The Invisible Labor of Authoring Dialogue for Teleoperated Socially Assistive Robots

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***Abstract*— Some labor is overlooked or devalued, while necessary within the context of paid employment. This is "invisible labor". Invisible labor is often performed by minoritized groups and is typically invisible to those in power. Novel technologies can introduce new sociotechnical labor paradigms that reduce labor visibility. In this paper, we consider how invisible labor might manifest for teleoperated Socially Assistive Robots (SARs). By combining an analysis of the labor context of teleoperated SAR use with insights from interviews with SAR teleoperators, we demonstrate how invisible labor manifests in the practical deployment of teleoperated SARs. Finally, we provide recommendations for developers and policymakers to remedy this labor invisibility.**

I. Introduction

Scholars and ethicists have called attention to the *invisible labor* required for workers across many fields [1], [2], [3]. Invisible labor, unacknowledged, unpaid, or overlooked work necessary to perform one's job [1], exists in many domains of interest to the Human-Robot Interaction (HRI) community, including healthcare, where nurses perform substantial carework to ensure their patients are well taken care of, and education, where teachers go above and beyond to ensure emotional safety for their students.

Considering how invisible labor happens facilitates critical examination of the identities of workers and how, when, and why their work might be rendered invisible. Worker productivity is typically tracked using various metrics that inform supervisors of their workers' efficacy [4]. Labor that is rendered invisible is typically performed by women and other minoritized groups [5], [6], [7], and is invisible specifically to those in power, such as those in management roles, who define what counts as work [8]. Understanding *how* labor is rendered invisible is important to technologists, as new technologies have been shown to reduce the visibility of labor through paradigms like crowdsourcing [9]. In this work, we argue that Socially Assistive Robots, which shift the way that labor is performed in healthcare and education contexts, present risks for the labor performed by minoritized groups to be rendered invisible in similar ways.

Socially Assistive Robots (SARs) provide assistance through social interaction [10]. SARs can support teachers and children in education [11], [12], provide companionship for the elderly and those suffering from dementia [13], [14], [15], [16], and aid in therapy [17], [18], [19]. While most previous work on SARs within the HRI community focuses on the development and evaluation of *autonomous* SARs, recent research suggests robots used in socially assistive domains should be at least partially teleoperated in order to best meet the needs of those receiving assistance and to honor those who typically provide that assistance [20].

When SARs are used in practice, they are typically teleoperated by caregivers [21]. In the absence of SARs, these same caregivers would have provided the social assistance themselves. These caregivers are typically women and members of other minoritized groups, and are often paid only for the time when they are visibly providing assistive services [22]. The use of SARs may exacerbate caregivers' need to prepare content ahead of time; a task that by definition would not fall within the scope of what is immediately visible and thus compensated. This raises significant cause for concern regarding the possibility of invisible labor creeping into caregiving work due to the introduction of SARs. This suggests that SAR research needs to be mindful of and actively work to head off this risk, so that SARs can achieve their desired benefits to those *cared for* without negatively impacting those *caring for*.

In this paper, we analyze interviews with experienced SAR teleoperators, with the goal of rendering their work visible. We identify important patterns within the experience of expert SAR teleoperators regarding the necessity and demanding experience of authoring SAR content. We then contextualize these results by considering the demographics of the individuals often providing social assistance and the caregiving pay structure typically followed in the United States. By contextualizing our results in this way, we render visible the invisible labor of teleoperated SAR content authoring. Our results present a key obligation of the HRI community to prevent and alleviate labor invisibility, and as such, we provide recommendations for how this could best be accomplished. Specifically, we suggest both technical recommendations for SAR developers and researchers, as well as legislative suggestions for policymakers and regulators.

II. Motivation

A. Invisible Labor

Invisible labor consists of the overlooked, ignored, or devalued activities that are necessary for workers to complete to adequately perform their jobs [1]. Invisible labor exists across many areas such as nursing, and K-12 education. Nurses perform substantial care work to support patients in typical daily activities, including seemingly simple tasks such as using the bathroom [23]. This work may be underappreciated by managers [23], despite it being crucial to patients' care since nursing care work is not just medical-technical care work such as handing out pills to patients, but also

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includes personal care and emotional care[24]. Similarly, K-12 teachers tend to perform care work [25] in addition to the educational tasks that they need to perform [26]. Specifically, caring teachers perform extra emotional labor outside of the classroom: encouraging students, displaying sensitivity to their needs, and engaging them in meaningful ways which contribute to students' success in school [27]. In this section, we describe the context in which invisible labor is performed.

1) What renders labor invisible: Productivity at work is often tracked and evaluated by management [4]. Much of management science is geared at determining the most appropriate metrics for tracking work and productivity [28], [29], [30], [31]. Management's choice in metrics defines the organization and determines priorities and values [32]. An institution's choice in metrics to track worker productivity determines what work is deemed legitimate and by proxy, what work is rendered invisible. Tasks are deemed legitimate when those tasks are "desirable, proper or appropriate within a socially constructed system of norms, values, beliefs, and definitions" [8]. While these metrics are often presented as neutral, they tend to codify political structures [33], [34] and can perpetuate oppressive systems [35], [36]. The choice in metrics determines what work is visible and what remains invisible to an organization as a whole.

2) Invisible labor by whom: Invisible labor is performed by women [5], people of color [37], [6], or disabled individuals [38], [7]. Pink collar jobs, those predominantly performed by women, have traditionally suffered from pay disparities in the US [39], [40] and commonly contain invisible labor performed by women [41], [24]. The division of labor is gendered [42] and care work, which is predominantly performed by women is commonly devalued [43]. Similar patterns are present in jobs that include care work in addition to technical work such as education and nursing. Female teachers often perform substantial emotional labor that is brushed aside as maternal or feminine[41], [26]. In nursing, men typically conceptualize emotional and personal care work as *extraneous* while women conceptualize them as *essential* to typical nursing care work [24]. These patterns result in the invisible labor of care work being performed by women. Similarly, racialized and colonialist systems have created labor inequities through structural discrimination where labor performed by people of color is undervalued or invisible [44], [45], [46]. When people of color are afforded opportunities, those opportunities often exist in predominantly white spaces where they must perform invisible labor that eases the difficulties that come with being in these spaces or reinforce the racial status quo [47]. The burden of invisible labor is often placed on people of color [48], [49] thereby exacerbating the already existing inequities they experience. Importantly, individuals belonging to multiple minoritized groups often experience compounding disparities in labor rights [50], [51], [52] and health outcomes [53], [54] which heavily impacts women of color [55], [37], [6], [56] or disabled people of color [57].

3) Novel Technology's Role in Invisible Labor: Novel technologies can introduce new labor paradigms that have a direct effect on lowering labor visibility. As we previously discussed, labor is observed through multiple context-dependent indicators [4]. Technology can introduce patterns that abstract away labor from view by separating the production of labor from its consumption [4]. This, in turn, can render the work and workers invisible. Even early technologies such as writing, remove the author from visibility and allow readers to consume content without the author's presence thereby rendering the author invisible. These patterns are replicated in modern technologies like crowdsourcing [9].

When new technologies are adopted, they can introduce additional labor necessary to (1) learn to use the introduced technology or (2) perform tasks that were unaccounted for in the technology's development. In an implementation of health information technology at two hospitals, nurses either performed additional invisible labor or delegated that labor to support staff so they could continue to effectively perform their jobs [58]. Technologists must understand their users' technical capabilities and the work they typically perform so they can design appropriate tools to meet user needs.

B. Socially Assistive Robots

Socially Assistive Robots (SARs), robots that provide assistance through social interaction, are a technology whose introduction may lead to a labor paradigm shift. In a lab setting, robots can support students' education, engage with elderly folks, and enhance therapeutic experiences. SARs used with children and young adults in education can result in more engagement and positive learning outcomes [59], [60], [61], [62]. Elderly individuals using SARs reported an increase in their quality of life and cognitive activities [63], [64]. SARs can engage with clients in therapeutic activities and result in pleasant and successful therapeutic interactions [65], [18], [66], [19]. In most of these scenarios, the robots involved are assumed to be autonomous [20].

1) Autonomous SARs: SAR research is largely motivated by a future with autonomous robots supporting people in a variety of tasks [20]. However, researchers typically limit the scope of their robots' capabilities so they can reasonably and effectively develop the robot's autonomy. Researchers must codify assistance expertise into the autonomous robots they are developing so that these robots can function independently. SAR researchers do so by relying on and collaborating with domain experts. By working on autonomous SARs, technologists themselves select and build assistive content into robots, thus taking control of the assistive interaction.

Content is built-in to autonomous robots: An autonomous SAR is expected to deliver social assistance independently. Researchers often partner or co-design with domain experts to extract their expertise and build robotic solutions [20]. Researchers' goals are often either to show the feasibility of building the autonomous robot, or to show that robots can perform assistive services effectively. In both cases, the robot is expected to deliver the assistive service, mostly independently. When researchers choose to develop an autonomous robot, they must also program its assistive content, which becomes a part of the technological solution.

Autonomous robots shift power towards technologists: By choosing to develop an autonomous robot and its content, technologists enter the realm of an assistive domain which may not necessarily be their area of expertise. Consumers naturally perceive robots as technological products and the robot's performance or lack thereof is then perceived as a technical achievement or failure. Traditionally, when human interactions are encoded into technical solutions, algorithmic work, and technical advancements become highly visible, while domain expertise is often hidden in plain sight. New assistive capabilities are then branded as new technological advancements despite these capabilities likely being the result of deep collaboration with assistive experts with years of experience. Who gets the credit for the robots' advancements may seem insignificant but it shows how Socially Assistive Robots may be presented more as a *robot* solution rather than an *assistive* solution thereby shifting power to technologists and away from assistance experts. This is especially important since technologists have treated domain expertise as a commodity instead of respecting and valuing the individuals who possess that expertise [67]. Moreover, there are examples of this specifically when technologists develop autonomous solutions that codify workers' expertise [68].

2) Teleoperated SARs: Despite the research community's focus on autonomous SARs, many SAR systems currently deployed in practice are teleoperated [21]. This real-world use trend aligns with what is recommended by level of autonomy guidelines [20]. These deployed robots are teleoperated for a number of reasons. First, they are deployed by caregivers who would otherwise provide the assistive services themselves. Second, teleoperation keeps a human in the loop who can ensure the task performed by the robot is performed effectively and can interfere when issues arise. Finally, these robots are potentially used in the context of critical tasks and with vulnerable individuals, and as such, teleoperation by a domain expert who is familiar with the task is extremely valuable.

Compared to autonomous SARs, teleoperated SARs provide more power and control to assistance experts. As the robot teleoperators, assistance experts control robots' actions and ensure the robot delivers an effective service. However, there are two obstacles that they must first overcome: experts must (1) learn the tools necessary to control robots, and (2) create the content they want to deliver. Critically, both of these obstacles are not natural dimensions of the socially assistive domains, but instead are introduced due to the change in the choice of robot autonomy [20]. Typically, robot control interfaces are designed for robotics experts even though assistance experts rarely possess the technical expertise to easily learn how to use these systems. As a result, domain experts typically need to spend a substantial amount of time to gain the necessary competence to use the robots and to program assistive content into the robot. As we will show, this labor is typically rendered invisible due to the broader labor context in which it is performed.

C. Who are SAR teleoperators?

Caregiver Pay Structure in the US: The majority of current SAR teleoperators are educators and therapists who are often involved with robots in addition to their typical practice. When educational programs are set up to include a SAR, they do so through after-school activities beyond teachers' typical duties. As of 2016, only about 44% of teachers get additional compensation for extracurricular activities [69]. These programs may be run in collaboration with nonprofits who provide funding to teachers running these programs [70]. Therapists in the US are paid hourly based on their in-session time [22]. In both these scenarios, individuals may be compensated for the highly visible work they do but not the work necessary to perform that work.

Caregivers are often under-paid women: In the US, 74% of teachers[1] 81% of child and family therapists[2] and 85% of elderly caregivers are women[3]. While women comprise the vast majority of workers across these occupations, they typically earn only 95%[1], 93%[2], and 98%[3] of what men earn, respectively. For context, in the US and as of 2021, women on average earn 83% of what men earn, with Hispanic and Black women specifically earning even less[4]. The current pay structure, pay gap, and gendered majority of these occupations are important to be aware of when it comes to invisible labor. As researchers interested in designing human-centered tools, our aim in this work is to help render work performed by these tools' users visible [34]. To do so, we analyzed interviews with experienced SAR teleoperators and found patterns that suggest that their content-authoring practices constitute invisible labor.

III. Methods

A. Study Design

The aim of our ethics-board-approved study was to uncover the needs of SAR teleoperators in practice. We recorded semi-structured interviews with experienced SAR teleoperators over Zoom. Interviews began by discussing participants' general experience in conducting and preparing for social assistance/therapy, to establish each participants' standard practice. Afterward, we discussed with each participant how their practice differs when incorporating a robot, followed by a discussion about robot teleoperation interfaces guided by a screenshot of a SAR teleoperation interface.

B. Participants

Due to the limited adoption of SARs, we relied on our professional network to connect to individuals with experience using SARs in practice, reaching out to 22 experienced SAR teleoperators, 9 of whom agreed to participate in our study. All participants had experience using SARs to deliver educational or therapeutic content to children in a work context that required them to use robots. All participants

[1]https://www.zippia.com/teacher-jobs/demographics/
[2]https://www.zippia.com/child-and-family-therapist-jobs/demographics/
[3]https://www.zippia.com/elderly-caregiver-jobs/demographics/
[4]https://www.zippia.com/advice/gender-pay-gap-statistics/

ID	Relevant Credentials	Experience with Socially Assistive Robots
Alissa (T1)	Registered Behavior Technician with 3-5 years of experience delivering behavioral and art therapy to neurodivergent children in one-on-one sessions.	Used robots in therapy with children in the past.
Blanche (T2)	Dance and movement therapist with 5-10 years of experience working with children who have various disabilities.	Extensive experience with robots and regularly uses robots for group social skills sessions.
Caroline (T3)	Therapist with B.S. in Psychology with 5-10 years working with children who have various disabilities.	Used robots in therapy one-on-one and in groups.
Emily (T4)	Occupational therapist for 5-10 years with 3-5 years working with children with various disabilities.	Used robots for some one-on-one sessions.
Fiona (T5)	Licensed marriage and family therapist with over 10 years of experience working with children who have various disabilities.	Regularly uses robots for therapy with children.
Greg (T6)	Behavior interventionist with over 10 years of experience working with children who have various disabilities.	Led social skills group sessions for many years then left to found a social robotics company.
Holly (E1)	Child development specialist with over 20 years of experience in teaching.	One year of using robots in one-on-one sessions with children who have various disabilities.
Isaac (O1)	No therapeutic credentials. Adapted Aquatics Instructor	Early adopter working with children to delivered social skills content using robots to groups of children for 5-10 years.
Jaclyn (O2)	No therapeutic credentials.	Organization leader using robots to regularly deliver therapy for groups of children with various disabilities for 5-10 years.

TABLE I

LIST OF PARTICIPANTS AND RELEVANT INFORMATION. INDIVIDUAL CODES USED START WITH T FOR THERAPISTS, E FOR EDUCATORS, AND O FOR OTHERS. ALL NAMES HAVE BEEN CHANGED FOR ANONYMITY.

consented to participate in this study. Information about our participants is presented in Table I. As we conducted our analysis, our participants shared consistent and similar narratives and we reached our data saturation requirement.

C. Analysis

We approached our analysis with the goal of uncovering the work that our participants perform and rendering it visible so that developers and researchers can design better tools to meet SAR teleoperators' needs [34]. To infer generalizable theories from our study, we followed a grounded theory approach. Grounded theory is an appropriate method for providing explanations for underlying processes that occur in a largely unknown context [71]. Grounded theory ensures that resulting explanations are traceable to study contents and are therefore grounded in the experiences of study participants. After transcribing our interviews, the first author verified transcript accuracy, and then open-coded participant statements based on the needs and difficulties participants described. Driven by the recent insights of Elbeleidy et al. [72], we grouped our open codes into axial codes with an eye toward practical challenges that our participants may face and with the goal of rendering their work visible. The authors discussed these axial codes and arrived at an agreement. We present the resulting axial codes in Section IV.

IV. RESULTS

Through our analysis, we identified four themes that collectively demonstrate the necessity and non-triviality of the uncompensated work performed by SAR teleoperators: (1) Pre-authored content is central to teleoperator workflows; (2) However, learning to author content is time-consuming, as is content authoring even once mastered; (3)Teleoperators share content to avoid authoring, but this does not meaningfully alleviate authoring load because (4) Content must be modified to meet client needs. In this section, we will explain each theme, sharing quotes from participants that ground each of these themes. We will demonstrate key insights that help us to understand how invisible labor manifests for teleoperated SAR use.

A. Pre-authored content is central to teleoperator workflows

First, what is immediately clear is that the use of pre-authored content is standard practice and the status quo. When teleoperating SARs, teleoperators are mostly selecting dialogue options from pre-authored content, and this is such a standard practice that teleoperators took it for granted, choosing to discuss the *consequences* of this practice rather than the practice itself. For example, Blanche (T2) describes content organization by saying how they "*like to work with separate palettes (grouped collections of SAR dialogue options) for opening and closing, and maybe sometimes separate palettes for transition.* " Similarly, Isaac (O1) focuses on the types of content they use, saying, "*I would have at least kind of a basic conversation. And some go-tos like either Simon Says, I Spy, and then some jokes.*" Moreover, Isaac (O1) adds that "*We always had a backup.*" emphasizing the necessity of making sure there was extra pre-authored content ahead of sessions. Alissa (T1) describes how not only is having pre-authored content important, but being the author or organizer is also very helpful. "*I had like very specific palettes that I created that had titles on them, so I knew exactly where everything was.*" Our participants' experiences demonstrate that using pre-authored content is standard practice. But does it really present a meaningful burden? The answer is a resounding yes.

B. Content authoring and teleoperation is time-consuming

The prospective teleoperators interviewed by Elbeleidy et al. [72] expressed concerns that learning how to teleoperate

appeared to be time-consuming; the experienced teleoperators we interviewed backed up this fear. Our participants described two key elements as a source of the time-consuming nature of content authoring: learning to author content and having to author every utterance by a robot.

1) Learning to author and teleoperate is time-consuming: Jaclyn (O2) discussed that to benefit from robots, teleoperators " *really need to understand how to use it and that takes an investment.*" Greg (T6) describes how some teleoperators can get better at using these tools over time, but then adds that " *But that definitely takes practice, and that was what I was seeing is a lot of therapists just wouldn't continue with it long enough unless they were super motivated to or if they had a kid really into it to get to that level of mastery.* " Greg (T6) shares that as a teleoperator, " *you have to have your content and your interface pretty well mastered ahead of time*" This aspect of effective teleoperation is so critical that Greg (T6) later adds that " *that's the biggest hurdle in social robotics in a therapy setting.*"

Experienced participants stressed that it takes time to learn how to author content and to navigate authoring interfaces. Alissa (T1) describes how using interfaces " *does require skill on the therapist.*" Caroline (T3) describes how they " *did have to learn how to use the software.*" Specifically, they mention how adding content " *goes beyond think(ing) what type of activities or questions I want to do*" but instead, they must now think about the robot doing this activity. Using a robot introduces a lot more time-consuming aspects. Caroline (T3) goes through several steps of that, saying, " *if I want the robot to ask those specific questions I have to open up a software, I have to type down the questions, I have to save them, to download to the right place, so there are some elements that take more time and energy.* "

Certain experts who were either tech savvy or had more experience, perceived the system to be easy, but only after a substantial amount of time or learning. Isaac (O1) mentions that at one point, "*I just was able to kind of program it on the fly real fast.*" Jaclyn (O2) similarly shares that "*creating content is not hard to do*" but goes on to say, " *, though, I mean, especially if you're used to doing it it's pretty darn easy*" Isaac (O1) also mentions that "*I took some practice because it was a tedious process in the beginning.*"

Regardless of ease or relative increases in speed, experienced teleoperators attested that even once the process of authoring was mastered, authoring remained an onerous burden because of the need for every utterance expressable by the robot to be pre-authored.

2) Every utterance must be authored: For social assistance conducted without a robot, individuals providing assistance can rely on their expertise in the moment and express themselves easily. When using a robot, however, teleoperators need to select each utterance necessary to provide the same assistance. Since teleoperators mostly depend on pre-authored content, they must author every utterance ahead of time. Alissa (T1) describes how drastic that can be, "*I had to type in literally everything. If a kid asked me a question I had to like pre plan what a potential answer could be to that question. for example, I had to type in all the colors (so) I had to type in random colors in case somebody said that they wanted... magenta.* " They add that, " *I had to pre-plan a lot with the robots.*" Blanche (T2) agrees, saying "*I would find that I would write so much because I was wanting to have all bases covered*" Caroline (T3) describes how this extra authoring is specifically in contrast to providing assistance without using a robot, " *if it's just me talking and speaking I have control, about myself. If I have to put things inside of the robot prior. he can only follow whatever I put there.* "

We have established that pre-authoring content is standard practice, yet incredibly onerous. This raises questions as to *why*, teleoperators perform this onerous task. That is, why is this onerous activity the assumed standard practice? To understand why, let us first consider the practices that teleoperators use to try to get around content authoring.

C. Teleoperators share content

In order to avoid authoring new content, teleoperators will often seek to identify when content created for previous sessions – by themselves or others – can be reused. Blanche (T2) , a dance and music therapist, says "*I do have those some base playlist (content) that'll be like this is my ASD kids playlist, you know, this is like, my I'm working on a memory care unit playlist*". Teleoperators typically share content, and emphasized the importance of the shareability of content. Greg (T6) mentioned creating online content or using technology to support teleoperators through an "*online version of this that was easier for other therapists to share each other's content with and share their learnings together and creating a social hub* " Those who worked at an institution that supported social assistance through robots already relied on the ability to privately share content. Isaac (O1) mentioned that "*we had a shared drive where if we had different lessons or switching groups. We could have, kind of like, you know, the giant hive-mind set where we would just pick and choose what we needed and customize that lesson.*" Fiona (T5) had a similar experience, emphasizing the importance of relying on others' expertise for content, "*as much as my brain will wrap around, it is limited by my brain, whereas this has hundreds of lessons inside of it, you know, a lot of brains went into this one.*" These quotes demonstrate that teleoperators are able to create content reuse strategies, create social and organizational structures and arrangements, and leverage existing strategies and structures afforded by their institutions, in order to re-use content whenever possible. However, these practices are not sufficient to alleviate the burden of content authoring, in part due to the need for content to be personalized to client needs.

D. Content must be personalized to client needs

Having content readily available saves teleoperators a lot of time. However, this is often insufficient as a workload mitigation strategy, since they must still tailor content to the specific individual they are assisting. Jaclyn (O2) mentions that "*for every session that we do, each session has something that we might take an old piece of content, but then*

we customize it... each session has its own goals and its own challenges." While content can be reusable, having pre-authored content is not sufficient since teleoperators still need to modify it for their interactions.

Different individuals may have different preferences or needs that content must take into consideration. Isaac (O1) describes this by saying " *if the kid was talking about Legos, then just go and search it and program, a whole bunch of basic knowledge and then the kid would like light up.*" Isaac (O1) describes how the teleoperator must spend some time authoring content to meet the individual's interests but then they can rely on that content in the future. Alissa (T1) agrees about the importance of customizing content, saying "*every child has their own special treatment plan so every child gets something specific to them*". Teleoperators must also customize content by excluding some content. Blanche (T2) mentions that "*one of my kiddos I work with is very averse to loud sounds. So I'm going to make sure that I don't have any songs on his playlist, in particular, that are like overly loud brass and a bunch of crazy drum fills or anything... So yeah it really does depend on the kid*". Blanche (T2) mentions that the importance of authoring and customizing content is a likely factor in the time it takes to prepare, "*the music (content) really has to support the goals of the clients so it is a big deal. I spend, a ridiculous amount of time nerding out about music but I love music, so we good.*"

Additionally, for some applications of social assistance, robots need to maintain engagement over time. Blanche (T2) adds that the "*robot needs to be able to have fun and on-topic conversations with those kids in that moment to keep them engaged.*" One way of making sure children continue to get engaged is by regularly creating or having access to new content. Jaclyn (O2) shares that "*I think, creating new content is key to really having successful sessions.*"

V. Discussion

In the previous section, we leveraged our grounded theory analysis to explain that while (1) pre-authored content is central to teleoperator workflows, (2) learning to author content is time consuming, as is content authoring even once mastered; that (3) teleoperators share content to avoid authoring; but also how (4) this does not meaningfully alleviate authoring load because of the need for personalization to client needs. In this section, we will begin by arguing why, when combined with knowledge of the labor context of teleoperated SAR use, the authoring of content for teleoperated SARs currently constitutes invisible labor. Then, we will discuss technical and sociotechnical recommendations that may help to address this concern.

A. Authoring Dialogue as Invisible Labor

To categorize activities as invisible labor, those activities must be (1) necessary to meet a job's implicit or explicit requirements and (2) overlooked, ignored, or devalued. In this section, we draw connections between our analysis and the labor context in which caregivers operate to argue that content authoring for teleoperated SARs often constitutes invisible labor. We supplement this argument by identifying shared trends in SAR content authoring and other domains commonly categorized as invisible labor.

1) Authoring content is necessary: Our analysis illustrates the necessity of dialogue authoring for teleoperating SARs. As we have shown in Section IV-A, the primary mode of SAR teleoperation requires pre-authored content. Despite teleoperator efforts to avoid the time-consuming process (see Section IV-B) of content authoring through sharing strategies, arrangements, and structures (see Section IV-C), teleoperators must still author content to customize dialogue (see Section IV-D) to meet their clients' needs. SAR teleoperators cannot effectively perform their jobs without spending time authoring content.

2) Authoring content is devalued or overlooked: Work activities can be considered devalued or overlooked if the compensation received for those activities is not commensurate with the effort required for completion. In extreme cases, this manifests as an expectation for uncompensated work. We have established that content authoring is a time-consuming process (Sec. IV-B). We can thus conclude that content authoring is devalued or overlooked if the compensation provided for content authoring does not match this time requirement. In the US, caregivers are often paid hourly salaries where they are compensated only for the time they spend working directly with clients [22]. Caregivers who teleoperate SARs are thus only compensated for their time spent actively teleoperating robots or otherwise working with their clients. This means that necessary content authoring must occur outside of those working hours, and thus remains uncompensated. This work is clearly devalued.

Our analysis suggests that experienced SAR teleoperators have an expectation that, to succeed, they must spend additional uncompensated time not only authoring content, but learning and practicing content authoring as well (see Section IV-B). This implicit expectation for teleoperators to spend time outside of working hours authoring content and learning and practicing content authoring represents clear evidence that these activities are devalued or overlooked.

3) Alignment of SAR content authoring with invisible labor trends: Our research provides compelling evidence that SAR content authoring is both necessary and undervalued, and that it thus constitutes invisible labor. This argument is bolstered by the observable ways that common trends and patterns of invisible labor also occur in dialogue authoring for teleoperated SARs. Invisible labor is often performed by women and minoritized groups [5], [37], [7]. SARs are typically used in education and healthcare settings where the teleoperators of these robots, teachers or nurses, are typically women and minoritized groups. At the same time, SAR developers are roboticists or technologists, who are typically white men, designing tools to be used by caregivers as teleoperators. Novel technology adoption and the resulting restructuring of jobs or introduction of new employment types can obscure the workers who typically perform the job [4]. SARs are a new technology that introduces a labor paradigm in which caregivers, who previously were

empowered to directly deliver services, have to learn to use a tool in order to deliver the same, albeit potentially more effective, services.

B. Recommendations

Recommendation 1: Develop efficient, caregiver-centered authoring interfaces.: Teleoperated SAR developers have a responsibility to build tools that honor the caregivers who use their tools in practice. As we showed in Section IV-B, caregivers spend substantial amounts of time learning to author content and authoring content. To support teleoperators in content authoring, we recommend that developers build authoring tools that minimize the time and effort needed to develop content. This may be facilitated by designing dedicated authoring interfaces tailored to the needs of caregivers, rather than including authoring as a secondary teleoperation interface capability [21].

Recommendation 2: Develop SAR content-sharing platforms.: In Section IV-C, we discussed how teleoperators share content to reduce authoring time. We recommend that SAR developers support easy content sharing within teleoperation interfaces. While content sharing does not completely mitigate the need for content authoring, it is a helpful first step toward decreasing the burden of content authoring.

Recommendation 3: Support remunerated content sharing.: Our analysis suggests that teleoperators typically author content outside of working hours and are therefore not compensated for that time. While, as we will later discuss, our ideal solution to this problem involves systemic change, a solution that can be directly pursued would be to enable SAR content-sharing platforms to support payment for access to content. Directly compensating content authors would (1) increase the visibility of the labor necessary to author content, (2) encourage teleoperators and organizations to support content authoring, and (3) encourage organizations to budget and pay for authored content. As a result, teleoperators may be encouraged to dedicate more time to authoring content, leading to more effective social assistance.

Recommendation 4: Support caregiver compensation through regulation and legislation.: Policymakers may be able to support caregivers at scale through legislation. Several nations have recognized individuals' "right to disconnect" that includes employees having a right to not perform labor outside of working hours such as sending or receiving emails unless explicitly negotiated [73]. This suggests that policymakers can introduce legislation that protects workers from invisible labor by labeling it as work. As robots become more commonplace, we recommend policymakers consider the invisible labor that these robots introduce, such as content authoring for teleoperated SARs, and pass legislation to label time for authoring as work.

C. Limitations & Future Work

The work presented in this paper has three key limitations that may be addressed in future work. First, our participants were all from the US. Future research should explore whether similar invisible labor patterns manifest in other application areas and outside of the US. Second, while in this work we focused on teleoperated SARs, patterns of invisible labor may be present in the development, or deployment of autonomous SARs as well. Future research should similarly investigate the work that stakeholders perform when using autonomous SARs. In general, we encourage researchers to consider the presence of invisible labor in their research areas. Third, our study qualitatively identified the invisible labor performed by teleoperators. Future research should consider measuring the hours of invisible labor performed.

VI. Conclusion

We have argued that content authoring for teleoperated Socially Assisted Robots (SARs) typically constitutes invisible labor, as it is (1) necessary for the use of these robots, yet (2) typically uncompensated. To support this argument, we presented key insights from interviews with caregivers and other experts who use teleoperated SARs in their regular practice, and contextualized these insights within the broader labor context of caregiving in the U.S. Based on our results, we present recommendations for technologists and policymakers to adjust the ways that teleoperated SARs are developed, deployed, and regulated to account for the currently invisible labor needed to author SAR content.

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