Adopting Diffractive Reading to Advance HCI Research: A Case Study on Technology for Aging

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Researchers in Human–Computer Interaction (HCI) have long developed technologies for older adults. Recently, researchers are engaging in critical reflections of these approaches. IoT for aging in place is one area around which these conflicting discourses have converged, likely in part driven by government and industry interest. This article introduces diffractive analysis as an approach that examines difference to yield new empirical understandings about our methods and the topics we study. We constructed three analyses of a dataset collected at an IoT design workshop and then conducted a diffractive analysis. We present themes from this analysis regarding the ways that participants are inscribed in our research, considerations related to transferability and novelty between work centered on older adults and other work, and insights about methodologies. Our discussion contributes implications for researchers to form teams and account for their roles in research, as well as recommendations how diffractive analysis can support other research agendas.

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CCS Concepts: • **Human-centered computing** → *Human computer interaction (HCI)*; • **Social and professional topics** → *Seniors*;

Additional Key Words and Phrases: Diffractive reading, entanglement HCI, critical HCI, reflexivity, Internet of Things, older adults, aging, aging in place

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1 INTRODUCTION

As part of the Third Wave of **Human–Computer Interaction** (**HCI**), some researchers have been considering the ways that their own perspectives, orientations, and methods impact the topics

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they study and the stances that they take with their work [17, 18]. One way that these considerations have manifested is in calls for critical reflection and reflexivity. For example, Feminist HCI urges researchers to critically consider and disclose their intellectual positions or assumptions, along with their goals and beliefs, as a way to provide more transparency and accountability [9]. Similarly, Social Justice-Oriented Design advocates integrating reflexivity in the design process itself by reflecting on researchers' and designers' positions and roles, as well as the political and cultural situatedness of their practices [33]. As part of this reflexive approach, researchers are tracing how societal perceptions shape experiences for diverse populations. For example, Mankoff et. al suggest that disability is often viewed as a problem to "solve or fix," and a socio-cultural model of disability can lead to better technology design [64].

A similar reflective turn is emerging in HCI research on aging. Much past work has considered how technology can support older adults in physical and cognitive wellness to improve quality of life, efforts which often fit into broader, cross-disciplinary agendas, such as active ageing [107], successful aging [88], and the goal of aging in place [74]. Some research is now engaging in a contrasting and sometimes conflicting approaches which reflects on, and questions a number of assumptions often taken for granted in aging technology research, from framing past efforts as overemphasizing cognitive and physical decline to questioning whether "older adult" is a meaningful designation to cluster people who demonstrate such tremendous variability [35, 53, 86, 102].

The design of **Internet of Things** (**IoT**) technologies for aging is a topic around which a number of conflicting discourses are currently converging. HCI researchers are designing novel IoT systems to address challenges such as social isolation (e.g., [28]), medication adherence (e.g., [55]), and broader assistance for daily living (e.g., [34]). At the same time, other researchers in **Computer-Supported Cooperative Work** (**CSCW**), HCI, and **Science and Technology Studies** (**STS**) are problematizing the design [40, 101], deployment [79, 80], and motives [31, 71] of IoT technologies for aging in place. Both veins of work are situated in broader, national, and international initiatives which are often framed around a need to manage demographic change as the population ages worldwide. These initiatives include those of governments pursuing aging in place and IoT technologies [25, 75], with industry eagerly following suit.

We select IoT for older adults as a case to demonstrate diffractive reading, which is an approach with the potential to bridge disparate and seemingly incompatible approaches in HCI research. To demonstrate diffractive reading, we first constructed three analyses of the same dataset from a study involving a workshop on IoT technologies. Each analysis was shaped by different kinds of training and norms within HCI. The first analysis uses affinity diagramming to analyze the artifacts produced in the workshops; the second uses affinity diagramming to understand older adults' needs for home-based IoT technologies; and the third takes a constructivist grounded theory approach to critically study the research study process. We then utilized physicist philosopher Karen Barad's notion of diffractive analysis to read these three analyses side by side. Through this process, we offer the following contributions. First, we demonstrate what can be gained through diffractive reading—the benefits that we can derive from examining the differences between the applications of intradisciplinary perspectives based on different orientations and approaches to research. We discuss how researchers can best utilize diffractive analysis in their own work. Second, through our diffractive reading, we offer design directions and methodological insights for HCI research on aging, IoT, and HCI research more broadly.

2 RELATED WORK

Below, we describe different approaches to aging research in HCI as well as past work taking multiple reads from the same dataset or project in HCI.

2.1 Aging Research in HCI

HCI researchers have focused on technology for aging for decades. Within the umbrella of technology for aging, smart and connected technologies in the home have been of particular interest, often in the form of IoT technologies. These technologies use sensors to collect information about older individuals' homes or daily activities, thereby enabling different forms of monitoring and support for aging in place. Projects in this space have included home sensing systems to support activities of daily living and monitoring by caregivers [5, 12, 27, 51, 66, 73, 84], smart pillboxes to improve medication adherence [54, 56, 78], and augmented appliances for building social awareness and interaction [4, 21, 81].

In the last decade, some researchers have begun to critically reflect on the way aging had been treated thus far in the HCI literature. These researchers argue that older adults are too often seen as a homogenous population, characterized in terms of deficits, such as cognitive decline and loneliness [36, 60, 85, 103], and that research too often frames aging as a problem for technology to "solve" [103]. To counter what these researchers see as problematic framings, a number of perspectives are being offered: framing aging as a process rather than a state [19, 61]; centering agency [60] and values [58] rather than assumptions of designers; and refocusing attention on the situatedness of activity in older adults' homes [3, 20, 63, 98] and communities [82]. Researchers are also challenging past framings of passive older adults seamlessly accepting aging in place technologies by centering tensions between the intentions of technologists and policy makers and the lives and goals of aging individuals. For example, one study highlights boycotts, refusal, and non-collaboration on the part of older adults reacting to a telecare service implementation [63]. Together, this past work complicates the discourse around IoT and other technologies for older adults.

Several projects have sought to provide a cohesive framework to describe these different ways of approaching aging technology research. Investigating the construction of aging, Cozza et al. identified that the older individual and the technologies designed for them might be characterized differently depending on whether one is viewing older adults through a public, private, or academic lens [29]. Reviewing past research, Soro et al. draw attention to how two distinct literatures have formed around IoT for aging, one focusing on technical perspectives and one from a human perspective [91]. The authors acknowledge the different epistemological underpinnings of each and stress the value of researchers trying on different views [91]. With Soro et al. as one exception, not many studies attempt to bridge different approaches, methods and models to offer a new perspective on conducting research with older adults. Like Soro et al., our work acknowledges the benefits of different perspectives on IoT, and we contribute a new approach to glean insights from disparate approaches with diffractive reading.

2.2 Multiple Reads in HCI

Our work extends a vein of research in HCI that revisits the same qualitative dataset as a way to glean new insights. Past research has taken the approach of conducting multiple readings of the same data to better understand research frameworks and methods. Bardzell et al. applied a multilevel analysis to a design fiction to better understand the relationship of Research through Design objects to knowledge [8]. Baumer and Tomlinson apply two different theoretical perspectives to the same data to gain a better understanding of the frameworks themselves [11]. They argue that the field of HCI can benefit from other researchers conducting similar comparative analyses [11]. Another project applies conventional social science analysis as well as an approach informed by critical theory to YouTube content, concluding that critical approaches are necessary to understand next-generation HCI [16]. Like in these prior works, the diffractive reading approach we take in this article sheds light on past approaches in our application domain, and also confirms the importance of critical approaches. Yet a diffractive reading offers several new elements as well, such as recognizing the importance of what non-critical approaches have to offer, particularly in how the analyses that they yield compare and contrast with critical approaches.

Another approach taken by HCI researchers uses multiple reads to show how research reflects the values, interests, and analytic tools that researchers bring to a project. Through analyzing data from an online community, Encinas et al. point to how researchers within HCI are active agents in the ways that they draw on different traditions to construct problems and solutions for design [37]. And Baumer et al. argue that rather than applying a single set of evaluation criteria, researchers should evaluate different research projects (specifically, design fictions) based on the epistemological and analytic traditions from which a project draws [10]. These past works seek to increase researcher reflection on the multiple ways in which knowledge is constructed and evaluated in HCI. We borrow on these past works' approach of constructing multiple rigorous analyses from the same project, drawing on different epistemological and analytic traditions to do so. We then conduct a diffractive analysis, which studies differences to generate new understandings, across the three sets analyses we constructed.

3 METHODS

Below, we introduce the notion of diffractive reading and then describe our process of data collection and analysis.

3.1 Diffractive Reading

For our analysis, we draw on the theoretical framework of diffractive reading. This framework was introduced by theoretical physicist and feminist theorist Karen Barad.[1] Diffractive reading brings thought from feminist theorist Donna Harraway alongside physicist Neils Bohr's framework on quantum physics [7].

Two elements of Bohr's epistemology are necessary starting points to explain before describing the analysis conducted in this article. The first key concept to introduce is that of a diffractive grating. In a physics experimental setup, light waves propagate through a slit, or a diffractive grating [6]. If one has information about the originating light waves, looking at the patterns of light and darkness that appear on a surface placed next to the slit can be used to derive information about the nature of the slit itself. Thus, a diffractive analysis approach can yield new empirical understandings about the approaches (methodologies) that produce the patterns. Applying this concept to the creation of knowledge, the patterns of light and darkness can be seen as revealing the different ways of doing science within (and beyond) HCI in terms of the ways that they constitute knowledge and subjects. Diffractive analysis yields understandings of how different approaches within and across disciplines materialize and matter.

Diffractive analysis can not only tell us more about our methods, but also contribute new empirical knowledge. As Barad states, "my approach is to place the understandings that are generated from different (inter) disciplinary practices in conversation with one another" [7, pp. 92–93]. Returning to the notion of a diffractive grating, the patterns of light and darkness that form on a surface after passing through a slit can also reveal information about the differences

[1]In drawing on Barad's work to analyze our data, we are situated within Entanglement HCI. Frauenberger developed the notion of Entanglement HCI as an evolved research paradigm that can address advances in technology that are challenging to think about in HCI's existing paradigms [39]. In making this argument, Frauenberger cites several key theories, including Barad's work on agential realism. Agential realism involves but extends beyond the concept of diffractive analysis that we introduce in thisarticle. This article is scoped to diffractive analysis and therefore does not involve a comprehensive account of or link to the broader theory of agential realism, though we believe agential realism is a theory with much to offer to HCI.

in the originating light waves themselves [7]. This understanding rests on a particular view of the nature of existence. A set of experiments have revealed that only one property of a particle is visible at a time (either momentum or position). The physicist Heisenberg argued that this is due to our approaches (including our instruments)—the approach that allows us to see one of these properties (e.g., momentum) is not the same approach that would allow use to see the other property (e.g., position). Bohr rejects this point, arguing that, "there is something fundamental about the nature of measurement interactions such that, given a particular measuring apparatus, certain properties *become determinate*, while others are specifically excluded" [7, p. 19]. In other words, the experimental apparatus used, plays a role in determining what is visible. Translating this concept to technology and design research, a diffractive interpretation is aligned with feminist and interpretivist approaches which see the researcher's stance and methods as playing a major role in the way research analysis takes shape (though diffractive analysis has important differences from feminist and social constructionist approaches, some of which we return to in the discussion). To summarize, diffractive analysis can reveal more about a researcher's orientation and methods, but, importantly, also can contribute new empirical understandings of what is being studied.

Diffractive reading does not only provide a way to inspect different ways of producing knowledge and the knowledge that is produced, but also comes with a particular orientation towards how to interact with what is being inspected. The different analyses examined with diffractive analysis are not seen as battling each other [68]. Rather, a diffractive reading "is a respectful engagement attempting to carefully read the questions being asked and the arguments being made while at the same time being attentive to their (necessary) presuppositions and limitations..." [68, p. 44]. Thus, this approach appreciates what different methods of knowledge production bring to the table. This article demonstrates the merit of diffractive analysis, particularly in analyzing the places that different approaches to research in HCI fit and do not fit together, through a case study in the domain of IoT for aging.

3.2 Data Collection

We conducted three separate analyses of data that we collected at a single design workshop. The workshop took place at Indiana University during an Alumni Association event, IU MiniU. At this week-long event, alumni stayed on-campus and took non-credit classes to learn about topics of interest. We opted to offer one such 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 about 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." Participants were not compensated. All study activities were approved by Indiana University's ethics board. 26 individuals participated between the ages of 61–89 (Table 1). Recruiting through this venue appears to have led to a lack of diversity in terms of race and ethnicity and a narrower range of educational background then we may have found recruiting through other means. All participants who reported their race were white and not Hispanic, which does not reflect the demographics of aging adults in the United States and is a serious limitation of our work.

Two members of our research team led the workshops along with 10 undergraduate research assistants. These undergraduate researchers had been trained to facilitate study activities and take notes on participant engagement in the weeks prior. During the workshop, attendees were split into five groups, with four to six participants at each table and undergraduate researchers spread out across the different tables (Figure 1). All tables had 360° cameras, voice recorders, and digital cameras, along with clipboards for undergraduate researchers to take notes. A visiting member of the research team from the University of Maryland observed part of the workshop and took notes.

Table 1. Participant Demographics

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

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

The 2 hour and 45 minute workshops (see Figure 2) 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. The first activity involved IoT Toolkit Cards [70] (see Figure 3). These cards have several categories, such as "things" (the objects in the home), "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 [2, 13, 70]. Each table then selected an idea to report back to the group.

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, ōura[2] (a ring-based wearable tracker), the social robot Vector[3], and sensors to detect gait (Figure 4). 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 [50]. Participants created three circuits, which when integrated

[2]https://ouraring.com.
[3]https://anki.com/en-us/vector.html.

Fig. 1. Room setup with participants and researchers.

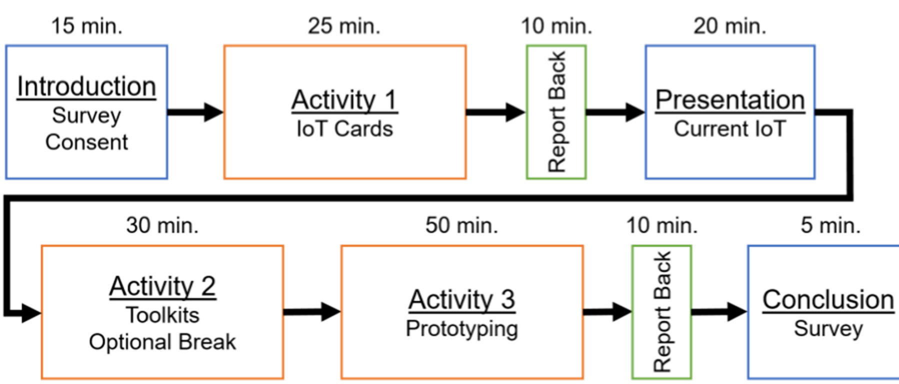

Fig. 2. Study design.

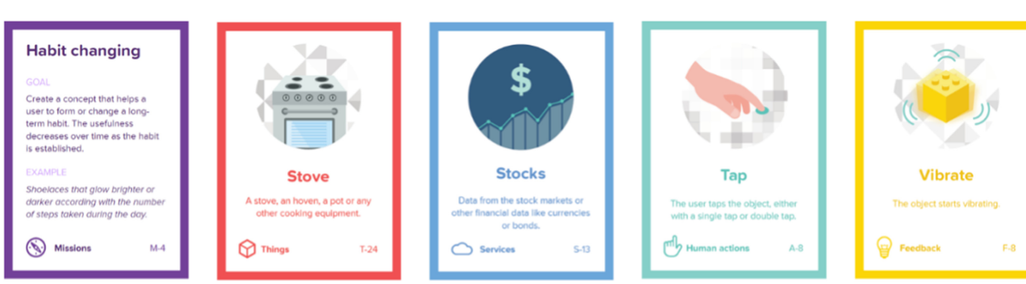

Fig. 3. Design card activity.

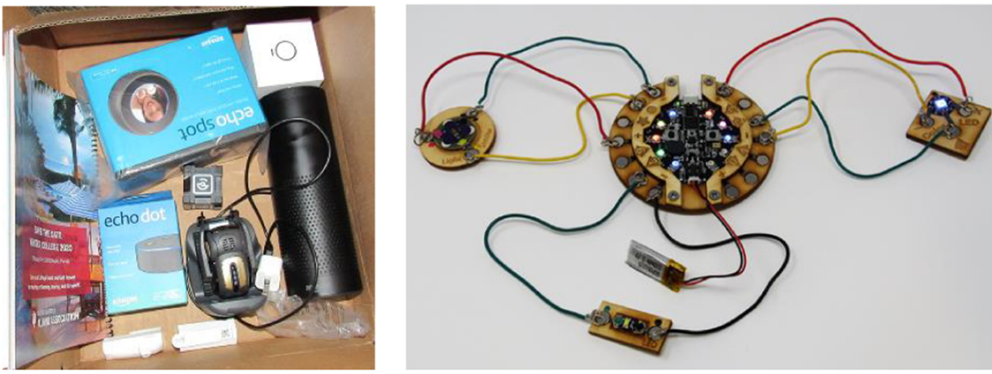

Fig. 4. Left: technology shown to participants, including Amazon Echo Dot, ōura ring, Amazon Alexa, social robot Vector, and motion sensors. Right: electronic toolkit participants used in an activity for building simulated IoT devices.

together, simulated an IoT-based system that used LEDs and a light sensor to allow someone to remotely check in with a friend (Figure 4). Then, participants constructed low-fidelity prototypes using materials such as construction article, markers, pipe cleaners, and pompoms to envision their desired *future* smart home technologies. Each table shared their low fidelity prototypes with the group. Participants completed a post-survey to conclude the session.

The data that were collected included observation notes, and video and audio recordings from each table, participant-created artifacts, digital images taken by researchers, and reflections of the research team after the event. The reflections included transcribed audio from the post-session debrief meetings and post-study reflection notes.

3.3 Analysis

There were two layers of analysis that informed this article:

- The first layer of analysis involved three separate analyses of the workshop data (Section 4).
- The second layer of analysis involved a diffractive reading of our three sets of analyses (Section 5).

Returning to the metaphor of diffraction, the initial three analyses can be seen as akin to the light wave passing through the slits of a diffractive grating. The second layer of analysis, then, involves looking at the patterns of darkness and light that result (and can be used to infer meaning about the originating wave or the diffractive grating). These two layers of analysis are described in sections 4 and 5 respectively.

4 THREE ANALYSES

Before describing our three analyses, we describe our process and the rationale behind the way that we created our analyses. In Barad's view, the scientist is not a subject "merely there to choose an appropriate apparatus for the investigation and note the results" [7, p. 144]. Barad cites philosopher of science Ian Hacking to illustrate how experimentation involves numerous tasks and much understanding: designing an experiment that can work, knowing how to then make the experiment work, and then the ability to know when an experiment is working. In other words, scientific practices cannot be considered separate from previous experimentation and accumulated field knowledge—and at the same time, scientific practices are dependent on the specifics of the equipment and material at hand. Our work in conducting each analysis should be seen similarly, with our ability to do so relying on practices honed over time and also based on interaction with the specific data at hand. In this way, the methods of analysis, findings, and writing style of each analysis are coherent within three different subcommunities within HCI. The point here is that while these are original analyses, they are not separate from traditions of thinking in communities within HCI, and thus, the next step (in Section 5) finds meaningful, rather than random, differences between ways of working in HCI.

As prefaced above, we created three distinct analyses that represent three routes researchers coming from different epistemological stances and training could take with this particular dataset. These routes exemplify three approaches within HCI—studying IoT for the home, IoT for older adults, and examining dynamics of participation in technology design workshop. This means we also utilized methods, portions of the dataset, and considered the demographics[4], which were coherent with these different positions.

A different researcher took the primary lead for each analysis, and researchers worked with the methods and orientation that best reflected their typical approach to research. The first analysis was conducted by a researcher with experience designing IoT with and for a variety of populations. Their approach focused on data **content**, with a goal of understanding the data in terms of designing for IoT for the home—an active area of research within HCI. The researcher leading Analysis 2 has largely studied IoT and other technologies to support aging—another active area of research within HCI. This researcher focused on older adults as a **target group** for IoT in their analysis. Given the typical approach to analysis for the researchers in Analyses 1 and 2, which is linked to the foci they take in general and for this project (i.e., on content and target group), they used an affinity diagramming process to analyze the transcripts. Analysis 3 was conducted by two researchers who often utilize a reflective or critical focus to analyze existing methods and approaches to design for aging, leading to a critical focus on the research **process** in Analysis 3. This kind of critical reflection on aging technologies represents another vein of research currently existing in HCI. Consistent with the critical, process-oriented focus of Analysis 3, researchers used a constructivist grounded theory approach [26] as this lent the ability to examine how participants made sense of different events that took place, as well as the researcher–participant relationships. Towards this end, the researchers utilized video data and observation notes that the first author had taken in her observation of part of the workshop. The analysis processes are described in more detail below, with Table 2 providing a breakdown of some of the most salient aspects of the process.

For the first and second analysis, the following procedure was followed: first, Activity 1 (IoT cards) was transcribed in full for each table, and the second and third activities for each table were spot transcribed. The lead researchers of Analyses 1 and 2 then utilized affinity diagramming to analyze the data in their respective analyses [47]. For both of the first two analyses, after identifying initial groupings and themes of codes, the research team met through several iterations to arrive at the final analyses. Though the literature implicitly shaped the researchers' orientation towards the data throughout the process, at these later stages of analysis, we began to compare our findings to existing literature to understand what aspects of our analysis were more novel. Different bodies of literature were most salient and shaping for the different researchers: for the first analysis, the lead researcher turned to the general literature on IoT, and for the second, research specific to aging and aging in place.

[4]Given that different characteristics of participants become important in different approaches to analysis, we report relevant demographics in each section. An overview of participant demographics can be found in Table 1.

Table 2. Dimensions of the Different Analyses

#	Focus	Researcher	Influenced by literature on:	Role in workshop	Data	Content analysis
1	Content (artifacts)	Katie	Challenges and needs for smart home use (e.g., [23, 104])	Presenter/planner	Transcripts/spot transcripts	Affinity diagramming
2	Target group (aging)	Ben	The complexity of the home setting for IoT for aging; how older adults can be active participants in designing the future of technology (e.g., [67, 86])	Presenter/planner	Transcripts/spot transcripts	Affinity diagramming
3	Critical (process)	Amanda and Alisha	Critical aging literature in HCI and CSCW (e.g., [29, 102])	Visiting researchers. Amanda observed a portion of the workshop	Video recordings	Constructivist grounded theory

Because of the process-oriented focus of the third study, we included the observation notes of the two visiting researchers from the University of Maryland as part of the analysis. We also spot transcribed video recordings so that we could attend to non-verbal expressions for richer description and interpretation [30]. We spot-transcribed all video recordings, starting with an open coding approach for the recordings from Activity 1 at three of the tables before switching to a more focused coding approach with the remaining recordings. We followed an iterative process of coding, memoing, discussions with the research team, and theorizing to generate themes. As the analysis process progressed, we began to focus on the dynamics of participation, the ways participants responded to prompts and directives, and mismatches between researcher and attendee expectations.

4.1 Analysis 1: IoT for the Home

The first analysis considers the artifacts produced by participants as a way to further our understanding of IoT for the home. Data came from all 26 individuals who participated in the workshop. A majority of the participants had at least a bachelor's degree with most having master's degrees ($N = 15$), though three participants reported some college experience without completing a 4year degree.

A key finding from this analysis was an understanding of the ways that participants' ideas increased in complexity over the course of the workshop. Further, in addition to the well established interest in IoT for monitoring and automating home tasks, participants also expressed an interest in IoT for social purposes such as connecting with others—an area that has been identified as overlooked in most IoT research [92].

4.1.1 Supporting Awareness and Automating Home Tasks. All participants discussed how IoT could help them monitor their homes, a common focus in smart home research [24, 32, 106]. Below, we view the evolution of participants' ideas on this topic through the micro and macro models of contextual awareness introduced for pervasive computing [1]. In terms of micro contextually aware tasks that require action based on a small set of sensing systems, participants brainstormed systems that would unlock one's home based on when they arrived (C3[5]), alert homeowners on

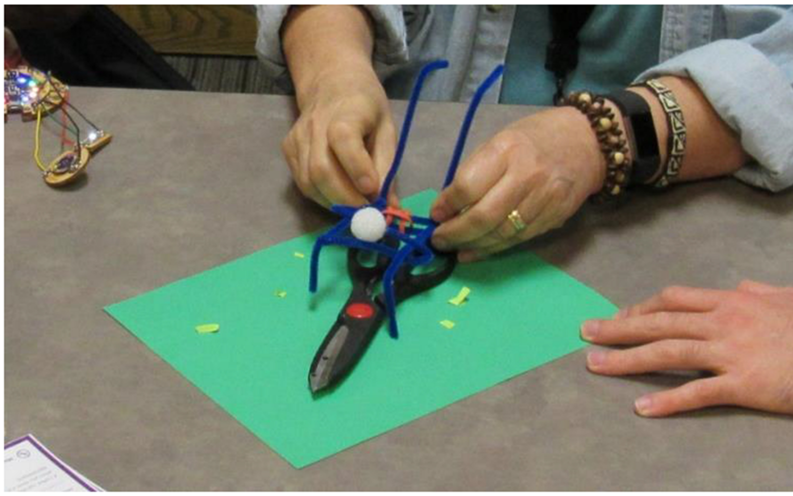

Fig. 5. Automatic lawnmower with the accompanying charging system prototyped at Table D.

the status of their transportation (e.g., car battery charge (A4) and tire pressure (E4)), and act based on the current shower temperature (C1, E5).

As participants discussed their ideas, their vision of IoT system complexity grew as they began to discuss automating tasks based on actions that were happening in a different part of the house. For example, after hearing E5's idea of getting notified when the shower reached the right temperature, E3 envisioned a connected coffee maker that would start brewing coffee as soon as they started showering.

Once participants used the electronic toolkit, their ideas expanded to macro-level contextually aware systems, requiring information from multiple sensors throughout a space to provide actionable information [1] that could assist with home maintenance and routine tasks. Participants at Table B commiserated over the burden of putting up holiday lights each year only to remove them shortly after, and they prototyped a system that could automate some of this work. Participants at Table A worked together to prototype: "a sensor in the back of the mailbox to let you know when the mail has been delivered." Table D participants prototyped an automatic lawnmower that required little effort to maintain. It was solar powered, sensed when the grass needed to be cut, navigated around obstacles, and detected when it needed to fertilize (Figure 5).

4.1.2 Connecting Remotely. Though the automation of home tasks was a major focus of workshop participants, three tables also brainstormed how IoT could be used to connect remotely with others. During the IoT card activity, participants thought of passive forms of connection, such as monitoring their older relatives remotely (an area of much past HCI research [14, 84, 87]). B5 described how they would use smart home technology for kitchen monitoring to support their mother in aging in place: "I'm concerned about my mom burning herself. I can have the kitchen connected to my smart phone so I can watch her when she is trying to prepare the meal." A4 even suggested monitoring older people through implanted chips.

After using the toolkits, participants thought of more active forms of remote connection. E3 provided a scenario he worries about, that his wife might get injured when he was not home. This concern prompted participants to think about how someone remotely can communicate with their loved ones in times of need. During the prototyping activity, participants at Table E considered

[5]Participants are referred to by their table letter and participant number for all analyses.

Fig. 6. Telepresence video communication robot from Table E.

two-way, active communication systems (Figure 6). They utilized the social robot, Vector, and took the 360° camera with E5 explaining, "combine this [camera] with that little robot because we are big on Facetiming phone calls because my wife's family lives all over and you're constantly passing an iPad or whatever." E5 described how a robot could respond to voice and swivel towards the person talking, so that their face would be shown.

Though at first counterintuitive, it appears that the progression of activities, starting with a broad overview of IoT and then interacting directly with electronics, led participants to refine their understanding of IoT and even gain technical understanding. In terms of home automation, through engaging in workshop activities, individuals gradually expanded from envisioning roles for IoT in their own lives to articulating the kinds of sensing capabilities these systems might need. When discussing social connection, participants went from more passive to more active forms of connection. The emphasis on IoT for social connection may provide new directions for research in this understudied area [92].

4.2 Analysis 2: IoT for Older Adults

Our second analysis focused on a particular target group—older adults—in terms of their needs in regards to IoT. Here, workshop activities signify an open-ended, older-adult-driven approach that aligns with HCI research that asserts that older adults are capable of envisioning the future of technology [86]. Specifically, in this analysis, the researcher role is seen as supporting older adults in being the primary designers of future IoT technology and engaging their peers in the design process. Our findings show the importance of considering older adult's life experiences in terms of how they shape engagement in technical design activities and also reaffirm the importance of research on reminders and safety for this population.

For this analysis, we included the data of 25 older adult participants, ranging in aged from 65 to 89.[6] Thirteen women, nine men, and three individuals who chose not to report their gender participated in the study. The average age of participants was 74 years old. All were white and

[6] We included the data of A2 who did not report their age. We excluded the data of a participant who was aged 65 (this individual's data are included in Analysis 1, as the analysis is not centered around the topic of aging).

non-Hispanic, and most of them (22/25) had at least a bachelor's degree. When asked what smart home technology they had prior experience with, the most common selected answers were motion sensors (13/25), smart lights (11/25), and smart thermostats and home hubs (e.g., Alexa) (10/25). Few participants had experience with smart appliances (5/25), smart door locks (4/25), and domestic robots (4/25).

Older adults' life experiences, driven by careers and hobbies, appear to have impacted the ideas that they shared during the workshop. A2 connected to their experience as a financial advisor when they brainstormed a piggy bank that displayed stock information as text. D5 drew on her music playing experience to propose an IoT idea to help her play: "[If] I'm stymied … a pen or pencil … interprets what I've written and can verbally tell me what I've written." Prior experience affected not only the ideas that were generated, but also participation in the use of the toolkits. Only E4 and E5—both engineers—had prior experience with small electronics. E5 said that they wished the toolkit activity involved a breadboard because the toolkit simplified the electronics too much. Conversely, many of their fellow participants—who had been accountants, social workers, and teachers—were less confident. For example, A4 stated that she was not very technical, and only able to "get away with it," when completing the first toolkit activity. C5 explained that they were simply not interested in the more abstract dimensions of technology, such as "how electricity works." Below, we discuss additional findings from this analysis, including two categories of ideas from participants: reminders and safety. Both of these categories tie to past work in HCI while also providing new design directions.

4.2.1 Reminders. Reminder systems have been developed by researchers to support older adults as they experience cognitive changes [49, 90]. In our study, participants at most tables brainstormed technologies that would serve as reminders during the IoT Card activity. Most of the reminders focused on tasks where they might be forgetful—locking the door (A3), closing the garage (A3–A5), turning the stove (A3, C1) or other appliances off (A2, A3, A5, E3, E5). Mechanisms to shut off stoves that were left on by older adults has been an area of interest for designers and developers [62], though the other areas discussed (e.g., garage doors) offer new areas for design.

The IoT card activity provided participants with the ability to not only come up with reminder systems that met their own needs, but also brainstorm with others about functionality and interaction form factors. For example, after A3 brought up checking on the garage door, individuals continued brainstorming about other things that he might forget, "Did you lock the door? Did you turn off the computer?" A5 suggested remembering to turn off the coffee pot, which A3 and A4 agreed with. Then, they brainstormed how they wanted to be reminded—A4 suggested, "… you can have a list on your key chain. You could put coffee pot, door down, light off as soon as you activated the one point on your key chain, that would take care of all those things." Then A3 suggested, "Your smartphone could flash or buzz." Distinguishing their concepts from existing commercially available and research reminder systems [52, 66, 72], participants noted that current systems do not support customizing the input and output modalities (i.e., selecting between a "wrist buzzer," voice notification, or light).

4.2.2 Safety. Participants envisioned different ideas that could support safety. Seasonal decoration emerged as a risky task that spurred designs at several tables. Participants at Table B prototyped a holiday decoration system to make it easier to put them up and take down decorations. The need for this sort of system was shared by others, with one participant revealing that they had left their holiday lights, up for three consecutive years. B3 was interested in this idea because his grandson, who usually helped him decorate, "isn't coming this year for Christmas." The final design was a bookcase that housed a fully decorated Christmas tree on a Roomba-style robot that rolled outside. It turned on automatically when it got dark and had light sets for multiple holidays.

Also based on his experience with seasonal decorations, E3 created a design (a remote communication device similar to a Life Alert button[7]) to notify loved ones if his wife fell and hurt herself in their home. His motivation for this design was because of his past experience falling over 7.5 meters (25 feet) while hanging Christmas lights. Together, these anecdotes shared by participants and the resulting systems that they designed indicate an opportunity for researchers to look into automating or assisting seemingly mundane household tasks which may actually be dangerous or difficult for older adults.

Individuals focused on safety in other designs as well. Some of these systems overlapped with reminders, such as A3's idea to check whether the stove was on and control it remotely on a phone, or have it turn off based on proximity if someone left. Another system used shoes with sensors to detect objects that might cause them to fall down (A1). A2 at the same table discussed how some new hearing aids incorporate a fall detection system with **Global Positioning System** (**GPS**) to alert others when they had fallen. The identification of falls as an important area for technology design by older adults themselves reaffirms the potential for research in this space [57, 94].

To summarize, Analysis 2 yielded an understanding of specific dimensions of older adults' past life experiences that appear to impact their current understanding of and preferences for technology [103]. Our work extends past research that emphasizes the importance of understanding the nuances of the home context [67] by highlighting previously unexamined areas for system design in the home, such as supporting mundane tasks that may place older individuals at risk. Our workshop supported older adults in identifying useful reminders and safety IoT systems, demonstrating that with appropriate scaffolding, older adults can be more involved in the design of future technologies [86].

4.3 Analysis 3: Older Adults Not Fully for IoT

In Analysis 3, we analyzed the dynamics of older adults' engagement in an IoT workshop.[8] As in recent work, we center refusal and non-collaboration on the part of older adults [41, 63, 105]—while past work speaks of refusal to use certain technologies, here we focused on refusal and non-collaboration in relation to engaging in a user-centered design process. Like past work, we did not see these behaviors on the part of older adults to signify a problematic non-compliance: rather, they invite opportunities for researchers to reflect on or modify their approaches.

The Indiana University-based research team went into the workshop of individuals aged 65 and over with the main goal of collecting data to advance HCI's understanding of older adults' needs for IoT. Some participants had contrasting goals: participants at Table C said that they had arrived at the session specifically to learn about existing technologies. Upon learning that they would have to do an activity where they put together a circuit, C5 said frustratedly, "You have to remember what our focus was, was to come in here and learn some things." Instead of participating in the activity to brainstorm future technologies, A3 said, "we've got a lot of things we want to buy... you want to go to Best Buy[9] and see?" C4's concern was practical, that participating in research would not directly impact him: "By the time that you discover and develop this, we may not be here."

In response to the mismatch between researcher and attendee expectations, some individuals refused to participate. Several individuals (B5, C4–C6) got up and left. Others stayed, but avoided

[7] http://www.lifealert.com.
[8] The researchers who led Analysis 3 were visiting from a different university. Given this and the ethnographic style of this analysis, the Indiana University research team is written about in third person.
[9] Best Buy is a US retail store that sells consumer electronics.

Fig. 7. Above: participant covering 360° camera with a plastic bag during workshop. Below: view through plastic bag.

participating in activities. These individuals often used the time to engage with each other or undergraduate research assistants: C2 left and came back with camera lens smartphone attachments that an undergraduate research assistant then helped her learn to use. Additionally, two individuals disrupted data capture: B2 and B3 placed items over the 360° camera in the center of the table at different points in the session to block the camera's view of their table (Figure 7). More common than this outright disengagement or disruption of activities was participating in a way that subverted what it means to be a "good participant." Participants did this in two ways—going through the motions and having a good time.

4.3.1 Going through the Motions. One way that participants resisted the role of a "good participant" was by doing the bare minimum needed for an activity. Individuals found shortcuts to reduce their effort. For example, in a low-fidelity prototyping activity, after an undergraduate student told the group that they had written down their idea, A5 responded with a smile, "okay, so we don't have to draw then." Table B decided to do an activity as a group because "that'll make it easier." And B3 roped an undergraduate student into cutting a bush for a Christmas tree light for them by asking them, "if you were me, how would you make a green bush?". The "if you were me" in this quote indicates that the participant understood that they were the ones supposed to be doing the activity in the workshop. As the undergraduate student responded by cutting the bush out, B3 said "You can do it for me, you know. You are doing a good job."

Another method of resistance was to go through research activities, but without contributing any real opinions or thoughts. During the post-session debrief, an undergraduate researcher at Table E described some of the participation during the IoT card activity where participants were supposed to align cards to form design ideas as "I'm just going to throw these in here, but I don't know what they are." Another undergraduate researcher said, "[Table A Participants would] be like, 'Okay I got this, what's next?' And then I give them a new [card], it's like, 'Okay I'm doing this, this and this. What's next?'"

Fig. 8. Table D holding their cards up to play "poker."

In this mode of participation, the measure of when an activity was done was whether an individual had done enough to satisfy researchers, not whether they had put together a design that reflected their actual preferences or needs. When asked by an undergraduate researcher if they were done with the activity, A5 said "I'd say as long as we are meeting what [researcher] needs...". A4 continued, "We already gave her four different things, what we want to do is sit around." An assumption of user-centered design research is that participants are revealing their genuine thoughts in response to researcher elicitations—in these instances, participants seemed to be sharing what would allow them to, as participants at two different tables put it, be able to say "we passed."

4.3.2 Having a Good Time. Another way participants went through the motions, but also satisfied their own motives for attending the session, was by figuring out ways to have fun with the research activities. This often emerged through interactions with the research materials. The card-based design activities were framed by some participants as game-like, with Table D referring to similar activities that they had done as part of the week-long alumni event: "Shuffle them up and redeal—like poker? It is like last night! I hope they have better potato chips than they did last night" [D2] (Figure 8).

This strategy of having fun was also visible in the idea generation process and the final ideas presented back to groups. Part of this was selecting topics that the research team later reflected on as "X-rated." Topics included sex and drinking at Table E, with E3 responding to the vibrate IoT card by telling the table, "I'd like to vibrate when things warm up," leading a student to laughingly put her head in her hands and say "oh my." Another topic the Indiana research team saw as edgy was thoroughly incorporated into Table E's design, where their bank account would be frozen if they had been drinking too much Scotch—which was detected by the vestibular balance sensor in their hearing aids.

Some ideas, particularly the ones that were very imaginative, such as Table D's notifier that would vibrate to let them know when the plane bathroom was empty, were met by uproarious laughter. One researcher from Indiana University later reflected that participants were acting quite theatrically, and their motivation appeared to be to entertain others. When D2 presented his table's idea, the presentation went as follows:

> D2: I've used four cards.
> Other participant: Ooooooh
> D2: The four cards are... stove, tilt, sound, and smart speaker [lays the cards down]. Here's the story. So you're at home and you are preparing in your stove something that is very temperature sensitive. It could be a roast and – and the roast the prime moment when it should be pulled out... I use the smart speaker —
> Other participant: Ahhhhhh

> D2: — to say, in the analogy of a bell, come and get it,
> [Laughter from group ensues, with a discussion of how to cook steak perfectly.]

From the Indiana University team perspective, these edgy ideas and performative presentations were interpreted as participants trying to relive their youth—one researcher said "Some of the ideas were definitely—MiniU has that culture of, 'Yay, you're finally back at the university again."' Though not all ideas may have been shared out of real needs for technology, the ways the Indiana team made sense of these ideas may also indicate their own expectations regarding what is appropriate engagement for an older adult, with ideas outside of these expectations being deemed spurious.

Regardless of the motivation of participants, even as they had a good time, they demonstrated an awareness of what they were "supposed" to be doing—after an undergraduate student at the table shared during the report out the Scotch idea, E5 sheepishly said to E3, "I think we just advanced their research." This analysis reveals that older adults may subvert participation in studies when their goals, such as social goals or learning about technology, are not met. Researchers cannot always expect that participants will passively comply with all research activities.

5 DIFFRACTIVE READING OF DATA

In each section above, we describe new empirical and methodological understandings, each with a merit for the field of HCI. Yet, rather than focusing on implications from any of the three individual analyses, this article introduces diffractive reading as a way to glean new insights from difference (in this case, between our analyses). We use diffractive reading as secondary level of analysis that can provide further insights for the topic of study. Below, we first describe our approach to a diffractive analysis. Then, we describe three insights from this process.

5.1 Conducting a Diffractive Analysis

Unlike methods such as content analysis, there is no established text that provides a step-by-step description of how to conduct diffractive analysis. Past research has described a range of approaches and motivations. Levy et al. had published three articles on the same interview data set with 13 preteens with eating disorders and their mothers before applying diffractive analysis. They had come to a point where they could not generate any new knowledge based on the current data, but through diffractive analysis, they identify how their own Western biases influenced their interactions that praised participants and the preteens destabilized power roles during interviews by questioning and being silent [59]. Taguchi understands diffractive analysis as an embodied engagement with study data (stemming from a different angle of Barad's larger theory which we do not review here) [97]. These articles often focus on a smaller excerpt of data, such as Mazzei's article diffractively analyzing a single response to an interview question [65]. We describe our approach to conducting a diffractive analysis below, which is based on our understanding of Barad's description of diffractive analysis [7].

A diffractive reading approach recognizes how the apparatus (in this article, our analytic approach) "enacts cuts around and within the phenomena [under study] and thus is part of the making of boundaries and distinctions that we as researchers apply in our empirical descriptions" [76]. For our diffractive analysis, we analyzed the differences between the three analyses in a particular way: "how different differences get made, what gets excluded, and how these exclusions matter" [7, p. 30]**.** It is key to note that this approach of diffractive reading is different than triangulation or mixed methods analyses. Those kinds of analyses confirm results from different approaches against each other, with the end goal of learning more about an object of study [76]. The goal here is to learn more about what does or does not ripple through the apparatus, to better understand the phenomena being studied and/or the apparatus itself.

Our approach to studying difference was as follows. The first author conducted the initial diffractive analysis, which was then refined through discussion with all authors. The initial diffractive analysis process involved iteratively revisiting the three analyses of Section 4 to understand where distinctions and boundaries existed (sometimes resulting in the need to sharpen details and analysis in the original three analyses). We created memos while reading findings "through one another" to attend to "the details and specificities of relations of difference and how they matter" [7, p. 71]. In some cases, we had insights about the meanings of differences when we examined data that was included by researchers in one analysis and excluded in another. In other cases, our analysis centered around ways that the same data was brought into different analyses but took on different meanings. For example, statements from participants like A4 of being able to "get away with" completing the electronic toolkit activity is seen as a sign of a lack of expertise with technology in Analysis 2 and a subversion of researcher expectation in Analysis 3. Below, we present two insights based on reading findings from our three analyses "*through, with,* and *in relation to* each other" [65] and a third based on turning our analytic approach to the apparatus.

5.2 Inscribing Participants and Corresponding Research Futures

A diffractive reading yields insights about the ways that we as researchers go about inscribing age and creating the categories of "older adults," older adults' interests, and older adults' technical know-how through our analysis. Approaching HCI research on aging as we did in Analysis 2 has led to important advances. Here, we argue that adopting diffractive reading can help us understand the ways that our research approaches may lead to certain conclusions, and gain new insights that can reveal key opportunities to pause and see the ways our research agendas might be accepted or rejected.

As an example, we revisit the differences between the ways that holiday decorations appear in the data. In Analysis 1, a holiday-decorating robot was evidence that participants deepened their thinking about IoT from micro to macro through workshop activities. In Analysis 2, holiday decorations meant something different: the poignancy of a house with lights left up 3 years in a row; a grandson neglecting their annual holiday visits; the risk of a 25-foot fall for an elderly individual. And in Analysis 3, the design of this concept was a task that an older participant sneakily convinced a young research assistant to do to appease researcher expectations.

If we do not take a diffractive approach, we can find new insights that fit within existing ways of doing research in different sub-areas of HCI. For example, Analysis 2 recognizes new areas important for older adults' wellbeing: mundane activities that may create risks, but are rarely discussed in the body of HCI literature on aging. We could take this point further, raising how the ability to conduct these tasks may reveal signals related to how well they are functioning—signals that can be monitored and shared with family members who may recognize the inability to maintain a home as meaning that they need to step in or make decisions about whether someone should move into a care home. In terms of design implications, incorporating or interpreting sensed data in routine tasks (for example, cabinet moisture sensors for laundry [2]) can provide a new way of monitoring the wellbeing of older adults and intervening early in downward trajectories [56].

Reading one analysis through another, however, can help make what is at stake in different interpretations clear, so that we can ultimately make more informed decisions about which paths to pursue in our research. When insights related to holiday decorations from Analysis 2 are "read through" findings from Analysis 3, which raise the prospect of older adults' resistance, we might pause at casting mundane daily activities as additional criteria to monitor and view through the lens of aging in place. Not considering these practices as regular, human activities and instead as something to study and manage may alienate and also "other" this group. The point here is not that reading insights through one another as we did here should prevent researchers from studying the topic of mundane activities for aging: but rather, that a diffractive approach can raise some of the practical or ethical considerations that may impact a research agenda down the line.

5.3 Probing Transferability of Knowledge and Declarations of Novelty

A diffractive reading of the three analyses lets us see what analyses researchers may tend to see as speaking for "all," and which tend to be restricted to a particular population (in this case, older adults). In Analysis 1, our findings appear to be applicable to many other groups, with promising areas of future research in, for example, IoT to take care of living things in the home or interact with those outside the home. Yet the mention of older adults in Analyses 2 and 3, in our experience, would mean that our findings would only be seen as relevant to HCI researchers studying aging.

Here we make a case that the specific ways of thinking and working in HCI research on aging can become useful to others. To do so, we first trace a path through HCI research on aging. Researchers have pointed out how there is an overwhelming focus on older adults as technology novices [36, 103], and (perhaps) in reaction a body of literature has emerged emphasizing the technical competence of older adults (e.g., [23, 44, 53, 96, 104]). The conversation stays framed in terms of technical experience as mattering a great deal, with the discourse centered around whether older adults have it or not. When doing a diffractive analysis, we realized that Analysis 2 fits this mold, with frequent discussions of technical experience: we report demographics of past experience with smart home technologies, just as we often do in our other publications on older adults, and one of our main findings is about how life experience affects use of technology. When we searched for discussions of technical experience in Analysis 1, we found none—references to interest and use of IoT were written more as a matter of fact, though it surely affected the data we reported there as well. Reading Analysis 1 in relation to Analysis 2, we recognize that one way out of the technology experience rut in aging may not be to neglect the topic in aging, but to emphasize the importance and findings from this examination for researchers studying other topics (which may have a secondary benefit of destigmatizing the topic for older individuals). Similarly, the particular emphasis on reminders and safety that accompanies much research on older adults can be used to inspire design efforts for other groups: by reading Analysis 2 through the "general population" lens of Analysis 1 (where we learned the data from a study on older adults can be feasibly written as a general population study), we can recognize that many populations desire reminders [22]. And, examining findings from Analysis 1 through the older adult-centered emphasis of Analysis 2 can bring new understandings for HCI research on aging: for example, that older adults may be caregivers themselves, for their parents or spouses, and that a promising design direction is supporting older adult who are caregivers.

What is seen as novel depends in part on whether we view participants as being a part of or separate from a "general population." In Analysis 1, we described IoT for social connectivity as an understudied area—but research on older adults has been examining precisely this purpose for many decades. Yet without a diffractive reading approach, we might not consider advances of past research in the aging domain as being relevant to others. We argue that HCI research on aging, as well as researchers who study other "special populations," have much to offer to HCI researchers who have previously seen these topics as out of bounds or irrelevant to their own work. A diffractive reading can allow us to take insights yielded through one methodological approach and interact with them in a way that opens up new opportunities.

5.4 Tuning the Instrument: Considering Methodological Approaches

Diffractive reading can also be used to examine the apparatus itself—the instrument through which the light passes to create the different patterns of light and darkness that we analyzed in the two sections above. The "sharp distinctions" we see in typical approaches to analysis (that we analyzed to make the points above) result from the specifics of the apparatus [76]. In this section, we analyze one aspect of this: the different methods that we used to analyze the data.

We analyzed the data from a single study by using two different analytical methods: affinity diagramming (for Analysis 1 and Analysis 2), and constructivist grounded theory (for Analysis 3). Affinity diagramming is a popular method of data analysis used in industry to derive insights, ideas and themes from data [43]. In this method, the primary focus is on the data itself and on how to categorize the data—likely associated with the popularity of using this method in the fast-paced industry setting to quickly identify design requirements and inspire design ideas [43]. Using this approach helped us quickly categorize the different ideas that participants came up with to find clusters of similar experiences and ideas. Our focus on artifacts more broadly (Analysis 1) or older adults (Analysis 2), then, drove the particular ideas that we recognized as meaningful. On the other hand, constructivist grounded theory emphasizes that the researcher should acknowledge how different aspects, such as participant–researcher interactions and the worldviews of researchers and participants, influence how the data and analysis are "constructed" [26]. While both affinity diagramming and constructivist grounded theory use an inductive approach to identify themes and subthemes of interest, the former focuses more on the grouping of ideas based on their similarity, whereas constructivist grounded theory also stresses focusing on processes, or why and how participants are engaging or thinking in the ways that they do. Thus, using constructivist grounded theory helped us uncover how the interactions between researchers and participants constructed our data, and the underlying tensions therein.

A diffractive analysis approach allows us to see the ways that both methods of analysis are valid and useful on their own, and also how they challenge and strengthen our research when they are brought together. For example, the ways that constructivist methods probe how individuals make meaning helped challenge findings from affinity diagramming. Consider the automatic garage door that could be controlled using a voice assistant that participants envisioned and we described in Analysis 2. When we analyzed the same data in Analysis 3, the goal of participants in producing this idea was actually to do just enough to meet the researchers' expectations. It seems likely that this specific idea was not based on their own actual needs, and if researchers converted these ideas into technology for older adults, they would not be adopted. This insight could potentially help researchers avoid situations where a technology is built around older adults' needs, but those individuals do not then, find that technology meaningful or useful [83]. And, methods such as affinity diagramming, which focuses more closely on artifacts, contribute insights that are different from what can be derived from constructivist methods. If Analysis 3 was the only analysis reported from our data, readers might assume that none of the ideas that participants shared reflected actual needs. This was not the case—E3's desire to check on his wife if she became injured is one memorable example. Thus, probing the places in different analyses that do not sit easily together can help our research stay closer to what is truthful to and can better serve the populations we study.

6 DISCUSSION

Diffractive analysis yields an opportunity in HCI, a field where researchers converge from many disciplines, taking contrasting and sometimes conflicting approaches. These contrasting approaches appear across HCI, in areas such as disability and accessibility research (with critical disability perspectives [38, 64, 93] and first-person accounts [46] coming up against traditional user-centered design approaches), design in the global South (where post-colonial perspectives [48, 95] may conflict with designing for development discourse) and health informatics HCI research (with public health and health activism approaches [77, 99] in contrast to individual-focused paradigms). A diffractive approach sees the benefit in attending carefully to different, specialized ways of doing research.

In this article, a diffractive analysis yielded several considerations for HCI research broadly and research on IoT for aging specifically. This includes extending past work on aging misconceptions and stereotypes [35, 85, 103] by accounting in a more nuanced way for the effects of reconstructing the aging adult as the "other"—specifically, how an emphasis on aging can meet real needs while simultaneously marginalizing older adults. We present one way out of this conundrum, which is recognizing the importance of specific findings and larger themes from HCI research on aging for other populations. This insight operates the other way as well—though recent work on IoT for the general population does examine some similar topics to aging research, such as privacy [41, 52], research has also expanded to take a broader view of IoT in a way that it has not for aging populations. For example IoT research has investigated the seamless incorporation of these technologies in daily lives [74] and new areas ranging from supporting outdoor play [35] to understanding IoT exploitation [39]. All of these areas may be fruitful starting points for HCI research on aging. Finally, our findings present considerations for taking multiple analytic approaches to the same data, particularly process-oriented versus content-oriented approaches. Below, we discuss implications for researchers to form teams and account for their roles in research as well as considerations for when diffractive readings may be most appropriate.

6.1 Analyzing The Role of The "Observer"

Barad does not see the researcher as standing back, observing as experiments unfold. Rather, the researcher's way of thinking and training as it bears on the topic at hand are all part of what is being and can be studied [7]. Here, we present some considerations relating to our own involvement as researchers in this effort.

Our own effort worked because of the diversity of our research team, not necessarily in terms of discipline (we are all HCI researchers), but in terms of how we approach the same topics, aging and health, with different research agendas and ways of interpreting data. In the case of this article, the different research practices included the specifics of the researchers themselves, who arrive at the project from different institutions, length of time in academia, and perspectives; the methods used, which included affinity diagramming or constructivist grounded theory; and the ways the purpose of the research is framed, whether for IoT broadly, IoT for aging, or a critical reflection on older adults' participation in research. Working together as part of a research team, but also having space to conduct rigorous analyses according to our own practices and viewpoints were necessary to conduct the diffractive analysis. The different roles the two sets of researchers played, with the Indiana University researchers planning and leading the sessions, and the University of Maryland researchers observing a portion of the workshop and engaging with the data afterwards, was also key to the ability to gain different perspectives that deepened our understanding of this space. We affirm the benefit of engaging not only in inter-disciplinary, but also intra-subdisciplinary efforts.

A diffractive analysis approach also has implications for the broader conversation about technology design that reflects on the ways that the researcher's background, approach, and views invariably shape our research and the ways that we present our findings. One way that this stance has manifested is in calls for reflexivity. Researchers are urged to share their own positionality, often disclosed in a methods section. For example, Feminist HCI [9] and Social Justice-Oriented Interaction Design [33] urge researchers to critically consider and disclose their intellectual positions or their assumptions, along with their goals, beliefs, and the political and cultural situatedness of their practices, as a way to provide more transparency and accountability. Barad and other feminist scholars urge researchers to rethink how to account for their own role, pushing back on reflexivity as the best approach to doing so [7]. Reflexivity implies that characteristics of the researcher are static and exist apart from interpretation [7]. In contrast, Barad's notion of the researcher is as playing an active role in what materializes in research. Barad explains that a static view of researcher characteristics that can be described somewhere like a methods section is akin to, "turning the mirror around [to show the researcher]... a bad method for trying to get the mirror in the picture" [7, p. 418]. Diffractive analysis is an alternative approach to critical reflection [97]: able to account "for how practices matter" [7, p. 90]—in other words, the ways that researcher positionality matters. Researchers can use a diffractive analysis approach to inspire ways to account more fully for their own role in research.

Diffraction lets us see researcher perspectives (and bias) in practice. Here, we discuss two of the changes that we as researchers experienced as a consequence of carrying out this analysis, simultaneously accounting for the effects of our epistemological stances [45]. The two researchers approaching the project from a more critical stance, Amanda and Alisha, are confronting a consequence of focusing on deconstructing interaction, which can involve missing taking seriously genuine participant desires for improvement in their IoT. Though difficult to pinpoint this shift to solely this study, the shift is evidenced in the ways that our research lab is now investigating topics that we previously had avoided due to critiquing them as reductionist, such as reminder systems for aging. Katie and Ben were affected in a different way, revisiting their goals of community based participatory research to ensure their participants benefit from participation in research and their findings not only provide research contributions, but—more importantly—community value. They plan to create adaptive protocols that can balance participant expectations with research activities. All researchers are more interested in cultivating relationships and collaborations that span different ways of thinking about aging and doing aging research.

6.2 When is the Time and Place for Diffractive Analysis?

Prior research has unpacked the importance of attending to the ways that researchers shape the design process for participants in ways that are typically not acknowledged, such as how researchers often determine who should or should not participate in projects [100]. This article provides additional ways to understand our roles and responsibilities as researchers. We examine the role of gatekeeping in analysis through the framework of diffraction, particularly in terms of what designs and ideas that we, as researchers, allow into the literature, and discuss when diffractive analysis might be most opportune.

When we originally discussed the findings from the workshop among the research team, before the idea for this article was born, it seemed that much of what might be coded in the data were well-worn topics in the literature – many of the ideas for safety and reminders participants brainstormed have already been pursued by researchers and industry. Though we always go through the coding process, we had essentially played the tape forward of what we might find clustering topics by theme and found nothing groundbreaking. In these initial reads, we saw discussions of alcohol and sex and Christmas trees on Roombas as clearly out of bounds of what we might write up in a publication related to aging. Yet in conducting a diffractive analysis, we found that the threads that had previously seemed banal or out of place had much to offer. Through studying differences rather than similarities, we were able to contribute to the well-studied area of aging in place IoT: for example, re-envisioning aging in place for older adults to extend beyond detecting falls and monitoring medication to also include rote home maintenance considerations; and highlighting that not all ideas shared are in good faith. Diffractive analysis does not merely offer the researcher new codes or themes, but rather "a moment of plugging in, of reading-the-data-while-thinking-the-theory, of entering the assemblage, of making new connectives" [65].

Yet, even as we strove to integrate that which was at first out of bounds, we left more topics out. Barad proclaims that "exclusions matter"—"that which is excluded in the enactment of knowledge-discourse-power practices play a *constitutive* role in the production of phenomena" [7, p. 57]. Findings are not excluded because of a researcher's conscious decision to prevent others from seeing them. Rather, according to a particular analysis and way of thinking, some data may simply be irrelevant. One possible way forward for researchers is to have avenues to share details that may seem extraneous to a particular analysis, even if we cannot make sense of them at the time. Some of us have seen the dynamics described in Analysis 3 repeatedly in studies we conducted, but had never considered including these in articles as they did not emerge as salient as we sorted our codes and themes. Though a neat, cohesive story is often a requirement for publication, there is an opportunity to look into ways to link publications with case studies or non-peer reviewed articles to share our "sore thumb research" (perhaps parallel with calls for sharing negative findings). As an example, in our own research, a "sore thumb" existed in the form of generational tensions, where participants brought up how the research team was younger than them in a dismissive way—while simultaneously turning to the younger research team for advice regarding technology. We can also follow practices towards providing as much context and transparency as possible [15], such as a "Table 1" that lists detailed demographics [69] or dimensions that are often left out of transcripts: laughter (and the different kinds of laughter), pauses, and responses from others (such as "Oohs and Ahhs") via approaches to transcription such as the Fefferson system.[10] These efforts may lead to data open to multiple analyses by a research team, and for others to conduct secondary analysis to compare and contrast findings (e.g., by using qualitative data repositories such as https://qdr.syr.edu/).

What does it mean that the initial three analyses, while providing some new insights, could not provide what we see as the more novel insights that the diffractive analysis did? This may be a sign that ways of thinking about a particular topic have been well-worn in our field—a typical study design applied to a broad topic, such as IoT for aging, may not yield further insights. We stress that this is not because everything about that topic has been found, but rather because the ways of doing research and engaging with data that have been honed within HCI have resulted in most of the findings that will be possible through those routes already. Diffractive analysis, then, may be a route for returning to a broad view of a topic that has been well-studied with established kinds of conflicting discourses to identify new ways of moving forward.

Future research can conduct diffractive analysis on other topics, but we believe there is more to be gained from applying this approach further to HCI research on aging. Our analysis was limited to data from a homogenous set of participants and a single study design. Therefore, there is much that we could not study deeply in our analysis, on a range of topics including ethical involvement of participants. Future research can conduct a diffractive analysis that brings together data from different ways of conducting studies, such as more participatory research and survey research. And, bringing in research methods that HCI researchers may not typically use into a diffractive analysis would be a way to further understand bounds that go unsaid.

7 CONCLUSION

In constructing and then diffractively analyzing three distinct analyses from the same set of data, we make a case for diffractive reading in HCI. Our work advances an understanding of how older adults are framed in IoT and technology research and enables us to recognize the importance of

[10]The Jefferson system uses notation to capture the ways in which people speak, (e.g., (.) to denote micro pauses, arrows to denote rises, and drops in intonation). https://www2.le.ac.uk/departments/psychology/research/child-mental-health/cara-1/faqs/jefferson.

asking what the implications are of the different ways we think about and define the populations that we work with, and the corresponding research agendas that we pursue. We highlight the benefits of accounting for our positions through what materializes and fades with different approaches to analysis, and advocate for collaborating with other researchers within our disciplines who apply different perspectives.

A diffractive approach does not require that we attempt to identify all insights in our analysis. It actually argues that we cannot understand everything there is to know in a single analysis. And, in stressing the value of different ways of doing research, diffractive analysis does not involve a relaxing of any standards of doing or understanding one another's research: on the contrary, it is rigorously attentive to important details of specialized arguments" [7, p. 25]. Diffractive research complements the very essence of the HCI community that weaves together epistemologies, theory, methods, and disciplinary expertise that simultaneously challenges and catalyzes sociotechnical systems. While in this paper we consider analyses from three specialized ways of thinking within HCI as they apply to aging research, we hope with our work to provide scaffolding for this approach such that we may inspire other diffractive readings in HCI.

Taking a diffractive approach is one way to "make it impossible for the bottom line to be one single statement" ([42, p. 105], cited in [89])—a sentiment that pervades this article. The "messy realities" [89] of research on aging and many other topics that we examine in HCI make diffractive reading appealing. We hope that our work will offer one path to derive benefit from what may appear to be insurmountable differences between research approaches.

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