example). Scenario cards included nudges for staying active and healthy, taking care of your house, taking care of your garden, customized exercise, and monitoring vitals.

For the design cards, we adapted an existing IoT card deck often used when brainstorming IoT technologies [149]. We printed human action (input) and feedback (output) cards from this set. Instead of using the default object (“things”) cards in the pack, we created 25 object cards based on the scenarios and common objects mentioned by participants in the focus group and initial interviews. Example of object cards include bed, smart speaker, oven, and television, each represented by a picture of the object and its name (Figure 6.3-left). My rationale to use cards was informed by prior success of cards in workshops with older adults due to visual images on them [3,210]. Figure 6.3. shows object, input and output cards used in this workshop.

In addition to the design cards and scenarios provided by us, participants also had the flexibility of using blank cards to create their own cards for scenario, object cards, or feedback cards during the activity (in case the ones we provided did not match their interests or needs). In addition to the design cards, we also provided craft supplies as prototyping materials including: colored post-it notes, glue, scissors, paper, markers, and scotch tape.

Structuring of the workshop

Each individual was given a set of six “what if” cards that depicted scenarios, from which they chose two or three scenarios that they were most excited about. Participants

were paired based on the scenarios they chose ensuring that each pair had at least one scenario in common so that they could work together. Three groups were formed- G1 (P1, P5), G2 (P2, P3), G3 (P4, P6).

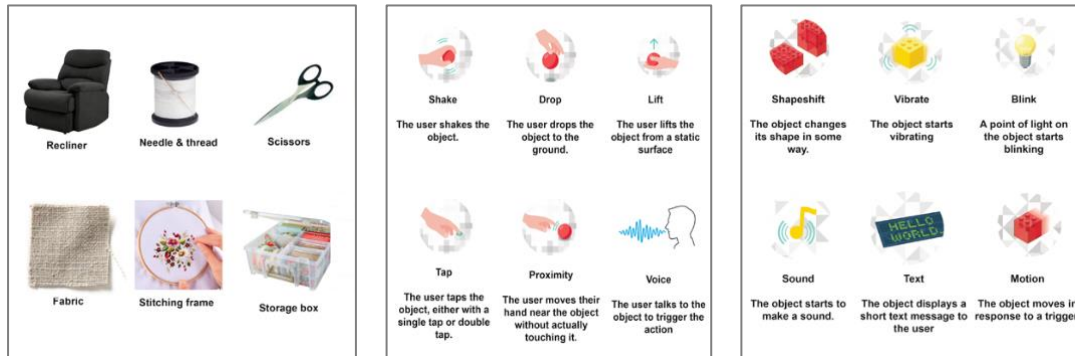


Figure 6.3. Object cards (left); human action/input cards (middle); feedback/output cards (right)

Upon grouping individuals, participants could choose any scenario to focus on. The scenarios participants selected were: “taking care of your house” (G1), “customized exercise” (G2), and “monitoring vitals” (G3). The group that selected the latter also created two additional scenarios: “sound system throughout house” and “organizing of files and ideas [on paper or post-it notes].” Figure 6.4. shows an example of a scenario card.

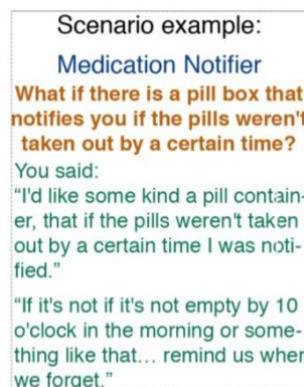


Figure 6.4. Example of a scenario card.



Figure 6.5. Final artefact on big paper from the design workshop

Follow up interview

After completion of the design workshop, I conducted remote semi-structured individual interviews with participants to understand their experiences of the workshop and any critical feedback they had for us. Though it was optional, all participants took part in this follow up interview.

Data analyzed: Given the focus of the current chapter is to understand the different actors that shape older adults' participation in design workshops, including the agency of design materials with respect to older adults, I analyzed the video and audio recorded data, and photos from the *design workshop*, along with the final artefacts that participants made (on big paper using the cards).

Workshop 2

The second set of design workshops also focused on the topic of designing IoT technologies. But, the second workshop differs in terms of the design materials used for the activity, which included an existing IoT toolkit cards for brainstorming [149] (unlike workshop 1 which used a personalized IoT card deck), and low-fidelity prototypes materials such as construction article, cardstock, popsicle sticks, and pipe cleaners. Although I collaborated in original analysis of this workshop, this workshop

session was organized and co-led by my collaborators, Dr. Ben Jelen and Dr. Katie Siek from Indiana University, Bloomington.

ID	Age	Gender	Education Level	Occupation/Industry
A1	75–79	Woman	Master’s degree	Education
A2			Bachelor’s degree	Finance
A3	70–74	Man	Professional degree	Psychology
A4	70–74	Woman	Associate degree	Healthcare
A5	70–74	Man	Master’s degree	Management
B2	70–74	Woman	Master’s degree	Education
B3	75–79	Man	Master’s degree	Management
B4	80–84	Woman	Master’s degree	Research
B5	75–79	Woman	Master’s degree	Healthcare
B6	70–74	Woman	Master’s degree	Healthcare
C1	70–74	Woman	Doctorate	Retired
C2	75–79		Master’s degree	Retired
C3	85+	Man	Some college, no degree	Law enforcement
C4	75–79		Doctorate	Healthcare
C5	70–74	Woman	Some college, no degree	Design
C6	65–69	Woman	Master’s degree	Education
D1	60–64	Woman	Bachelor’s degree	Finance
D2	65–69	Man	Master’s degree	Finance
D3	65–69	Woman	Master’s degree	Social work
D4	65–69	Woman	Master’s degree	Social work
D5	70–74	Woman	Master’s degree	Education
E1	80–84	Man	Bachelor’s degree	Management
E2	80–84	Woman	Master’s degree	Education
E3	75–79	Man	Bachelor’s degree	Engineering
E4	65–69	Man	Master’s degree	Engineering
E5	65–69	Man	Bachelor’s degree	Engineering

Table 6.2. Participant IDs refer to their table letter and participant number for all analyses. Blank boxes were left unfilled by participants.

Participants

The workshop took place at a University’s Alumni Association event. At this week-long event, alumni stayed on-campus and took non-credit classes to learn about topics of interest. Participants were not compensated. All study activities were approved by the University’s ethics board. 26 individuals participated between the ages of 61–89.

Five to six individuals were grouped together and were seated at five different tables. At each table there were two undergraduate research assistants who facilitated the discussions at the table and answered participants' questions. Participants' demographic details are provided in Table 6.2 above.

Workshop Configuration

At the Alumni Association event, we opted to offer one class as an opportunity to disseminate information about the ways that technologies are designed for older adults, as well as to conduct a research study to collect data from a geographically diverse group of older adults' interests in IoT. We designed a session and advertised it with the title, "Explore the Future of Smart Homes." Attendees were told that they would learn through a mix of informational presentations, demos, and hands-on activities, "how a smart home can be tailored to people with different technical ability, interests, and needs."

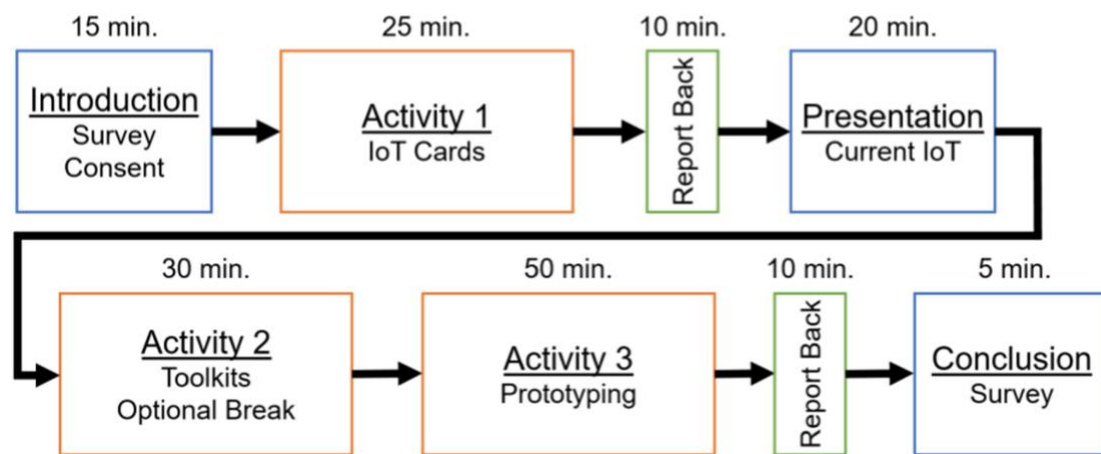


Figure 6.6. Study design

The 2 hour and 45 minute workshop (see Figure 6.6) began with a discussion of how data would be collected on the interactions in the workshop as part of a study, giving individuals the ability to opt out. Activity 1 through Activity 3 were audio and

video recorded. The first activity involved IoT Toolkit Cards [149] (see Figure 6.7). These cards have several categories, such as “things” (objects), “feedback” (output), “human action” (input), and “missions” (provocative design goals to inspire creative combinations of things, human action, and feedback). IoT cards were selected as a way to introduce individuals to the capabilities of IoT and to give them a tangible way to brainstorm and express their preferences [3,149]. Each table then selected an idea to report back to the group.

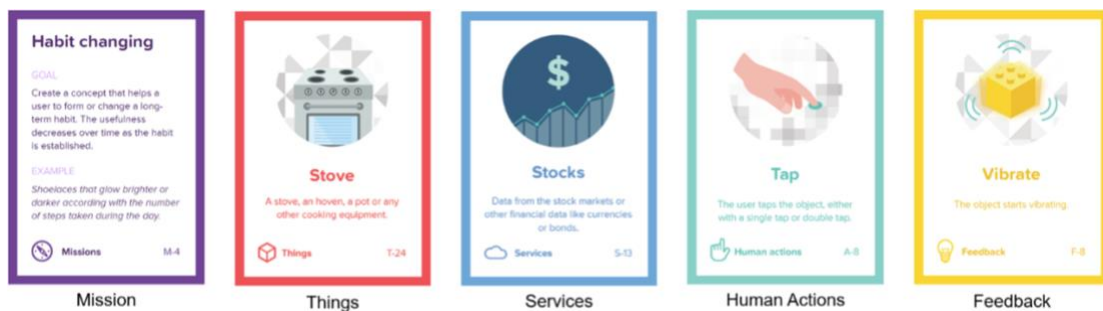


Figure 6.7. Design card activity

Then, to give participants a sense of capabilities of the current state-of-the-art commercial technologies, we gave a brief presentation on current IoT-based smart home technologies. This included demos of Amazon Echo Dot, oura2 (a ring-based wearable tracker), the social robot Vector3, and sensors to detect gait. Following the presentation, to understand participants' interest in building their own smart home technologies, we conducted a hands-on activity with modular electronic toolkit Craftec [97], to understand how older adults engage and interact with this toolkit. Participants created three circuits, which when integrated together, simulated an IoT-based system that used LEDs and a light sensor to allow someone to remotely check in with a friend (Figure 6.8.). Then, participants constructed low-fidelity prototypes using materials such as construction paper, markers, pipe cleaners, pompoms, scissors, and tape to

envision their desired future smart home technologies. Each table shared their low fidelity prototypes with the group.

Data analyzed: Given that the goal of this chapter is to understand how different human and nonhuman actors participate and shape design workshops where older adults brainstorm new technologies, I analyzed participants' engagement in the activity 1 (focused on IoT cards for brainstorming technology ideas) and Activity 3 (focused on using prototyping materials to conceptualize IoT technologies). I also analyzed the pictures from the design workshop.

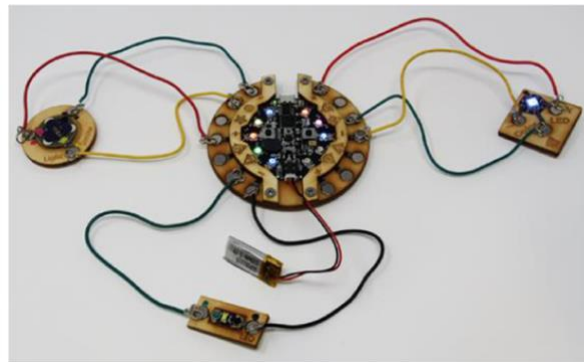


Figure 6.8. Electronic toolkit participants used in an activity for building simulated IoT devices

Limitations

Older adults as a population are so broad, in terms of age, education, and other factors [212], that it is useful to reflect on the specifics of our sample as they shape the findings in this study. Both workshops included Caucasian older adults, and therefore lacks in terms of racial diversity—a limitation of this work. More specifically in the workshop 1, participants were tech-savvy users, which represents a growing demographic of the older adult population [148]. Also, workshop 1 participants were recruited from a longitudinal technology study – an approach used in other HCI studies [13,209,210]) which is likely to have contributed in part to the firm grasp participants had on their preferences towards technology.

6.3.2. Posthumanist Theoretical Orientation

The analysis of this work is inspired by theoretical orientation of Actor-Network Theory (ANT). ANT posits that agency is not something that should be associated with human intentionality alone. Instead, it argues that agency is distributed between human and nonhuman actors. Here, an actor can be anything that does something, makes a difference, and thereby contributes or influences an action. Latour describes an actor as “something that acts or to which activity is granted by others... An actant can literally be anything provided it is granted to be the source of action” [118]. My analysis is inspired by this theoretical underpinning of ANT, and its notion of actors and their relational agency which provided me a way to understand the nuanced ways in which nonhumans, including mundane design materials (e.g., pen, paper, design cards) play a role in design activities involving older adults.

Inspired by Latour’s work, as Storni outlines ANT for designers [191], he notes “what actors are and do is the effect of their relations with other actors.” And, given that entities become actors in relation to other actors participating in the phenomena at the very moment, it also means that these entities do not pre-exist in isolation with predefined roles and qualities but rather emerge together in the moment [191]. This view of actors and their relational agency shaped my analysis. In my analysis, to draw out how a nonhuman entity acts, I sought to understand and explain what the nonhuman actor does, or what it becomes and produces “when in relation” to other actors, particularly older adults. This theoretical orientation helped me conceptualize how different nonhuman entities act (not independently) but in relation to other actors in

design workshop. Below, I describe the process I followed to analyze the empirical data from the design workshops with older adults.

6.3.3. Analysis

In this section, I first describe how my analysis in the previous chapter (Study 2) shaped my approach for this study (Study 3). Next, I describe in detail the analysis approach I followed.

By engaging in the analysis of the previous Study 2 (in Chapter 5), I had learned that instead of coding data, writing descriptive memos was central to the analysis process. This is because the process of coding, specifically focus coding, restricts us to search for data that align with a set of codes. This, in turn, can limit us to take into account phenomenon of interest that might not fit with the already defined set of codes. Reflecting on my analysis of Study 2, let us consider how P5's cat or P18's dog played a role in how individuals' technology use unfolded. Although these are phenomenon of interest (i.e., in terms of showing the role voice assistants' play in mediating relations between older adults' and their pets), only a few participants (2/20) owned a pet. This means, even though I have an open code as "voice assistants shaping relations between older adults and their pets", this would not have gone forward as a focused code, and ultimately would not be reported in the final writeup (findings). Therefore, after analyzing Study 2, I had learned a) the need to surface phenomena of interest which could be situations where tensions emerge or situations that are unexpected, b) instead of coding, descriptive writing informed by theoretical orientations is helpful in explaining such phenomenon of interest. Here, I found post qualitative inquiry (PQI)

[188,189]—an approach that focuses heavily on writing for data analysis— as a helpful way of engaging and interpreting my data.

Elizabeth St. Pierre who formulated this way of approaching data analysis, suggests “reading, thinking, writing, and living with theory”. First step is to familiarize and immerse oneself in relevant theoretical concepts (related to my analysis, I describe my theoretical orientations in the prior section 6.3.2). Next, is writing, which St. Pierre argues as a mode of inquiry, which serves as a “free space” for the researcher to think, live and interpret the data. And, this thinking, writing, and living the data is heavily shaped by the theoretical orientations of the researcher. Below, I describe how I adopted a post-qualitative inquiry in this study.

Videos and audio recordings (~16 hours), along with pictures, and notes from the workshop constitute the data I analyzed. Moving to the analysis process, I watched and listened the recordings, and was iteratively thinking and writing memos about the data (capturing the relevant quotes and images). Since the goal of this study was to understand the role different actors in shaping design activities involving older adults, during my analysis, I paid attention to the different human (older adults, researchers) and nonhuman entities (chair, table, design materials, camera, audio recorder) present in the session. One such nonhuman entity of interest was design materials, because design materials and their agency has been a topic of interest in HCI [73,195,196]. I attuned to the nuanced ways in which design materials (as nonhuman actors) act in design workshops and sought to uncover how older adults chose to express and represent their ideas using those materials. I also paid close attention to phenomena

where controversies or tensions emerge, particularly to identify the different actors that contributed to controversy or the tension.

The complete analysis document had 74 pages of memos (including relevant images and quotes). Below is a snapshot of how I analyzed a small chunk of data from the workshop 2 (Table C). In this example, as I watched the video, I noted a phenomenon of interest emerge i.e., the camera is acting in an unexpected way. I captured all the related quotes, and the pictures (i.e., snapshot of the video recording). Using these quotes and images as evidence, I interpreted and thought about this data by writing memos (in blue). In the memo I wrote, inspired by theoretical orientation of ANT, I draw upon the concept of relational agency to interpret how the camera as a nonhuman entity acts and shapes individuals' participation of "discussing" instead of "writing".



In the beginning, Table C discuss how they should proceed with the brainstorming activity
C5 asks "are we supposed to write them down or ...
C2: discuss them, because if we are writing down, this (pointing to the camera, picture below) isn't doing anything. If we discuss it, it is recording us. C2 pointing to the camera

According to C2, the camera is doing something, i.e., recording their brainstorming discussions. Here, just because the camera records, it is, in a way, configuring how participants decide to engage in the brainstorming activity. Note how C2 takes into account the agency of the camera in her decision of how to engage in the design activity. She decides to "discuss" instead of "writing", so that the camera is "doing" something by "recording" them. Here, the camera, which according to C2 captures their engagement in the design activity and their brainstorming discussions, saliently becomes a design material.

As such, descriptive memos became the central element of analysis for this study [105]. Within our research group, we discussed these memos, and watched select

video snippets to ensure the memos reflect the reality unfolding in the data. In the next step, I sifted through these memos and noted patterns and anomalies that emerged in the data. Example themes include “toolkit as an actor”, “design materials that go unnoticed”, “camera as a design material”, “mundane paper files at home as actors”. We iteratively discussed these patterns and themes and the associated memos to refine the high-level themes reported in the findings.

6.4. Findings

My analysis uncovers how beyond older adults, different human and nonhuman actors participate and play a role in design workshops. Below, I first describe the nuanced ways in which these purposefully chosen design materials act and shape the final artefact, and the dynamics of older adults’ participation in the design workshop (design cards in 6.4.1, prototyping materials in 6.4.2.). Next, I elucidate how in addition to these purposefully chosen design materials, unexpected entities (e.g., a camera) become a design material (6.4.3). Finally, in 6.4.4., I describe how other socio-material actors (despite being physically present in workshop), play a role in shaping design ideas. Some of these actors include: commodity technologies, mundane material objects (files, notes, air filter) at home, and social actors (family, pets).

In the findings, I refer to Workshop 1 as W1(P1 to P6), and Workshop 2 as W2, with participant IDs as A1-A5, B1-B5 to capture which table they belonged to.

6.4.1. Design Cards Shaping the Design Process: from Prompting Design Ideas to Limiting Creative Brainstorming to Contributing to Clash of Design Ideas

In HCI research, design cards are a popular tool for creative brainstorming, and have been found successful in supporting ideation [24]. So, as expected, there were many

instances where these cards supported older adults in the creative brainstorming process. For example, from workshop 1 consider P5's engagement with the design cards such as stove, bed, refrigerator. Here, each of these cards contributed to specific design ideas. Below I present multiple snippets from the session: note how technology ideas are linked to different object on the cards (highlighted in orange color).

Cards in P5's hand	Quote
 Stove/induction cooktop  Garmin watch  Phone  Refrigerator  Bed	P5: what I had in mind was... something kind of command central...and all of these things should be linked to that...like if your stove is turned on and you forgot to turn it off, it would send a signal to this thing as well as yes maybe send it to your watch or your smartphone, should go to multiple sources I think. You can be in your bathroom...and you have left your oven on.. P1: Yes absolutely. P5: and so the fridge you know, I'd like to know the door was open or not. but I want a really smart fridge, so it'd say "I know you organized so here's your vegetables, you should go have a look". The refrigerator should say, my vegetable compartment is getting really empty. Just think you have to go and get some more vegetables...It'd be really cool if the bed could say, "we detected that you haven't changed the sheets on your bed in two weeks you think you might want to get around to that."
Cards in P5's hand	



Figure 6.9. P5 holding the cards and discussing how she would want the stove to be connected with her watch or smartphone which would convey to her if her stove is on, or how her fridge would tell her when she needs to get more vegetables, or the bed would tell her when sheets need to be changed.

Here, in addition to the visual feedback on the cards (i.e., the text and image on the card), note how the material properties of the cards come into play in supporting the set up for creative ideation. The design cards are light in weight, small, and tangible, and therefore easily make their way into P5's hands, where she holds multiple cards fanned out (figure 6.9). At the same time, there are cultural aspects of using cards, such as fanning out cards during card games such as poker. Here, both the material properties and the cultural aspects associated with playing cards come into play and shapes how P5 decides to engage with them. And this, in turn allows her to see the visual feedback from all of these cards together, which possibly plays a role in shaping her idea of something that is “central” and “linked”.

For most participants these design cards contributed to technology ideas in both the workshops. Often the object or interactions mentioned on the cards prompted participants to think of technology ideas. But, in some other cases, these same design cards instead of helping participants think of design ideas, the cards limit the creative brainstorming process. For example, in W2, D3 had Facebook as one of her design cards, and because D3 had not used Facebook in general, this card was not relatable to her: *“Well I’m just stymied. Because I got Facebook and I never used Facebook. So I’m looking at this one and I go I cannot relate to this at all”*.

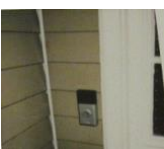


Figure 6.10. D3 holding the Facebook card from her set of cards laid in front of table

Here it is worth noting that although D3 had other cards (as visible in Figure 6.10.) that she could have used to think of a design idea, she did not do so. To understand this situation further, let us consider another salient participating actor—the researcher on the table. The research assistants on this table had earlier instructed participants to incorporate several design cards when brainstorming technology ideas. As a result, in this actor-network— which includes D3, the design cards she currently has, and the researchers on the table—the Facebook card limits the participant from being able to relate to the card or use the card in conjunction with other cards to conceptualize a technology idea. In another instance, E4 shared a similar sentiment when he got Twitter and Instagram cards: *“to be entirely honest, I’m not exactly sure what Twitter and Instagram is...I know they are social media. I’m not on even on Facebook.”* But unlike D3, E4 used these cards to come up with an idea which might not be meaningful to E4, perhaps, just to comply with the instructions of using design cards to conceptualize technology.

E4: I have a pile of jewelry (pointing to jewelry card), I have motion detector (putting that card), to me on Twitter or Instagram [puts both of those cards] to tell me something wrong is going on with my jewelry.

A third way in which design cards played a role in the workshops is by contributing to clash of ideas and driving individuals apart. In such situations, instead of helping participants move towards a design idea, the cards led to clashing of ideas, to an extent that it drove individuals apart. Consider snippets of data from Group 2’s participation in W1:

Below, as P2 and P3 started the activity, cards such as smartphone and tablet prompted them to initiate discussions around these technologies they own, with P2 saliently trying to convey being “low tech”, and P3 trying to find a common ground.	
 Phone Tablet	P2 -I don't have a smartphone. I have a dumb dumb phone P3 -My house is not smart in general. Do you have a tablet? P2 -Yeah... but most of the things I do are probably on hulu or TV...
Next into the activity, cards such as stove initiated discussion around current habits of setting timers and future preferences for setting timers. This discussion further reinforced their differences. P2 who currently used her microwave for timer wanted a stove that had a built-in timer, whereas P3 who currently used her Alexa probably didn't feel a need for this idea.	
 Stove/induction cooktop	P2 -I wouldn't mind having [timers on] a stove top...and you could set the timer like you do on your microwave for you know, 15 minutes or so I wouldn't mind having something like that. P3 -My stove doesn't even have a timer. I tell Alexa, I tell Alexa to set my timer P2 -I set my microwave oven for a timer ...
Next, using the recliner card, P2 discusses her idea for a nudge to move/walk, but the idea doesn't use much technology (a recliner that pushes the user out once in a while). Here, P3 subtly hints that she is interested in incorporating a bit more technology into the idea and talks about Alexa or the Garmin nudging her to move.	
 Recliner Garmin watch Smart speaker	P2: I wouldn't mind it if my recliner tilted or pushed me up out of it once in a while P3: so like I said Alexa need to push, come over and hit you in the butt to get up out of the chair or sofa to move. I don't have a recliner but my chair, which I sit in way too much. Yeah, it [the garmin] needs to...this thing will say move...
Sometime later into the activity, P3 used the polaroid picture ¹⁴ of her smart doorbell that she took using the take home polaroid camera activity. She uses the picture to share her experience of using this technology. To this P2 reacts by saying how she feels that “smart” technologies are “taking the power away from you.	
	P3: my ring doorbell that I have, it's handy, because I don't have to open my door. It brings it up on my phone and then, I can say who are you, what do you want? P2: my TV shows me who's calling me...one thing I think when things get too smart, I feel like it's taking the power away from you. That's what I said yesterday, I said "I'm a low tech."
Throughout the session, P3, communicated how she owned multiple smart devices (e.g., Alexa, ring doorbell, smartphone) perhaps wanting to have more smart technology in life, whereas, P2 considered herself “low tech” and throughout the discussions wanted to communicate how “when things get too smart, I feel like it's taking the power away from you.” And these discussions prompted by the design cards (of smartphone, tablet, smartwatch, and smartspeaker) and the polaroid picture (of Ring doorbell) as actors, made P2 and P3 realize that they did not have similar attitudes towards technology.	

¹⁴ We gave participants the option to use the polaroid pictures as design cards during the activity.

The above data shows how the different cards led to P2 and P3 discussing about their habits and practices (e.g., around setting reminders), or their technology preferences. And these discussions unfolded in a situation which drove them further apart. This resulted in P2 and P3 working independently unlike the other groups which worked collaboratively. This is evident from P2's quote in the final debrief of ideas, where she points to the final artefact (cards on the big paper), saying “these are mine, those are hers.” (Figure 6.11.).



Figure 6.11. Group 2 (W1) final artefact

For Group 2's case, the design cards incrementally contributed to drawing P2 and P3 apart by situating discussion around topics where they could not converge, thereby indirectly signaling how different they are and how different their preferences are. This, in turn, contributed to drawing P2 and P3 further apart to an extent that each had their own idea on the big paper (Figure 6.11). This group spent the majority of their time just discussing the cards in an attempt to find some commonality between them. But the more they situated their discussions around the cards, the more it drew them

apart. In case of Group 2, one might argue, not having design cards might have been more fruitful. We see that although design cards can facilitate creative brainstorming, at times, they can also lead to clash of ideas, particularly when participants in a group are expected to work together and have diverging preferences.

6.4.2. Agency of Prototyping Materials: Representing Design Ideas to Evoking Sentiments about Artistic Abilities

Using low fidelity prototyping materials to prototype or even sketch technology ideas has been a popular design tool in HCI [67]. Here, much of the research has focused on younger adults and designers to understand the agency of these prototyping materials in relation to designers [195,196]. This body of work shows that prototyping activities have been successful for brainstorming, where participants collaboratively tap onto the material properties of the supplies to situate their design ideas [196]. My findings, described below, provide preliminary insights on the agency of prototyping materials in relation to older adults and how older individuals engage with such materials in design workshops.

Prototyping materials we provided included paper, cardstock, pipe cleaners, markers, scissors, glue, popsicle sticks, colors, and pompoms. Each of these materials has experiential qualities [70], e.g., a paper is more foldable than cardstock; the form of paper is two dimensional whereas that of pompom is three dimensional; colors speak of arts. In our workshops, these experiential properties of prototyping materials spoke to some participants, who carefully chose and adapted their prototyping materials as well as their ideas. For instance, consider Table B's participation in the prototyping activity.

The idea that this group decided to prototype is a tree which is on a “stand”, “like Roomba”, can be moved indoors and outdoors, and “when you say it’s Christmas time...it comes”, and can change the color of lights based on the occasion, “red for Christmas, green for St. Patrick’s day, orange and black for Halloween”.



Figure 6.12. B1 using paper and pipe cleaners for representing a tree

B1 started using a pipe cleaner along with green paper (Fig 6.12.). She twists the pipe cleaner to somewhat resemble the triangular shape of a Christmas tree (Fig 6.12. left). And then puts the pipe cleaner on the green paper to draw an outline of the structure (Fig 6.12., center), followed by folding the paper to take the structure of the outline she had drawn (6.12., right).

Here, it is possible that certain properties of the paper and the pipe cleaners might have inspired B1 to make use of them. Properties of paper that are imminent are its ability to be easily folded or be easily cut into a particular shape, and its color (i.e., green for a tree). Similarly, the pipe cleaner is also visibly foldable. Seeing the paper and the pipe cleaners together, could have inspired B1 to use the pipe cleaners to provide a more stable structure to the paper tree.



Figure 6.13. B1 questioning if LEDs will shine through this green paper folded in triangular shape

But, as B1 starts using paper and pipe cleaners to prototype their idea, material properties of paper come into play and make B1 question if paper as a material would shape or limit the representation of their idea (as a team they wanted the toolkit's LED lights to shine through the tree structure). B1 realizes how the opacity of paper would not allow LED lights to pass through and that they needed something transparent, to which B3 saliently agrees by providing alternative ideas.

B1 lifts her paper folded into a two-dimensional triangular structure (to resemble a tree) and asks "will it shine through this?...If not we could use the plastic" (Fig 6.13).

B3 "can we put the plastic bag on top of this (holding a folded pipe cleaner vertically in Fig 6.14.)

B3: maybe we can cut a circle, stand this (pipe cleaner) on top of that and put the plastic bag so the light goes under

B1: oh you're having them stand up straight

B3: we'll have two of them stand up straight



Figure 6.14. B3 puts the pipe cleaners vertically, while B1 is holding the plastic wrapper

While deciding how to position the plastic bag, pipe cleaner structure, and the toolkit with LEDs, B1 and B3 first draw an outline of the toolkit to mark where the LEDs will be (Fig 6.15., left), and then cut that part from the paper (Figure 6.15, middle), and then they placed the plastic bag through that hole (Figure 6.165, right). Finally they put the pipe cleaner structure on top of the transparent plastic bag, taping it's legs to the paper (Fig 6.16). Note, how B1 and B3 here are still making use of paper in their prototype, not to represent the tree, but instead to make a slot for positioning of the LEDs that would shine the tree.



Figure 6.15. B1 and B3 working on positioning the pipe cleaner structure, toolkit and the plastic bag



Figure 6.16. The final artefact of lighted Christmas tree

While B1 and B3 determined that paper would not be successful in representing their idea of a tree through which LED lights would shine, B4 (in the same group) had ascertained that she would use paper, and folded it to represent the “closet” that houses the tree, “where the tree will be living” when it is not being used for decorations, i.e., off holiday time (Figure 6.17). For B4, the opacity of the paper was preferred for prototyping the closet to hide the technology (unlike B1 above).



Figure 6.17. B4 flaps the folded paper to mimic opening and closing of the closet door

From the above example, it is worth noting how materials communicate different experiential qualities (e.g., transparency, opacity) to our participants. And taking these experiential qualities into account participants either used the material as is (e.g., B4’s paper closet for the tree), or adapted their prototyping materials as well as ideas (e.g., changing the structure of the tree upon realizing that light wouldn’t shine through the paper, or deciding how to position the plastic bag, pipe cleaner, and toolkit together). These findings which showcase the careful considerations that some of our participants made as they engaged in the prototyping activity, challenge previous tropes such as older adults experience challenges in creative brainstorming [131].

Above, I described how the experiential properties of prototyping materials spoke to participants and shaped how individuals engaged in carefully choosing materials to prototype their ideas. In some other situations, these same materials evoked

different sentiments for other individuals. These participants made it explicitly clear that they did not want to engage with these materials, through their actions of avoiding the activity i.e., by getting the researcher to do their prototype (e.g., B5, table B), or by getting others in the group to make the prototype (e.g., A5 in table A). B5 who was on the same table as B1, B3, and B4 (above), tactfully avoided the activity, saying *“I’m glad we have a creative table”*. However, B5 who probably was forced to participate by others in his group to make a house and green bush: *“you need to make a house”*, and *“you might want some green bushes to show it will be outside”*. B5 who was not enthusiastic about participating in the activity, turned to the researcher on the table and asked: *“if you were me, how would you make a bush?”*, *“you can do it for me, you are doing a great job”*. Eventually, the researcher as an actor participates here and made the bush and the house for B5.

A similar situation unfolded in Table A as well which helps us further understand the reason behind individuals avoiding the prototyping materials. In Table A, when the researcher started putting craft supplies in front of participants, A5 reacted asking A4, *“are you nervous”* (pointing to the crafts, Fig 6.18.), *“hope somebody has more artistic ability that I do”*, and asked people on his table *“are you an artist?”* (A1 confirms that A2 is an artist). When the researcher announces that it’s time to prototype, A5 subtly hints A2 that it is time for him to get started by saying *“okay, artist”*.



Figure 6.18. A5 pointing to the craft supplies and asking A4 if he is “nervous” seeing these supplies

Examining A5’s reactions from the snippet above, it is evident that A5 is associating these prototyping supplies with “artistic ability”, and feels that he lacks those skills to be able to contribute to this activity. Here the craft supplies in the form of prototyping materials are evoking a sentiment that the individual needs to have certain skills (i.e., “artistic ability”) to use them. As a result, the crafts just by being present on the table are evoking this intimidation for A5. These prototyping materials which are supposed to facilitate creative brainstorming, are now creating expectations of making objects of artistic quality. These cultural expectations could be because of certain properties of the materials, for e.g., seeing markers and paper together speaks of drawing skills. Seeing scissors, markers, and paper together might convey need for having creative cutting and crafts skills. Here, the outcome of how these materials speak to some older adults is not desirable, as it can make some people “nervous”. And this contributed to a situation at Table A, where A1, A2, and A5 were participating collaboratively in the prior activities, but as the prototyping activity started, except for A2, others did not engage with the prototyping supplies. Instead, the other participants (A2, A5) chose to have informal conversations about different unrelated topics (e.g., tile tracker, a friend who spent \$300 to set up Alexa, previous day’s opera experience). In a way, these prototyping materials and the activity contribute to drawing the group

apart, where only one member ended up engaging with the prototyping materials and others decided to have casual conversations.

Both examples above (Table B and Table A's engagement) provide evidence of how crafts used as prototyping materials have agency through their experiential properties or the cultural expectations associated with them which speaks to older adults in nuanced ways and configures their participation or non-participation in the prototyping activity. Next, I want to briefly discuss if people participate in prototyping activities, how this participation unfolds in terms of evolution of design ideas. Continuing with A2's example: A2 was the only person on his table who was engaged in prototyping a mailbox that tells them when they have new mails. Being immersed in this experience led him to identify further nuances about his design idea. Their original idea was to place a camera inside the mailbox to detect input. But, as A2 was physically interacting with the prototype (Figure 6.19.), i.e., opening and closing the prototype mailbox door, he realized that the prototype does not need a camera to detect mail. As he was flapping the door of the mailbox, he said: *"I don't think we need a camera, just put a sensor in here (on the door)...I think we have gone too far with the camera"*



Figure 6.19. P1's mailbox prototype with a flapping door

It is worth noting how the action of flapping contributes to this design idea. As A2 was flapping the door, he possibly realized that opening of the door could detect

mail, so the opening of the door detects the input for the technology. This phenomenon of A2's prototyping activity evolving his design idea confirms that prototyping does have value: when people build prototypes and interact with the physical prototype, ideas can get shaped and fine-tuned in new ways. While this is true, it is also important to note that not these prototyping materials speak differently to individuals, at times even shaping their non-participation in this activity.

6.4.3. Unexpected Materials Become Actors to Shape the Design Activity

When planning the workshops we originally thought that materials such as design cards and prototyping materials would constitute design materials that would support brainstorming of technology ideas or facilitate material representation of the idea (aligning with the traditional norm in HCI studies e.g., [67]). However, my analysis reveals that beyond these materials that have traditionally been considered as design materials, other materials such as a camera or bodily movements also emerge as salient design materials in workshop settings involving older adults. Below I describe the ways in which these materials shape representation of design ideas or configure the dynamics of participation. In specific, I describe two unexpected design materials from data: a) bodily movement and spoken language as design material, b) research apparatus such as a camera that video records our study sessions.

Bodily movements and words as design material

Traditionally in design workshops, we often pay attention to the final representational artefact from the session, which could be a prototype, or a sketch, or the cards used (in case of design cards). This is because these artefacts make use of the design materials provided by researchers to represent and communicate individuals' technology ideas.

But, in both of our workshops, many participants used bodily movements and spoken words during the design sessions to communicate their technology ideas. Here, instead of using the design materials provided by us (e.g., paper, pen, marker) to represent their ideas as a prototype or sketches, they chose to use bodily movements along with spoken language to communicate their idea. Through one example from Group 3's session (P4, P6) in W1, below I describe how bodily movements emerged as a design material.

P4 and P6 were brainstorming a technology idea for managing clutter due to paper and post-it notes at home: P6- *"I have post it notes [in my life] Kitchen counter, post it, post it, post it. My car, its everywhere... And I need things to be visible."* In this workshop, as researchers, we had assumed that the design materials would include big paper, design cards, post-it notes, markers, pen, paper, scotch tape, and glue. As such, we had instructed participants to make use of these materials to represent their technology idea. However, interestingly, as P4 and P6 brainstormed their idea, they did not make use of any of the design materials provided by us. Instead P6 chose to use bodily movement to convey the technology idea of a holographic screen that would digitally store notes and could come down and go back when needed (see Figure 6.20) for the bodily movement and the corresponding in-the-moment quote).

P6: "So we have a, like a projection screen of some sort that could come down and go back. So you don't have to see them the whole time, it's just that when you want to look at your little ideas, you can pull it [the screen] back down. Or if you want to put something on it. It's got a grid, organizational grid."



Figure 6.20. P6 describing a projector screen that “could come down and go back. So you don’t have to see them the whole time, it’s just that when you want to look at your little ideas, you can pull it back”

P6’s example shows how she used bodily movement to communicate her technology idea, in particular the interface of the technology. Other participants also readily made use of their hands to communicate specific aspects of their technology. Figure 6.21. shows some of these movements: A5 uses bodily movements as the design material to express how the opening of the mailbox interaction would notify him of receiving the mail (left); A2 describing his idea of having a technology that gives a list of things to check while leaving the house (right). He is describing this through movement of his hand.



Figure 6.21. Using hands to communicate technology ideas

Here, it is possible to argue that participants could have chosen bodily movement to communicate ideas because it is quicker and easier than materially representing them through sketches or prototypes. But, carefully examining P6's phenomenon above, we also note that the materials provided by researchers could have communicated a sentiment to P6 that they would not easily support the complex interface and interactions she was conceptualizing. For example, the piece of paper lying flat at the table did not readily evoke inspiration for being used as a material to represent a holographic screen that digitally stores notes. Therefore, one can argue that seeing these traditional design materials in relation to their technology idea made participants realize that these materials might not easily or successfully capture their idea, and therefore some individuals purposefully chose bodily movements as a design material.

In addition to bodily movements, another design material that emerged in tandem was spoken words. In our workshops, we instructed participants that they could use the materials we provided and write any of their ideas, sketch it, or prototype it. While some participants adhered to these instructions, some did not. For example consider this artefact from Group 2's session in W1 (Figure 6.22). They brainstormed technology ideas by laying the cards on the big paper, but chose not to write on

the white paper to communicate/expand their idea. After being nudged by researchers, they wrote on the white paper to communicate their idea.



Figure 6.22. Group 2's artefact on big paper which only has the cards and no words or drawings that would connect the cards.

We noted a similar observation with Group 1 (W1) as well. P1 and P5 had all their cards, and they used these cards to think about technology ideas verbally by talking, e.g., “We want to have a control panel, like an electronic bulletin board. Everything feeds into that that’s related to the house. So if there's a leak in the furnace that would be reported to that bulletin board and the bulletin board would speak to you and it will send you a text message and by flash or vibrate”, P5. Here, the cards prompted rich ideas about technology and the cards themselves had made their way into the white paper design space. But the design space did not have any written representation (similar to G2 above).

Here, I want to bring to attention, how another salient actor, i.e., the researcher and their study protocol shaped the activity. Instead of giving participants the flexibility of choosing their preferred mode of expressing the design ideas, the researcher tried to maintain the consistency in terms of expression of ideas between different groups, and asked participants to “write” stuff on the big paper or connect cards by drawing lines

(“Let's write it on this one [card]”; “do you want to add that here? “; “you can draw a line from here and write a note or anything you might want to write to”). Throughout as P1 and P5 were expanding their ideas (e.g., refrigerator, electrical, wiring, plumbing leak, air quality monitor) by talking with the researcher, the researcher seemed to have her own motive of materializing these ideas on a sheet of paper. The final design artefact that we see is a result of this nudge. However, it's important noting that, instead of materially representing design ideas through written text or drawing or prototypes, for many participants spoken words were more intuitive to use to communicate their design idea. In discussion, I return to these findings to discuss implications around how we configure design activities and what is considered as design materials.

Research apparatus as design material

Our research apparatus such as a camera emerged as an unexpected material actor that shaped older adults' participation in the activity. We had used camera to video record older adults' participation in the design workshop. For us, as researchers, the camera was a mere data collection tool (or our apparatus as Barad would call it [104]). However, our analysis of the video recordings from these cameras reveals how this mere research apparatus actively participated in the design sessions, and in itself becomes an actor in many situations. In Table E (W2), during the prototyping activity, the camera directly became an actor by becoming a part of the group's final prototype. E5 succinctly describes a technology idea that makes use of the camera and the robot on the table where the camera detects who is speaking and the robot turns to that person during video calls (Figure 6.23).

E5: My idea would be to combine this (pointing to the camera) with the robot, because we are big on face-timing, because my wife's family lives all over, and you're constantly passing your

iPad...and if you had a robot that responded to voice, this thing would go around and if you're saying something it'll go this way or turn that way.

E5: If this thing then could hear, it would turn immediately to whoever [was speaking].

E4: you know you have a speaking stick (passing the cube around), you hand it there...

E5: and when you can't talk, you hand off the cube. That would work.

E3: the cube then is a signal to the robot to turn to this side

E5: I'm so tempted to take three rolls of tape and tape it (camera) to top of that (robot).



Figure 6.23. E5 holding the robot (left) and then the 360 camera (right) during the prototyping activity, during this time the above discussion was taking place.

Note how the 360 camera and the vector robot, just by their presence and their qualities act and shape how participants' idea is represented. For example, the robot's property of being able to move with respect to the cube, and the camera's ability to see 360-degree surroundings perhaps spoke to E4 and E5 who decided to use both of these materials to represent their technology idea. In the above snippet, it is also interesting to note how for E5 the camera (and robot) have become prototyping materials. E5 even suggests "*let's use scotch tape to tape these two*". However, for R2 this camera is still a research instrument or apparatus which is why she tries to protect it from any damage" "*maybe we should set it up on its top so we don't break the camera.*". Note how this same camera subtly speaks differently to the researcher versus the participant.

In the above phenomenon, I described how the camera, through its property of being able to view 360 degree, becomes an actor, and lends itself to be used as an

unexpected prototyping material, thereby contributing to material representation of the technology idea. In some other instances, the camera becomes a salient design material and actor because of its functionality of *recording*. Consider this phenomenon from Table C in W2.

In the beginning, Table C discuss how they should proceed with the brainstorming activity

C5 asks “are we supposed to write them down or ...

C2: discuss them, because if we are writing down, this (pointing to the camera, Figure 6.24 below) isn’t doing anything. If we discuss it, it is recording us.



Figure 6.24. C2 pointing to the camera to say "if we are writing down, this isn't doing anything. If we discuss it, it is recording us."

According to C2, the camera is doing something, i.e., recording their brainstorming discussions. Here, just because the camera records, it is, in a way, configuring how participants decide to engage in the brainstorming activity. Note how C2 takes into account the agency of the camera in her decision of how to engage in the design activity. She decides to “discuss” instead of “writing”, so that the camera is “doing” something by “recording” them. Here, the camera, which according to C2 captures their engagement in the design activity and their brainstorming discussions, saliently becomes a design material.

A third notable way in which the camera shaped the design activity was by making participants restrict the camera’s action. For example, B4 (pointing to the

camera), asked is this “thing recording” and then she puts a plastic wrapper on the camera (Figure 6.25 top). Later in the workshop, she also puts a paper box on the camera (Figure 6.265 bottom). These actions of B4 saliently speak how she did not like what the camera was currently doing (i.e., recording her actions) and thus wanted to restrict what the camera was doing.



Figure 6.25. B4 puts plastic wrapper on camera (top), B4 puts paper box on camera (bottom).

6.4.4. Material and Social Actors' Role in Shaping Design Ideas

In this section, I describe how different social and material actors beyond the design materials play a role in shaping design ideas. Most of the actors I describe in this section were physically absent in the workshop setting, yet they played a role in shaping the workshop. For instance, many design ideas from both the workshops were situated around taking care of things currently at home, such as: Group 1 (W1)'s idea of a smart monitor that would help them “take care of their home” by telling residents about wiring issues, fires, when to change air filter, unlocked doors/windows, or flooding of

crawl space in the house¹⁵; D1 (W2)'s idea of caring for house plants by using a sensor that alerts the need for water or fertilizer; C6 (W2)'s idea of managing “draws full of files, paper files” at home. In all these technology ideas, **different material objects at home (e.g., mundane paper files, plants, air filter)** act by becoming a source of inspiration for design, thereby shaping how the design activity unfolds.

In some instances, **social actors, such as family members (grandchildren or elderly parents)** became inspiration for technology ideas, thereby shaping the design workshop. For example, B5 wanted a technology that would do Christmas decorations for him, because his “*grandson typically helps me decorate it, is not coming this year.*” As another example, B2's idea was intended to take care of her elderly mother.

“with stove, my mom is living by herself and I'm very concerned about her burning herself. I can have her kitchen connected to my smartphone, so I can watch her when she is trying to prepare the meal, and that would help me to decide what services to have for my mom. So I could communicate that to the rest of the family, siblings.”

One can argue that both B2 and B5's brainstormed technology ideas came into existence because of their relation to other individuals, who as social actors are becoming an inspiration for these design ideas. Beyond family members as social actors, at times, nonhuman pets (dog) also emerged as social actors inspiring design ideas.

¹⁵ W1 included a take home activity to prepare participants for the design workshop. As such, the take home activity with polaroid also acts in this situation and could have contributed to some participants of W1 thinking about material objects at home.

“Ok, so the dog. I want the dog to automatically have water and food. So it is set up that I can control this from my cell phone. And I can have it on my calendar to notify me when I am supposed to put the food out. So we have that connected to his “food”

In many instances **current commodity IoT technologies** such as smart speakers (Amazon Echo), smart doorbell (ring), voice assistants (Google Assistant, Siri, Alexa), iRobots (roomba), become actors, and shape discussions around design ideas, despite not being physically present. One of the ways in which commodity technologies shaped ideas is by becoming a part of the design idea, e.g., P3’s (W1) Alexa giving her a nudge to be active, or A2 (W2), who was currently using Alexa at his home came up with “if you have a checklist, like Alexa or something would go through every time I leave the house, are these things done?” Here, participants directly wanted to use the commodity technology (e.g., Alexa or Roomba) in their design idea. For other participants, these commodity technologies shaped their preferred interaction modalities for the technology they were currently brainstorming. For example, P1 (W1) chose *voice* as the interaction modality for their idea of a smart electronic bulletin board (that informs residents about wiring, fires, utility consumption, unlocked doors and windows, indoor and outdoor air quality), because using Alexa “on a daily basis all the time”, has made her “biased” about voice interaction.

A second way in which commodity technologies configured the design activity is through their inaccessibility and lack of intuitiveness to use, unfolding in what might look as non-participation activity (at least on first glance). For example, during the brainstorming session, Table C did not make use of the cards to discuss technology ideas. Instead, throughout the session, the inaccessibility, lack of intuitiveness, and the disparate nature of current technologies incited discussions around the need of

developing universal paper-based instruction manuals for technology (parts of excerpts from 10 minutes of the brainstorming activity below).

C5: In a simple one, just commands, you know, how Alexa is sending out on email all you can ask sort of things. Nobody else seems to be doing that. That's another thing, for the iphone, every week they'd send out sample of good commands, because I remember it, and then I don't need it for three weeks and then I forget what it is. There is a tonne of memory involved in this, and if you don't remember you are out of luck.

C2: Siri very often will not get what I said. I rarely use it...so it would be nice if the voice commands got better, when we talk to Siri or whatever.

C1: I think the voice commands would be...I have a shower one, so it would be nice to talk to the shower and say "Set it to 90 degrees"

C6 adds to C2's point: and something else would list those commands...and if you had a dictionary that had a universal set of commands...because it is hard everytime, or you are at a friends house and you can't because you don't know the command...something I think.

C2: yes, universal

C6: universal commands in either small books or big books...I don't want an app. I want a book, a hard copy of paper

C5: this is the internet of things (laughingly)

C6: I know, that's why I am saying, you can't use the internet if you don't know what the command is. They say, oh look it up. I have to tell you, I am at the Apple website, to try to find the command to tell Siri, you know how hard [it is] for a person like me to click click click click, I can't find it. And even when you go to the apple store, some of those people can't find it either, because they don't need that and they are all 19-years old. But, people like me need a solid black and white reference.

C2: And I have a smart car, and it's commands are totally different from Apple. So if I want to do something on my car, I can't even figure out what the command is, verbally.

C6: And it requires a tonne of memory. Young people go oh it's all intuitive... but I don't know how to get that, because this stuff is not easy and it's not intuitive for a whole lot of us

C3: It's designed by and made for engineers.

C6: Even they don't know some of the simple things that can be done on it.

C1: One thing that really upsets me is, when you go on the computer to find out something, something will pop up, it says do this or do that, I have no idea what this is, I have no idea what that is. Should I click on this, should I click on that.

C6: It is not obvious, one of those cookies, pop-ups, now it's going to get you to another website, not where you are.

C3: My favorite expression "it's complicated"

C5: I think one of the problems is that we don't even know the terminology to use to search for what we are looking for.

C2: Right. And it changes, my car's terminology is different from my Apple's terminology, they are not in sync. They are not speaking the same language.

C3: And in another 30 years, you're going to be sitting here saying the same thing.

C5: Back in 95, when I first started my email, I thought, I'm gonna read everything, that comes in so that I can understand how to work my computer, how to work my phone or whatever. But then they started doing away with instruction templates. Then, you never have a ground for education of what you're even doing.

C5: the only idea I have is it needs to be streamlined. I am really interested in technology, and I can't figure it out. Well I don't want to take the time to...

During the debrief when this team was asked to talk about their design ideas, C6 said "standardized voice commands that go across every brand, for e.g., iphone and android, you have the same voice commands, could also work on your stove in the house, could work on everything. You learn, I'm gonna say a paper book, you have a list of standardized commands that you can always use, you don't have to worry about forgetting them for whatever item it is to work. For example, we were talking about a

shower, that your could have voice command to heat up the water to a certain temperature. But then when you went to your friend's house you couldn't take shower because they have a different system. So if they were standardized, universal commands would help.”

From the above excerpt it is evident how the commodity IoT technologies shaped this group's discussions during the brainstorming (using design cards) activity. On first glance, it might seem like this group did not engage in brainstorming technology ideas. But let us revisit what C6 said during the debrief: a shower that could control heat through voice commands, but going to a friend's house one cannot take a shower because they have a different system. This snippet shows how this team understood what we as researchers wanted, i.e., new technology ideas (e.g., a voice controlled shower), yet, in salient ways they chose not to engage in discussing new technology ideas to rather discuss how the technology ecosystem is not intuitive and accessible, how their means of knowing about technology through “instruction templates” are disappearing. Although this group was not brainstorming novel technology design ideas (as we expected them to), one can argue they did engage in technology design: by conveying how designing a new technology should not always be the goal (e.g., the shower), and instead discussing solutions to current day inaccessibility of IoT technologies (“a paper book, you have a list of standardized commands that you can always use”). [Note: Missing manuals also emerge an important actor in this phenomenon of older adults' use of emerging IoT technologies, which corroborates with the findings of my second chapter].

The ways in which commodity technologies play an active role in design workshops is interesting, especially in Table C, because in beginning (before the above discussions unfolded) one of the researchers had already told these participants that “what’s already out there, we are not that worried about”. Below is detailed context of when this discussions emerged.

C2: Are you letting us to talk about things that we would like for ourselves, or just things that could happen out in the real world

R(f): more that you’d like for yourself. What’s already out there, we are not that worried about. We want to design new, what would be helpful, what do you come up with ideas that maybe could help your life.

C5: that’s why we are here. That’s why I came here.

C2: I wanted to hear what was already out there that we could use versus this (pointing to the design card)

C4: by the time you discover or develop this (holding the design card), we may not be even here.

In the above phenomenon, in addition to commodity technologies, **the researcher is also a salient actor**. The researcher saying “we want to design new...” (which is a traditional goal of design workshops) could have also played a role in shaping how the discussion around inaccessibility of current IoT emerged. Participants, who realize that they might not be present by the time the “new” technology is developed, rather wanted to engage in something that would be helpful for them in the current time. Here, the inaccessibility of current IoT, its currently disparate nature, and missing instruction manuals to learn present day IoT technologies become actors to unfold a situation where participants resist designing further “new” technologies.

6.5. Discussion

In this analysis, I adopt a posthumanist perspective to attune to both human and nonhuman agency in shaping how design workshops with older adults unfold. My analysis reveals the nuanced ways in which designs materials act in relation to older adults: from facilitating creative brainstorming, to limiting creative brainstorming, to leading to clashing of ideas, and even contributing non-participation in the activity. Attuning to nonhuman agency also surfaced the salient ways in which our research apparatus such as a video camera becomes a design material. My analysis also sheds light on how beyond design materials other socio-material actors including family members, material objects at home, and current IoT technologies also become inspiration for design and play a role in how the design workshops unfold.

Here, I reflect on how my findings relate to past body of design research literature. With respect to design cards, I found that apart from a few instances where the cards were not relatable to our participants (e.g., Facebook, Twitter cards), in most situations our participants were successful in using the cards for brainstorming with minimal scaffolding by the researchers (unlike past work with younger college students who at times found it challenging in terms understanding how to use the cards in the brainstorming process [24]). With respect to prototyping, I found that the prototyping materials provided by us (which included paper, pipe cleaner, colors, markers, scissors, glue,) inadvertently implied need of artistic skills to some older adults. Unlike past design workshops with younger adults where similar materials have been used successfully used to facilitate creative exploration of ideas [196], our work shows that not all older adults are enthusiastic about engaging with these materials to represent technology ideas. The ways in which our participants used bodily movements and

words in the design activity also relates to past work. When designers engage in sketching, researchers have found that talk and bodily action including gesture are intertwined with the act of sketching, where talk and gestures are situated *around* the representational artifact of the sketch [195]. But, contrasting these findings involving designers, when working with older adults my findings show how bodily movements or gestures and spoken words completely replaced the representational artefact (i.e., the prototypes or sketches).

Building upon the findings from this work, below I discuss opportunities in shifting our focus of design workshops to move *beyond designing technology in isolation to designing meaningful configurations of which technology is a part of*. Next, I argue the need to re-think representational artefacts (e.g., sketches, prototypes) from design activities focused on IoT to instead take into account unexpected modes of expression and representation of design ideas. Finally, I reflect on my secondary analysis of the same dataset, in specific, the difference and value in terms of adopting a posthumanist turn.

6.5.1. From Designing Technologies to Designing Meaningful Configurations in Design Workshops Involving Older Adults

My analysis reveals how individuals' engagement in the activity went beyond focusing on just the artefact (i.e., the self-bounded end-product). Our participants often took into account the larger actor-network within which the technology would exist. For example, consider Table B's prototyping session where participants' brainstormed technology was a tree on a Roomba-like stand that can be moved indoors and outdoors and can change color of lights based on the occasion. Here, individuals could have chosen to simply prototype the tree on the stand or just the stand itself which would be

the technology piece of the idea. However, in addition to prototyping just the technology, individuals also prototyped the closet that would house the technology when it is not in use. In a way, this shows how our participants also took into account the other physical objects or the environment associated with the technology. For B4, who prototyped the closet, perhaps the décor of the house as an actor contributed to B4 thinking about the material world that surrounds the technology.

As another example of older adults taking into account the larger actor-network, consider Table C's discussion on how current IoT technologies lack technology manuals for learning. In salient ways, this team discusses with emerging IoT technologies, technology manuals are an important actor that are being slowly replaced by apps to support learning. As such, instead of designing further "new" IoT devices, this team decided to spend a significant part of the activity discussing the need for and importance of technology manuals. In both the examples, older adults are bringing to attention that technology cannot be seen or used in isolation, and that technology exists or needs to exist within specific configurations of actor-networks (with actors including décor of house, technology manuals, limited finances, or social actors at home). Based on these observations from my findings, I argue that our participants were not designing technology in separation, but were rather thinking of the larger actor networks within which this technology would fit and exist.

Here, one might ask, what is the significance of older adults taking into account the larger actor-network within which technologies exist? Why should this matter to HCI researchers working on aging? One implication which is evident is, as researchers, it is important that we note the different actors that older adults surface in such design

workshops. But, beyond that, I argue that this finding matters because it pushes us to re-think what we are really designing in such participatory design workshops. In our workshops which was planned and configured as per the norms of user-centered design and had an original goal of understanding what kinds of future IoT technologies older adults want, we instructed participants to think of “technology ideas” during these sessions (with an assumption that the goal is to design technology). But, the fact that our participants took into account and purposefully included other actors beyond technology (e.g., décor, manuals, pets), shows that the broader actor-network—of which technology is just a part—matters to older adults and plays a role in how they see technologies fitting into their lives. Based on this, I argue the need to reconsider the actual purpose of such participatory workshops and shift our focus of design workshops to move *beyond designing technology* in isolation to instead purposefully situate our participants to *designing meaningful configurations*¹⁶ of which technology is a part of. Below, I reflect on some approaches researchers could take to involve older adults in designing meaningful configurations.

The workshops I described in this study were not originally planned to take into account the role of the nonhuman world, yet the findings adopting a posthumanist perspective illuminate how nonhuman actors that play a role in how technologies fit into older individuals’ lives. Future researchers can purposefully configure design activities to situate older adults to brainstorm desirable configurations involving human and nonhuman actors. One approach that could be helpful is design fiction [194] where participants immerse themselves to brainstorm a fictional reality, which in turn can

¹⁶ Configurations are hybrid networks in which humans and nonhuman actors act to unfold a reality.

facilitate participatory speculation of future socio-technical configurations. Another approach that could be helpful for designing meaningful configurations is to situate older adults to design for their larger nonhuman world (similar to [132]), such as for their pets (an important social actor noted in both study 2 and 3), plants, or photo albums. At times, such out-of-the-box design prompts can uncover nuanced human-nonhuman relationships and how technology fits in these configurations.

6.5.2. Re-thinking Representational Artefacts for IoT Technologies

In participatory design workshops, end users engage with design materials to create artefacts such as sketches or physical prototypes, which are material representation of individuals' technology ideas. As HCI researchers, we are trained to pay attention to these artefacts, often taking pictures of them and putting them in our papers. As such, these representational artefacts as actors have contributed to a reality where there is an unsaid expectation within our research community that papers with design workshops should include visuals representations of such artefacts created by end users. And this unsaid expectation shaped our behaviors as researchers where we wanted our participants to use the design materials in certain ways (e.g., through drawing, writing, or prototyping) to brainstorm technology ideas. However, the salient ways in which unexpected actors emerged as design materials, and the ways in which some of our participants resisted using traditional design materials to create artefacts, sheds new insights on the representational artefacts that emerge from design workshops.

Consider P6's bodily movements to represent her idea of a holographic screen to keep and organize notes: she used her bodily movements to show the visualization and size of the screen, and how data moves between her physical notes to this digital

screen. Here, one can argue that individuals like P6 understood the computational concepts that they wanted to represent and communicate, and at the same time, perhaps found the design materials provided by us, researchers, to be inadequate in capturing those concepts and ideas. As we want older adults to brainstorm emerging IoT technologies of the future, the way our participants think about technology surfaces or interfaces to focus on is changing as well. This brings to attention how our traditional design workshop materials that have been successful for decades to represent traditional interaction surfaces such as user interface of mobiles or computers, might not be intuitive for all older adults to represent IoT technology ideas. This could be because, with IoT technologies, technology is no longer restricted to one surface or interface where the interaction is supposed to happen. And, in such situations individuals might find bodily movements, gestures, and spoken words easier to represent and communicate their ideas. Based on these findings, I argue that there is a timely need to go beyond material artefacts and consider other modes of expression (such as words and bodily movement) for representation of design ideas, particularly when working with emerging technologies such as IoT, virtual reality, artificial intelligence systems.

Next, I discuss methodological considerations for accounting these unexpected modes of expression. Taking into account these unexpected modes of expression and representation of design ideas might not be that straightforward as compared to traditional analysis of the representational sketches or prototypes. For instance, my first analysis of the same data's transcripts and representational big paper artefacts (published at [165]), failed to surface these findings of how bodily movements, words,

or a camera represent design ideas. But in my re-analysis in this chapter, I analyzed data recorded in video format and carefully attuned to the ways in which unexpected entities support or restrict representation of design ideas. Therefore, I suggest analyzing video recorded data that allows researchers to understand participants' natural engagement in their physical environment. This form of data collection where we video record the physical space in which older adults engage in brainstorming ideas is somewhat straightforward for design workshops conducted in-person. However, it is challenging for remote sessions where the researcher loses access to the physical space or material arrangement surrounding the participant. Here, systems (such as [135]) which support researchers in capturing participants natural interaction remotely by using overhead cameras and projectors would be useful.

6.5.3. Reflections on Secondary Analysis of the Same Dataset

The initial analysis and writeup of Workshop 1 was lead by me (published at [165]), and used constructivist grounded theory approach [105] for analysis. Workshop 2 (published at [120]), was led by my collaborators Dr. Ben Jelen and Dr. Katie Siek (in terms of structuring and organizing), and Dr. Amanda Lazar (in terms of paper writing and a diffractive reading of the data), and used three different approaches for analysis i.e., affinity diagramming [48], constructivist grounded theory¹⁷ [105], and diffractive reading [104]. Both the initial analyses of W1 and W2 data was more in line with traditional humanistic paradigms of HCI. As I reflect on my approach of doing a secondary analysis of this same data by adopting a posthumanist perspective, I note

¹⁷ I contributed to data analysis that adopted a constructivist grounded theory approach.

how attuning to the nonhuman agency can help shed further insights about a particular phenomenon.

One of the major findings that I report in the previous analysis of W1¹⁸ is how differences in attitudes towards technology caused disruptions in the ability of a group to come up with a coherent final idea. This finding was interpreted based on P2 and P3's participation in W1 where they failed to identify a common interest and therefore did not participate in the activity collaboratively. In the findings section of my prior paper [165], quotes such as "*P2 and I were looking at two different things...she was more concerned about...her furniture, her recliner and things like that, whereas I was thinking of other ways to utilize what I had with technology. She isn't into that much technology that I'm aware of*", had shaped my initial interpretation that P2 and P3's attitudes towards technology is at play here. In my re-analysis of this data attuning to the nonhuman agency of entities, I pose that in addition to attitudes towards technology, the cards that P2 and P3 were holding in-the-moment are also actors and play an important role in contributing to this situation.

This change in interpretation matters because it helps us not oversimplify in terms of holding one actor as responsible for the situation (in this case: attitudes towards technology), and instead distribute accountability and responsibility among all actors contributing to the situation. When we distribute responsibility among all actors, we will have more opportunities to brainstorm possible solutions to overcome the undesired reality. For example, through the initial analysis of W1, the solution I

¹⁸ For consistency, in this reflection I include only the data from W1, for which I led the analysis initially by adopting a human-centered constructivist grounded theory, and now by adopting a posthumanist perspective.

proposed previously was in terms of grouping participants based on their interest [165]. It's worth noting how this recommendation is largely human-centered. But, based on my secondary analysis that acknowledges the agency of cards as design materials and how they contribute to clash of design ideas, I propose another solution taking into account the nonhuman world: changing the design material altogether; in this situation perhaps design fictions could be a more suitable channel to elicit participants' desired technological futures especially when participants have diverging preferences.

6.6. Conclusion

In my final study, I adopt a posthumanist perspective— that takes into account the nuanced ways in which nonhumans actors, in addition to human actors, shape our reality—to analyze older adults' participation in design workshops. I investigate the role of different human and nonhuman actors, particularly design materials, in shaping design workshops involving older adults. I analyzed data from two IoT-focused design workshops involving 32 older adults by attuning to the agency of both human and nonhuman actors and how they contribute to unfolding and shaping of the workshop. My analysis reveals the nuanced ways in which designs materials act in relation to older adults: from facilitating creative brainstorming, to limiting creative brainstorming, to leading to clashing of ideas, and even contributing to non-participation in the design activity. Attuning to nonhuman agency also surfaced the salient ways in which unexpected actors including bodily movement along with words, and our research apparatus such as a video camera become design materials. My analysis also sheds light on how beyond design materials other socio-material actors including material objects at home and current IoT technologies become inspiration for design and play a role in

how the design workshops unfold. Based on these findings, I provide recommendations with respect to engaging older adults in design workshops by: re-thinking the concept of representational artefacts when engaging older adults in designing IoT technologies, and propose a shift from designing technologies in isolation to designing meaningful configurations of which technology is a part of. In doing so, this work contributes the larger body of HCI research on understanding and configuring design workshops with older individuals for designing technological futures [129,131,165].

Chapter 7: Conclusion and Future Work

7.1. Summary

Till date, research on aging in HCI and CSCW has largely adopted human-centered approaches, such as user-centered and participatory design. My dissertation, on the other hand, is inspired by recent research which argues that a sole focus on the ‘human subject’ alone might fail to capture the lived experiences and social relations that involve both the human and nonhuman world [4]. Through the three threads of my dissertation, I provide a case of adopting posthumanist entanglement perspective in the context of technology and aging to further understand older adults’ use of emerging technologies (Study 1 and Study 2), and their participation in designing emerging technologies (Study 3).

The first study of my thesis investigates how and when ontological uncertainty¹⁹ emerges when older adults use conversational voice assistants (a popular emerging technology). My analysis reveals that instead of straightforwardly categorizing the voice assistant as “human-like” or “object-like” (or nonhuman-like), participants fluidly move between the two categories. This movement between ontological categories was based factors such as characteristics of the voice assistant (such as nature of interaction) along with duration of use, the location, and moment of interaction. Qualities of the human, i.e., the user’s desire for social contact or affiliation also contributed to one’s ontological categorization of the technology.

¹⁹ Ontologies deal with how things exist, what categories they belong to. Entanglement HCI inspired by posthumanist thinking, argues that emerging smart technologies can pose ontological uncertainty in terms of separating the human and the nonhuman [71].

My second study investigates a) the role of nonhuman actors in shaping, restricting, or enabling older adults use of voice assistants (a popular emerging technology, and b) how an emerging technology such as voice assistants mediates relations between older adults and their world. Here, I draw upon theoretical orientations of two posthumanist entanglement theories used in the context of technology design: Actor-Network Theory (ANT), and Post-Phenomenology. My analysis reveals how nonhuman actors, including materials as well as norms, shape older adults' preferences for and use of voice assistants. Additionally, I find that the voice assistant plays an active role in mediating relations between older adults and their larger social world (including humans and pets), and this in turn shapes social practices around what it means to give company to pets, to live alone, or to give and receive care.

The first two thread of my thesis focus on the specific mode of older adults' *use* of an emerging technology. In the third study, I focus on another mode that can shed new understandings, i.e., older adults' *participation in design* workshops. **In my final study, I adopt a posthumanist perspective— that takes into account the nuanced ways in which nonhumans actors, in addition to human actors, shape our reality—to analyze older adults' participation in design workshops** (focused on IoT technologies). My findings shed insights on the nuanced ways in which design materials (e.g., design cards, low fidelity prototyping materials) act in relation to older adults: from facilitating creative brainstorming, to limiting creative brainstorming, to leading to clashing of ideas, and contributing to non-participation in the design activity. Attuning to nonhuman agency also surfaced the salient ways in which unexpected actors including bodily movement along with words, and our research apparatus such

as a video camera become design materials. My analysis also sheds light on how beyond design materials other socio-material actors including material objects at home and current IoT technologies become inspiration for design and play a role in how the design workshops unfold.

Below, I first reflect on the methodologies I adopted for analyses in this dissertation, followed by discussing the overall contributions of this dissertation and scope for future work.

7.2. Reflections on Methodology and Posthumanist Theoretical Orientations

7.2.1. Methodological Reflection

From my initial literature review, I learned that in HCI there is no well-defined method to use posthumanist entanglement perspectives as an analytic lens. Some researchers have adapted existing methods of previous paradigms, e.g., content analysis [72]. Hence, for the first two studies I had to draw upon my training in analyzing qualitative data and adapted it to include the theoretical perspectives in the process. The analysis in my first study (which I conducted early in my Ph.D. program), draws heavily on open coding, focus coding, and memoing as outlined in constructivist grounded theory [105]. This approach worked for the first study because it needed a formal analysis structure to answer *when* and *how* older adults categorize voice assistants as human-like vs. object-like.

However, I found the traditional analysis approach (of coding data) to be limiting for my second and third studies. This is because these approaches provide less

flexibility to capture atypical data that does not fit the *a priori* codes or themes. Hence, while analyzing the second study, I still conducted open coding, but soon realized that to interpret the data and communicate my findings, memos were the most helpful. The descriptive nature of memos allowed me to use the vocabulary of Actor-Network Theory and Post-Phenomenology to explain my data (e.g., draw out how Alexa mediates an embodiment relation, or how a wall acts). Therefore, in Study 2, memos became the central element of analysis. Throughout, I read through transcripts and interpreted data by writing memos.

For my final study, I looked for other ways of doing *analysis that focuses heavily on writing* instead of coding. At this stage, Dr. Shannon Jette (my thesis committee member) suggested me to look into post-qualitative inquiry (PQI), an approach developed by St. Pierre in the field of Education Studies [188,189]. PQI aligns with the epistemological orientation of posthumanism, particularly in terms of critiquing the notion of traditional representationalism of data through codes that focus on finding first fleeting signs of patterns in data [71]. Hence, for my final study, I adopted PQI for analysis. PQI advocates the researcher to first familiarize with theoretical lenses of relevance, and then approach data analysis by *writing, where writing is considered as a mode of inquiry*. In this approach of analyzing data, instead of thinking about codes from the beginning, I started watching video recorded data to write and interpret different emerging phenomena of interest (e.g., when tensions emerged in the workshops, when participants engaged in activity in unexpected ways) to identify the actors contributing to unfolding of such phenomena. This provided the flexibility of not constraining the analysis by a rigid code structure, and instead probe

into any phenomena that seems interesting. It was later when I sifted through all the written analysis, I noted patterns and anomalies which I report in findings.

7.2.2. Reflections on Posthumanist Theoretical Orientations

Below, I reflect on the posthumanist theories²⁰ that shaped and contributed to analysis in Study 2 (S2, chapter 5) and Study 3 (S3, chapter 6).

Theoretical orientations of ANT (S2, S3) and Post-Phenomenology (S2) shaped my analysis of Study 2 and Study 3. This is because within our research team, we deemed these two theories as appropriate for capturing our findings based on our initial engagement with the data. As other posthumanist entanglement theories, though these theories differ in terms of philosophical backgrounds, they share an underpinning of non-separation between human and their material world and acknowledge nonhuman agency. While the theoretical orientation of ANT and Post-Phenomenology allowed me to draw out new considerations for research in aging (e.g., understanding older adults-technology-world relations, designing meaningful configurations instead of technology in isolation), I do not wish to oversimplify the nuances of these complex theories. Specifically, as one example, there are differences in terms of ontological ordering²¹ which could be important in other analysis (e.g., in terms of thinking who should be held *more* responsible or accountable in a situation such as when considering ethical practices around data sharing by corporations).

²⁰ I reflect on use of other non-posthumanist theoretical frameworks e.g., Epley's a three-factor theory of anthropomorphism in Study 1 (chapter 4), where I use it.

²¹ ANT views humans and nonhumans as symmetrical, but Post-Phenomenology wants to maintain that things (or nonhumans) are not symmetrical to humans [175].

It is also key to trace the ways that my approach to data collection affected my study results. Both S2 and S3 conduct a posthumanist inspired analysis of data that is collected using traditional humanistic approaches (qualitative interviews or design workshops focused on older adults). While this approach contributes to aging research in HCI in terms of understanding *older adults-technology-world* relations or the role of nonhuman actors in design activities, it is also limited in terms of the data that is analyzed. For example, both studies did not include explicit prompts or steps in data collection phase to capture the larger social-material world of older adults: Study 2 findings are largely based on what older adults self-reported in the interviews, and study 3 is based on what the researcher observed and heard from the video recordings of the design workshop. This limits my findings in accurately tracing some of the other concepts of Actor-Network Theory such as intermediaries and mediators, unlike other studies which, interviewed different social actors [155], or explicitly included prompts about nonhuman actors in study protocol [72] or took ethnographic approaches [115]. In both the studies, during the data collection process, I did not purposefully include prompts for the nonhuman actors [72] or interviewed others social actors [155]. Adopting such approaches in future would help identify actors beyond what older adults report or are captured in video-recorded data, as well as help examine how mediators and intermediaries play a role in older adults' use or design of technologies.

Beyond ANT and Post-Phenomenology, a wide range of other theories have shaped posthumanist entanglement thinking, including Agential Realism [104], Object Oriented Ontology [85]. In combining perspectives from all these theories and sketching Entanglement HCI as the Fourth Paradigm in HCI and CSCW, Frauenberger

argues that to account for the ways in which our technologies change us and our societies, adopting these posthumanist entanglement perspectives will be valuable in designing the next generation of technologies [71]. As the broader research community begins to adopt these entanglement perspectives, through my work I argue that aging research in HCI and CSCW will also benefit from these theoretical orientations. Going forward, there is an opportunity in adopting other posthumanist entanglement perspectives in the context of aging research, such as using Barad's Agential Realism to examine how agential cuts [104] are enacted and configure technology use by older adults.

7.3. Contributions of Dissertation

My thesis stands as one preliminary works that adopts a posthumanist entanglement perspective in the intersection of technology and aging, to provide evidence of how aging research in HCI and CSCW will benefit from these theoretical orientations. Previously, I discussed contributions of each study of my dissertation in the Introduction (section 1.3) and in context of the specific studies (chapter 4.1.1., 5.1.1., and 6.1.1.). In this conclusion, I discuss the overall contributions of my thesis across the different studies.

- 1) **My work sheds insights on the new directions that HCI researchers working in aging can take:** First, instead of designing effective *interactions*, focus on designing emerging technologies that support meaningful *relationships* between older adults and their larger world; Second, take into account the nuanced ways in which the nonhuman entities act and hold them accountable for undesired realities; Third, purposefully situate older adults to

design meaningful configurations of human and nonhuman entities (of which technology is a part of).

2) Next, to investigate these new directions, I **discuss approaches that researchers working with older adults can employ**:

- a. ethnographic approaches of visiting the field site and conducting home tours (e.g., [3]) to attune to the relations older individuals have with their socio-material world at home;
- b. conduct life story interviews by having people describe the social and material entities that have shaped their past lives (e.g., [14]);
- c. engage older adults in co-design fictions by asking participants to flesh out a fictional reality with details such as ethics, politics, social perspectives, and emotions [194] which can help uncover salient relations and the important nonhuman actors.
- d. use data collection techniques such as photovoice to allow older adults take pictures of their daily lives and share with researchers [159] to give participants space to capture meaningful configurations in their own environments; and
- e. Situate older adults in design workshops to design for the nonhuman world by including purposeful prompts to design for nonhuman entities such as pets or plants.

3) Finally, in my dissertation, I adopt different analyses approaches to **offer new methodological insights for researchers seeking to adopt posthuman entanglement perspectives in HCI**. Through my analysis, I show how we need

an analysis approach that goes beyond our traditional representation of data through rigid codes and allows us to capture the significance of atypical data. Here Post-qualitative inquiry (PQI) of video-recorded data could be a helpful methodological tool for HCI researchers. PQI does not start with identifying patterns from the beginning, and thus provides flexibility to probe and further investigate atypical data that could be phenomena of interest. It provides the flexibility to inquire about phenomena of interest through writing (where theoretical orientations shape the writing). As such, **my dissertation contributes to the ongoing discussions within the HCI community on developing methodologies for the posthumanist inspired Fourth Paradigm** [45,71].

7.4. Scope for Future Work

Below, I provide a bulleted list of scope for future work including those that I have described above or in prior chapters:

1. Adopt posthumanist entanglement perspective in data collection by intentionally accounting for nonhuman actors and other social actors. Here researchers could adopt approaches that explicitly include other social actors and nonhuman entities in data collection, through study methods I discussed above such as ethnographic field visits, photovoice, co-design fictions, or life story interviews.
2. The findings from this thesis are limited in terms of engaging with a diverse sample of older adults (mostly Caucasian, college educated). Future work needs to engage with older adults from diverse backgrounds including race, income,

education, and region which might reveal other important actors contributing to technology becoming less meaningful for some older adults. For example, norms around “commonly understood English” as an actor might be playing a role in forcing Black older adults with dialect to “code-switch” in order to use voice assistants [87], or even contribute to non-use of voice assistants for some older adults living in Global South [75].

3. This thesis identifies scope for future work in aging research in HCI: to account for the agency of the nonhuman world and to think about these nonhuman entities in our design processes. Example topics that researchers could pursue further include designing technology manuals to support learnability of new technologies for older adults by including older individuals in the design process. Another example topic would include designing for nonhuman entities such as pets or plants.
4. While this thesis was inspired by theoretical orientations of ANT and Post-Phenomenology, future work can adopt other entanglement theories in context of aging such as Agential Realism or Object-oriented Ontology. For example, using Barad’s Agential Realism [104] can help understand how agential cuts are enacted and configure technology use by older adults.

Appendices

Study 1: Semi-structured Interview Prompts

Initial interview:

Introduction

Hello, my name is [name]. Thank you for participating in our study. The purpose of this study is to gain an understanding of how you use voice controlled intelligent personal assistants, like Amazon Echo and Google Home in everyday life.

Consent Form

Background questionnaire

Thank you. Let's begin with some background questions (background questionnaire). Follow up on frequency of use of the devices mentioned in the form- How often do you use ___?

Physical abilities

Let's talk about your physical abilities.

- Do you have any vision difficulties that affect your daily activities? If yes:
 - Do you use any visual aids
 - How it affects your daily activities
- Do you have any difficulties with motor control? If yes:
 - a) Please describe your motor impairments
 - b) Do you use a mobility aid (e.g. wheelchair, walker, cane)? If so, what? And since when do you use it?
- Do you have any hearing loss? If yes:
 - Please describe your level of hearing.
- Do you have any difficulty remembering every day activities? If yes:
 - Please describe any memories difficulties.

Do you use any memory aids such as paper lists, digital reminders, digital calendars, and so on for everyday tasks? What do you use?

Interview

- 1) How did you become interested in being a part of this research?
- 2) Have you heard of the Amazon Echo or Google Home before?

[if yes, can you tell me what do you know about it?]

Give the description: Yes you are correct...These devices...(repeat same description as below, adding details they missed)

[if not: These are devices that you can interact with by voice, instead of typing or through a screen. They can help you with a number of tasks. It can be your

personal assistant and help you set timer, maintain a to-do list, maintain a calendar, play music, play radio, give weather update, give traffic update, create and maintain shopping list and much more, all by simple voice commands.

[Show the video on Amazon Echo to everyone] [VIDEO LINK](#)

- 3) What do you think of devices like the Amazon Echo?
- 4) Do you think you might like to use a device like this?
 - a) Why/Why not?
- 5) Do you know people who are using a device like this? [probe for: who these people are (peers? Children/grandchildren?)]
- 6) What do you think about being able to communicate with the device by voice? [probe for: differences from traditional tech in terms of accessibility, cognitive requirements]
- 7) Do you think the device might be useful for you?
 - a) Can you give an example of what you think it might be useful for?
 - b) Is there anything you are currently not doing that you think you might be able to do with the device?

Transition

Now, let's move on to setting up the Echo Dot device. I'm going to set it up for you, following these instructions here in this manual. You probably won't have to do this yourself at any point, but you can always call me for help if you do. After I get it set up, we will start playing around a little with the Echo Dot.

Connect device to power outlet, set up the device following the instructions on the instruction sheet.

Now let's talk with the device a bit and see what you think about it.

Alarm: Let's set an alarm for 5pm today. "Alexa, set an alarm for 5 pm today."

Now let's delete the alarm, "Alexa, delete the 5 pm alarm."

Reminder and timer: Now, let's set a reminder for the device to remind us calling someone: "Alexa, set a reminder at 8pm to call Alisha tomorrow."

Similarly, let's set a timer to remind us to call someone in 2 mins. "Alexa, set a timer for 2 mins."

- 8) What do you think of these features?
- 9) How do you normally do these activities?

Shopping list: Now let's create a shopping list and add some items, say, milk and eggs to it. "Alexa, add milk and eggs to my shopping list."

Now let's add potatoes to the list. "Alexa add potatoes to my shopping list."

Now let's check what's on your shopping list. "Alexa, what is on my shopping list?"

To-do list: Similarly you can also create a to-do list and ask Alexa to read the items on your to-do list.

- 10) What do you think of these features?

11) How do you normally do these activities?

Device feature: entertainment, humor, joke: *Now let's ask the device to play a song. "Alexa, play the piano man." Okay. Let's ask her to stop playing it. "Alexa, stop." Alexa can also tell you a joke or a story for humor. Let's ask the device to tell a joke. "Alexa, tell a joke."*

12) What do you think about this?

13) What do you normally do for entertainment?

a) And how about the humor? What do you do for that?

Device feature: Information finding: *Now, let's try finding some information on the internet using the device.*

"Alexa, what restaurants are near me?"

"Alexa, how hot is the sun?"

14) What do you think of this?

15) How do you generally find information?

Device feature: Chat: *Now, let's try chatting with the device. "Alexa, let's chat". Okay. Let's ask her to stop. "Alexa, stop."*

16) What do you think about this?

17) Have you ever used technology for chatting with someone or with some device like this?

18) What do you think about this idea of talking to a device like this?

Overall: Voice interaction

19) Overall, what do you think of being able to use this device with voice?

20) Are there any challenges you can foresee in using the device? What are they?
[challenges similar to using any other tech, challenges specific due to voice interface, challenges due to setup and information finding]

Mid-interview

1. How was your experience of using the device in this week?
2. Did you find out anything new about the device this week? If so, what? How did you find it out?
3. Where did you keep the device, mostly, this week? Why?
 - a. Did you move it around at all?
4. Did you find the device useful?
 - a. For which activities did you find the device useful?
 - b. Could the device help you with any task that previously you couldn't do or had difficulty doing?
5. Did you find the device entertaining? Please describe.

6. Did you enjoy using the device? Can you please give me an example of such a situation?
7. Did you find any new skills this week? Can you tell me more about the skills? [ask detail description of each skill and the experience.]
8. So, [X- interesting challenges or limitations pointed out by the participant in the daily telephone call] was a challenge that you experienced and mentioned over the phone call. Can you describe that? How did you overcome that?
 - a. Apart from that, did you face any other difficulty?
 - b. *(Or, if no challenge mentioned in weekly diary study)* Can you describe any challenges you encountered while using the device this week?
 - c. Do you have any suggestions for making it better?
9. [Y- any interesting topic they mention over the phone call e.g., if a participant says: “she (*Alexa*) is just like a friend to me”]. Earlier you mentioned Alexa as a friend, can you talk a little more about that? What made you address Alexa a friend?
10. Did anyone apart from you use the device this week? If so, please describe who, when, and for what.
11. Overall, did you like talking to the device? Can you please describe a specific conversation which you enjoyed?

Final exit interview

1. What are your overall thoughts about this technology? [probe for: usefulness, enjoyment using, willingness to use]
 - a. Overall did you find the device useful? [Y/N]. In Q2, follow up on this response.
 - b. Willing to use: will you be interested in continuing to use this device?
 - c. Enjoyment using: Did you enjoy using this device? Can you tell me about a time when you enjoyed using it?
2. For which tasks or activities do you find AE/GH most useful? Why?
 - a. How did you do those tasks before?
3. *Challenges*: Can you describe the challenges that you encountered using the system?
 - a. Were you able to overcome these challenges? If so, how?
 - b. Were there things you couldn’t do that you wanted to do?
4. *Perception of digital technology*: Do you think your perception of the device has changed over time? [probe for: changes in ideas of usefulness, willingness to use, confidence of using digital technology]

5. *Comparison with other technology:* What do you think of a voice-based technology like Echo Dot as compared to traditional digital technology devices such as smartphones or tablets? Personally, what would you prefer and why?
 - a. Has this device affected your use of other digital technology devices?
[If earlier mentioned about using smartphones or similar devices]
6. *Memory aid:* What do you think about these devices in terms of assisting memory?
 - a. During the three-week period, did you encounter situations where reminders, timers, alarms etc. were helpful for you?
 - b. Where there situations when the device didn't do a good job of or couldn't support in assisting memory? Please describe.
 - c. How does Echo compare to the previous memory aids that you used (if any mentioned in the background interview)?
7. *Entertainment:* How was your experience of using the Echo for entertainment?
 - a. How does it compare to your previously used entertainment devices?
8. *Information finding:* What do you think of using Echo for finding information on the internet by using voice commands?
 - a. How does Echo compare to the other devices used by you for accessing internet?
9. *Skills:* What do you think of the various skills of Alexa? How was your experience using them?
 - a. Did you find any skills particularly enjoyable or useful?
 - b. Was any skill, particularly, frustrating to use?
 - c. Are there any skills which you wanted to use but was not available?
10. *Companion:* During the three-week period, was there any instance when you enjoyed having a conversation with the device? Can you share your experience of a specific such time?
11. *Suggestions:* Do you have any suggestions to what we could do to improve the device?
12. *Tab usage:* How was your experience of using the Fire tablet? Apart from using the Alexa app, did you try anything else with the tablet? If yes, what did you try doing with the tablet?
13. *Smart home:* These devices can also connect to smart home devices like lights, blinds, switches, thermostat, television, etc. and you can control all these by simple voice commands. For e.g., you can change the temperature by saying: "Alexa, set the temperature to 72 degrees" or "Alexa, close the blinds", for closing the blinds of your window.

- a. What do you think about this?
 - b. Are there any appliances you would want to connect? Why?
- 14. Were you ever uncomfortable while speaking to the device because there were people around you? Can you please describe a situation when that happened?
- 15. *Privacy*: Do you have any privacy or security concerns about using this device? If yes, please describe.
[If yes] Have any of these concerns affected how you use the device?
- 12. Is there anything else you want to share about your Echo Dot or Fire tablet?

Study 2: Semi-structured Interview Prompts

After participants fill demographic questionnaires, we engaged them in a semi-structured interview. Prompts to initiate discussions include:

- First, I want to know how you refer to your smart speaker that talks to you?
[Note: in all of the following questions, during the interview we used the exact word that the participant mentioned for this question, but for sake of readability below we write voice assistant]
- How long you have been using your [voice assistant]?
- How often do you use your [voice assistant]?
- Where in house do you use your [voice assistant]? Why that specific location?
[see if the location of placing the device is different from where they use it, if so, try to understand why]
- Overall, what do you think about using [voice assistant] in your home environment?
- Can you walk me through the last time you used your [voice assistant]?
 - Where were you when you did?
 - What made you do that?
 - How did the voice assistant respond?
 - Do you remember how you felt?
 - Is this typical or do you use it differently at times [try to understand their specific uses of the voice assistant]?
- Have you ever found yourself or other members in your house use your [voice assistant] in unexpected ways?
- [by this time of interview, note if the person calls the voice assistant with gendered pronouns, or refer the voice assistant as she/her/it and ask this next question:
 - As we were talking, I noted now you referred your [voice assistant] as _____ [she or it whatever they referred the voice assistant as]. Do you often refer your [voice assistant] as that? [Probe for it vs. she/her? And why? when?]
- In our past interviews some people mentioned Alexa as an object in the house whereas other felt like Alexa is some entity or presence in the house. What are your thoughts on this?
- Anything else you would like to share about your use of [voice assistant]?

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