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Forms of Care in Human–Nature–Technology Environments

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Abstract

With the ongoing environmental disruptions, designers are increasingly interested in exploring nature–technology entanglements that create sustainable and collaborative futures. Although largely unarticulated, these emerging design inquiries are motivated by care for nature, which indirectly depends on cultural and social human practices. Drawing on a broad set of works on care from feminist theory, science and technology studies, and human–computer interaction, this article introduces a care framework that focuses on revealing tensions in the interrelationship between humans and nonhumans. The framework is used to examine an initial study in which five participants engaged with a speculative design probe, specifically a combination of a device and a plant, envisioning a scenario in which plants generate electricity. We reveal how forms of care manifest differently in a human–plant–technology dynamic and identify tensions, such as plants being considered utilities, proxies, or humans.

Keywords: *Care framework; Plants; More-than-human design; Research through design*

Introduction

Human-centred design has long been a crucial part of human–computer interaction (HCI) design research (Cooley, 1989). However, human-caused environmental crises call for rethinking techno-centric and human-centric design approaches. To tackle this issue, design researchers have moved towards exploring more-than-human interactions (J. Liu et al., 2018; S. Liu et al., 2019). This body of work is continuously growing. Emerging design practices that apply post-anthropocentric theories include multispecies ethnography (Smith et al., 2017), thing-ethnography (Giaccardi et al., 2016), human–computer–biosphere interaction (HCBI) (Kobayashi, 2015), animal–computer interaction (ACI) (Aspling & Juhlin, 2017; Mancini, 2011) and collaborative survival (Liu et al., 2018). We argue that this tendency in design research is, to some extent, implicitly motivated by humans' care for nature and thus indirectly depends on their cultural and social ways of expressing care. It is important for design researchers to understand how care for nonhumans is embedded in social dynamics that inherently include humans, as it can reveal unarticulated tensions within more-than-human relations. We thus ask: what forms of care are enacted by humans in human–plant relations, and how does care shift when digital technology is embedded in the assemblage? We have chosen a broad care lens since care for nonhumans is embedded in social and cultural practices of care for humans, such as those present in previous work in HCI (Dye et al., 2019;

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Friese, 2013; Harmon et al., 2017; Houston & Jackson, 2016; Kocksch et al., 2018; Martin et al., 2015; Puig de la Bellacasa, 2015; Schrader, 2015; Zegura et al., 2018). We believe a broad perspective is needed as the topic is heterogeneous and ambiguous (Puig de la Bellacasa, 2015). We draw on works from feminist theory (Murphy, 2015; Tronto, 1993) to conceptually understand what care is, along with works from HCI and science and technology studies (STS) (Atkinson-Graham et al., 2015; Puig de la Bellacasa, 2017) as they investigate how care occurs within socio-technical and cultural contexts. By reviewing these works, we outline a framework of care composed of six forms of care: practice, relations, noticing, decision making, response-ability, and emotion.

Figure 1. The design probe Juniper, with a kalanchoe plant (left) and in stand-by mode (right)

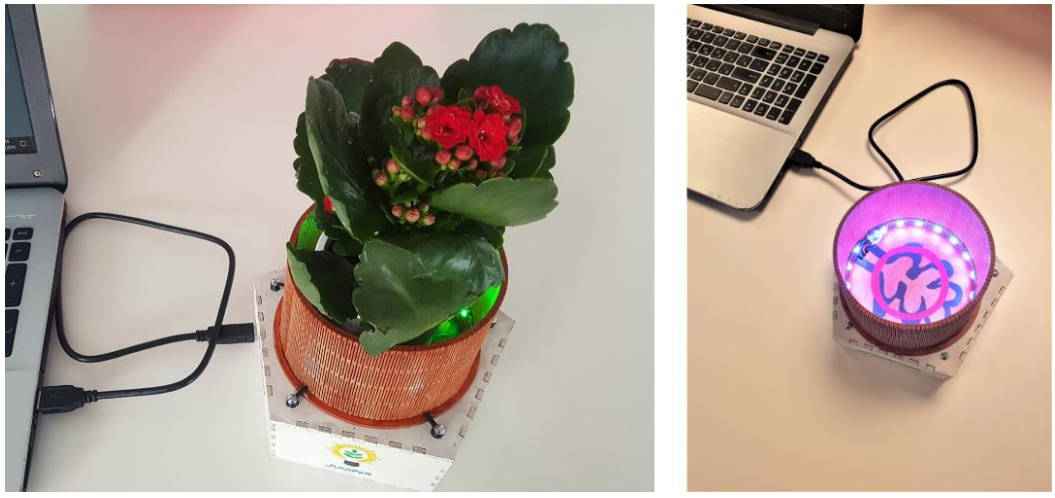

Image: Project archive

We then apply the care framework to unpack the ties between humans, nonhumans, and technology. We chose to focus on a specific group of nonhumans – plants – as they are a vital part of addressing environmental concerns (Kobayashi, 2015), and they have been gaining interest within HCI design research (Angelini et al., 2016; Budinger & Heidmann, 2019; Degraen et al., 2019; Steer et al., 2015). The importance of caring for plant needs and not caring for them as a vehicle for human needs was formulated in ACI (Aspling et al., 2016). We contribute to this literature by using the care framework to uncover this friction in an initial design study of a human-plant-technology interaction. For this study, we invited five participants to articulate their interaction with plants in daily life and their interaction with a speculative design probe (see Figure 1 left). We use the probe method (Gaver et al., 1999; Wallace et al., 2013) to design a speculative computational device combined with a kalanchoe plant that portrays a future in which plants are a source of electricity. This device was created by considering current technological trends into alternative sources, such as plants used to generate electricity, and through speculative thinking of living with plants as an alternative energy resource "to nurture political imagination about what the world could be" (Puig de la Bellacasa, 2009, 307). As a speculative prototype, Juniper does not generate electricity but instead represents this function through LEDs. Without the plant, the probe is in standby mode, with LEDs emitting a blue light that fades in and out (see Figure 1, right). With the plant, the LEDs switch to a green charging pattern, with each LED turning on one by one.

Wallace et al. (2013, 3441) define design probes as "objects that are usually small in scale, whose materiality and form are designed to relate specifically to a particular question and context." The approach follows a combination of Research through Design (RtD) (Zimmerman et al., 2007) and speculative design (Dunne & Raby, 2013). RtD supports a process of exploration and use of methodologies from design practice to investigate ambiguous topics (Zimmerman et al., 2010). Speculative design aims to question current practices by imagining alternative ways of being (Dunne & Raby, 2013), thus inviting us to examine the impact of new technologies from multiple perspectives (Nonhuman Nonsense, 2021). The methodological approach is supported by Puig de la Bellacasa, who argues that "for more caring affective ecologies to become possible, we need speculative thinking" (2017, 219) and a "speculative commitment to neglected things" (2011, 85). As such, there is value in looking at care at a local and personal level to understand and discover new ways of interacting. We can thus critically reflect on which futures certain technologies are pushing us towards (Tonkinwise, 2014) and whether these futures are improving or harming more-than-human worlds. We learn that care presents itself in different forms by applying the care framework, depending on the social context. Additionally, by exploring more-than-human worlds within a human context, we can uncover unseen interactions and how these interactions evolve when technology is embedded. In the following, we outline the six forms of care that comprise our proposed framework: practice, relations, noticing, decision making, response-ability, and emotion.

Establishing a care framework

Research on care is diverse and occurs in many domains. As a step towards unpacking its role in our area of interest, we will summarise these bodies of work as an initial approach. This framework includes research on care for nonhumans and humans. The latter is included as care for nature occurs in a social and cultural setting. By using such a double approach, we hope to articulate what it means to care for nonhumans and how care is enacted in more-than-human settings, thus contributing to a systematic formulation of care to better understand ambiguous interactions. The framework is based on previous framings of care (Puig de la Bellacasa, 2017, 42; Tronto, 1993) with a more explicit, systematic, and consistent scheme to apply in design research contexts. Thus, the care framework comprises the following forms of care: practice, relations, noticing, decision making, response-ability, and emotion. For each form, we look at relevant work that unpacks care between humans and then with nonhumans. Care is imbued with practical experimentation, or *tinkering* (Mol et al., 2010), of adjusting between the subject and the object of care. As Puig de la Bellacasa (2009) explains, ready-made explanations cannot be provided when it comes to care, as it is contextually dependent. Among other conceptualizations of care based on principles for collaboration among species (Modi, 2021), we introduce the following care framework for a more structured approach to understanding how care is generated in more-than-human interactions, all the while sustaining the space for further additions and modifications.

Care as practice

Human care emerges through action. This care giving (Tronto, 1993, 107) is represented through physical labour, initially studied in medical contexts in which a patient is cared for by a clinician or in domestic settings. It is a malleable practice, a set of "efforts that are ongoing, adaptive, tinkering and open ended" (Heuts & Mol, 2013, 130). Practising care requires

continuous work, routine, and adjustment (Bennett et al., 2020, 2), along with innovation and creativity (Wong-Villacres et al., 2017, 13). However, while improving the lives of certain groups, these care practices can become harmful to others (Murphy, 2015, 726).

Examples of direct care practices for nonhumans are acts of maintenance of objects and systems (Houston & Jackson, 2016, 2) or using soil sampling techniques to identify the needs of the soil (Puig de la Bellacasa, 2015, 704). These go along with indirect care practices, such as supporting animal rescue organisations (Harmon et al., 2017, 1639). Nonhumans can also be subjected to care that ultimately becomes harmful, such as weeding a garden or improving the conditions of animals intended for slaughter (Puig de la Bellacasa, 2017, 164).

Care as relations

Care is emerging in and from relations of various kinds. Puig de la Bellacasa (2012, 198) points out that caring is "inevitably to create relation." Between humans, care is built on interdependence (Light & Akama, 2014, 153), on relations that are co-constitutive (Bennett et al., 2020, 5), empathic (Toombs et al., 2017, 46) and socially-situated (Howard & Irani, 2019, 12). We see this in the context of local communities (Sabie & Parikh, 2019, 5; Toombs et al., 2015, 636), where a caring collective ethos is built to deepen the relationship between the community members.

Care as relations between humans and nonhumans emerges depending on the arrangement. Having the human at the centre of the relation implies a different dynamic to a nonhuman in focus. When the nonhuman is the direct focus of care, this creates a relation similar to that found between humans, whereas when human needs are ultimately at the centre, this depicts what we refer to as proxy caring. In this situation, nonhumans are the care receivers, but the subject of care is a human. For instance, proxy care is represented when care for human patients is improved by better preclinical care for laboratory animals (Friese, 2013, 131).

Care as noticing

Noticing is an important aspect of care. It is a required skill of "learning to pay attention" (Haraway, 2008, 19) and caring about (Tronto, 1993, 106). Care as noticing requires "attuned attentiveness and adaptive tinkering" (Mol et al., 2010, 15). This attentiveness exposes aspects of the world that are often invisible or neglected (Puig de la Bellacasa, 2011, 94). For example, it occurs when recognising someone else's given care and reacting accordingly (Tixier et al., 2018, 141). Care as noticing is encouraged by asking power-related questions, such as "who has the power to care, and who or what tends to get designated the proper or improper objects of care" (Martin et al., 2015, 636) and further uncovering power asymmetries (Howard & Irani, 2019, 7).

Care as noticing within nonhuman worlds requires humans to attune to different temporal rhythms, such as the time of the soil that requires pauses for regeneration (Puig de la Bellacasa, 2015, 705). By being attentive to, for example, the surrounding environment (Atkinson-Graham et al., 2015, 742) or the data that a system produces (Kaziunas et al., 2017, 2262), there is a sense of accountability that forms for different ways of living within more-than-human worlds: "care and accountability are inextricably entangled in shifting relationships" (Kocksch et al., 2018, 14).

Care as decision making

Decision making is an aspect of care concerned with "balancing values" (Mol, 2008, 42) and requires sensitivity and consideration. Mol (2008, 7) describes it as a logic of care concerned with facts when making choices. For instance, in a researcher-participant dynamic, the participant can choose whether to prioritize care for the researcher, the research project, or themselves (Toombs et al., 2017, 53).

This form of care becomes a process of negotiation or tinkering between humans and nonhumans (Karusala et al., 2017, 17). For example, with care-oriented data science, the choices involved in gathering the data imbue the data with specific values, which further affect the communities where it is used (Zegura et al., 2018, 8). The negotiation process is ethically and politically charged (Puig de la Bellacasa, 2011, 90), which means the decider has "to trouble oneself" (Schrader, 2015, 666) whether to care for nonhumans and how. When the care subject is not known, which is usually the case with nonhumans, the carer, i.e. the human, can even experience hesitancy and the "ordeal of the undecidable" (683).

Care as response-ability

Care as response-ability (Haraway, 2008, 88) is the ability to respond to being affected and the responsibility of affecting others (Puig de la Bellacasa, 2011, 2017), the care receiving and taking care of described by Tronto (1993, 106). It is a "capacity and willingness to be moved, in both the affective and kinesthetic senses of the verb 'to move'" (Martin et al., 2015, 635). We see this form of care exemplified within practices that are of assistance to others, such as creating a network that can provide Internet access to an entire community (Dye et al., 2019, 2). In research, we can identify the same kind of commitment through examples of humans caring for each other by becoming "agents of change" (Toombs et al., 2017, 47) or being "custodians of care" (Light & Akama, 2014, 160).

Response-ability within more-than-human worlds requires consideration of how to develop an affective response towards nonhumans (Schrader, 2015, 670). It can take the form of moral and material responsibility, from the human side, for repairing and maintaining of devices and systems (Houston & Jackson, 2016, 2; Kocksch et al., 2018, 5). A responsibility for nonhumans can be engaged when connected with care for humans, such as when care for patients is improved by taking responsibility to provide care for the nonhumans that are part of preclinical research (Friese, 2013, 136).

Care as emotion

Care is intrinsically about affectivity. It is being "emotionally attached" (Murphy, 2015, 721) and "troubled, worried, sorrowed, uneasy, and unsettled" (721). Within human relations, this aspect of care, referred to as affective labour and usually performed by women, has been undervalued both in domestic and professional environments (Murphy, 2015, 723). However, such caring emotions are necessary for collective living and take the form of emotional and moral support within communities (Kocksch et al., 2018, 15; Vyas, 2019, 9). For example, this is the case when acknowledging vulnerabilities within power-laden relations (Toombs et al., 2017, 53).

Nonhuman care is also about emotions. For example, the maintenance and repair of nonhumans enact affective relations between the human repairer and the human user (Houston & Jackson, 2016, 2) or using data, which in specific contexts nurtures "empathy and togetherness" (Kaziunas et al., 2017, 2270). Having an emotional response towards the well-being of nonhumans, while not solely sufficient to prompt care, has a role in becoming affected (Schrader, 2015, 683).

Thus, the care framework outlined above reveals how care is a heterogeneous and multifaceted activity. Previous research has focused on human interactions, while the nonhuman, if present, remained in the background or acted as a media or proxy. Care can influence the interaction in many ways, overshadow the nonhuman through technical implementations, and perpetuate a sense of control over the natural world. In the following, we will investigate how this framework performs in an initial study of care responses to a speculative computer-mediated plant probe.

Probe design and initial study

As a means to evoke care for nonhumans, we conducted an initial study using RtD and speculative design. Speculative design is a method where functionality is imagined rather than implemented, used to provoke discussions and expose issues around emerging technologies in the context of an alternative present or a future scenario (Dunne & Raby, 2013). RtD is a widely adopted approach within HCI design research that embraces the practice-based nature of design investigation, where the knowledge is articulated in and through ongoing design work. By adopting RtD, our approach is twofold (Giaccardi, 2019). First is a practice-based design exercise resulting in a speculative probe based on current technological trends in biotech. Second, there is a focus on care, which opens up the design space within human-nonhuman relations. Given the intricacy of the topic, following a speculative and qualitative approach allows us to uncover the hidden dynamics within human-nonhuman interactions and how technology transforms them without having this context as a set reality. We can thus learn how care is enabled as it unfolds in the study. In the following, we describe the probe and the setup of the user study.

Probe design

Juniper represents a potential human–plant–technology relationship, where the human relies on the plant as an energy source, and the technology is the mediator that sustains the dependence. The increasing interest in introducing technology to the biotic inspired us, such as the system developed by Plant-e (Living Light, 2020) that uses plants to generate electricity. Juniper is a speculative prototype of this technology, as our probe does not generate electricity but instead represents this function through LEDs. Our speculative probe consists of a wooden box with an Arduino unit[3] and a kalanchoe plant, a flowering succulent with low watering needs. We chose this particular plant in order for the participants to focus on aspects of care different from the ones they usually express with plants, such as watering. The impression of an energy source in this design probe is indicated by the LED strip that displays either a "standby" or "charging" sequence. Without the plant, the probe is in standby mode, and LEDs emit a blue light that fades in and out (see Figure 1, right). When the plant is positioned in the wooden enclosure, the LEDs switch to a green charging pattern, with each

[3] Arduino is an open-source electronics prototyping platform used to create tangible interactive devices.

LED turning on one by one (see Figure 1, left). We seek to understand how this technology affects human–nonhuman relations with this probe. Furthermore, we reveal which frictions are perpetuated or created in these interactions through the care framework.

Initial study

This subjective study was carried out with five participants, three women and two men, who we recruited by word-of-mouth. The participants were students between the ages of 21 and 28 originating from Spain, the USA, Sweden, Poland, and Peru. They will be referred to by their assigned pseudonyms: Ivy, April, Olivia, Jade, and Jordan. While two of the five participants worked in the same interaction design lab where we created the probe, the study's primary concern relates to the participants' experience using the probe and the reflections expressed afterwards. Juniper was fostered independently by each participant between one and four days. We informed each participant of the probe's functioning and their position as speculators in what it would mean if the plant was a source of electricity. They were requested to have the probe always connected to their personal computer.

Before handing out the probe, we conducted semi-structured interviews with each participant to reflect upon their current relationship with plants and how care towards them was manifested. These questions explored the overall position of caring for plants. We conducted a follow-up semi-structured interview at the end of the study to assess their experience fostering the probe and whether new forms of care emerged. The pre-probe interviews shaped the questions, building on the experiences as the participants recounted them. They were also encouraged to report their accounts by posting photos on a shared Instagram account dedicated to this study. We referred to the visuals during the post-probe interview to encourage the participants to recount their experiences in detail. We transcribed the interviews and the data was coded deductively in collaborative sessions that included both authors. We used the six forms of care previously formulated as our theoretical framework, which we assigned to the gathered data. We used a deductive content analysis approach as it allowed for systematic analysis and identifying structures, in this case, the various forms of care, in different types of content (Krippendorff, 2018). The coding was not always straightforward. This was due to overlaps between the forms of care and the interpretative nature of the coding. Thus, we revisited the gathered data from the interviews in at least two rounds before assigning a primary code to the transcript.

Figure 2. Instagram posts with captions from April (a) and Olivia (b-c)

Image: Project archive

Analysis

We analysed the participants' accounts given the care framework. For each form of care (practice, relations, noticing, decision making, response-ability, and emotion), we first describe their care for plants in general and second their care for Juniper.

Practices of care

As described in the framework, care as practice emerges through actions. Taking care of plants is similarly a hands-on activity, a "material vital doing" (Puig de la Bellacasa, 2017, 42). In the pre-probe interview, the participants mentioned various plant maintenance practices such as adding nutrition sticks, replanting to a bigger pot, buying nicer-looking pots, changing to fresh soil, watering the plant and placing it in the sun. Notably, the participants' usual care practices included looking at the plant and touching the soil to feel the humidity.

When they engaged with Juniper, the following practices were added to the list: shifting location, transportation, and supplying power. First, we observed the adaptive quality of care as practice through the need to change location depending on the human's or the plant's needs. Participant Olivia, who looked into how to care for a kalanchoe plant, made sure that it got enough sun and water. Second, it was also necessary to transport the probe, as the requirement was to have it with them every time they used their computer. Olivia, Jordan, and Ivy were commuting to and from work with the probe. Olivia mentioned her tinkering with how to place it, adjusting accordingly: "I took the bag and carried it on my shoulder, but not as a usual bag that you whip at the back of your body. I kind of had it more in the front and occasionally cradled it and held it upright because it has this flat surface." Third, some of the Instagram posts reflected the action of supplying power. We see this when April presented the power supply practice from the plant's perspective, stating that it is "giving energy for a master thesis student" (see Figure 2 (a)). The care work was a form of donation in order for her to complete her work. Similarly, Olivia follows this anthropomorphic, other-than-human viewpoint, speculating how the plant could practice care work by powering an electric bike (see Figure 2 (b)). This suggests that by adding an extra property to a plant, namely the capacity to supply electricity, there is a more direct physical engagement with the plant.

Caring relations

Human–plant care relations can be of various kinds, for instance, customary, symbolic, and proximal. Customary relations draw on routine practices, such as between family members, that have been practised for a long time. These are socially-situated relations that sometimes extend over generations. We see socially-situated relations when April mentioned her parents passing on their care for plants: "I am used to it because my parents have always had plants at their house. [...] So for me, it is something natural." The plant can act as a symbolic mediation of past or present human relations. This is what we termed proxy caring in the framework when the plant receives care on behalf of a human. Jade, Ivy, and Jordan describe this type of relational care through accounts of how they became interested in plants because of a loved one. Jordan's case represents the love between him and his partner: "It feels good taking care of it since I know other people care about it. So, in that regard, by taking care of it, I am taking care of the other people." Finally, relationships also depend on the proximity, or distance, to the object of care. For example, care for house plants differs from care for plants in a distant forest. Olivia states that she has a relationship with plants, although just those indoors: "Sometimes I am more curious about plants that are wild, like trees [...] But I

mostly have a relationship with my plants indoors and also the plants that I grow for my own food." Here, the distance fosters an intellectual focus, whereas the co-presence or close proximity grows through caring.

New forms of relations emerge with the care of Juniper, specifically direct social sharing, direct nonhuman relations, and co-dependence. Direct social sharing is represented by how April shared the probe with her partner. She speculates how such a system could be introduced in more public spaces, such as libraries or group rooms: "You could see maybe a plant in the middle that gives electricity for everyone that is working there [...] it could be something social that connects everyone together." There is also a switch from personal or dyadic to collective experiences, including nonhumans, such as when Juniper became part of April's "plant family." It can also be seen in Olivia, Jordan, and Ivy's posts that position the plant as "having friends," collaborating or spending time with humans (see Figure 2 (c) & Figure 3 (a–b)). Relations are also co-dependent, creating a form of interdependence when both sides need each other to fulfil their needs, or as Ivy says: "you need it, it needs you."

Figure 3. Instagram captions by Jordan (a) and Ivy (b)

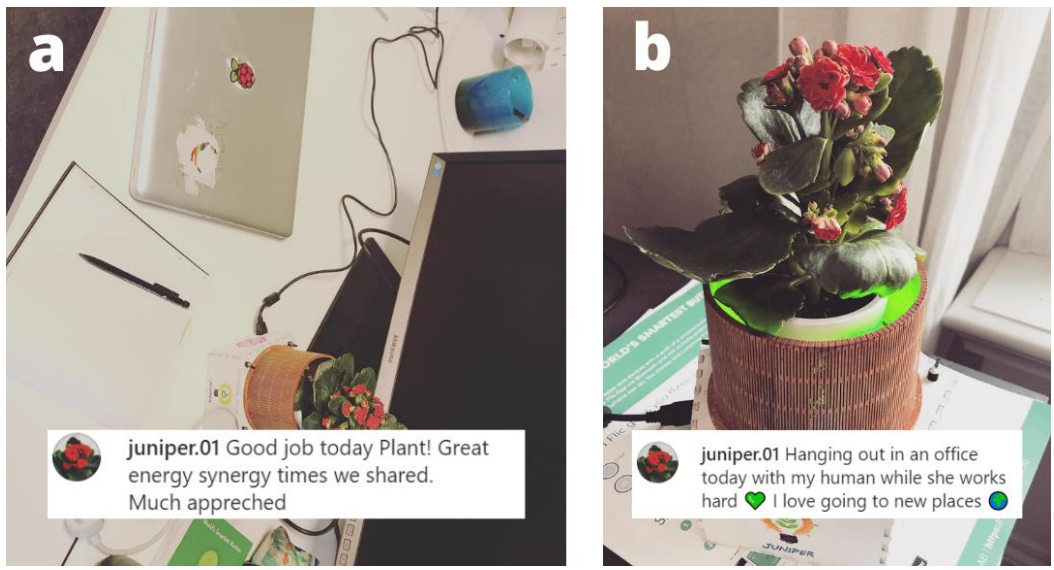

Image: Project archive

Careful noticing

Participants in the pre-probe interview stated the noticing aspect of care in that they would "check on" plants and "watch them grow." They observed dropped or new leaves that sprouted as signs of the plant's health. They touched the soil to notice its moisture. Noticing also leads to speculations. According to Jordan, attuning to the rhythm of plants made it possible to visualise the future: "They give me clues about what is going on in the world, short-term future, nearby, and what people and things are up." Thus, noticing seems to be a step toward practice. It prompted an attuned attentiveness to the ordinary doings, the uneventful ways of caring for plants, and what plants can show us about the future.

Juniper added new dimensions into noticing, for instance, the light from the LEDs. For April, it was a sign of the plant's "breath": "With the lights [...] it showed you more that this is

something living and that the lights are in some way a sign that it is breathing, that it's there. [...] It feels more of a living thing than just beautiful on a stand." This design aspect helped April bridge the gap between human understanding of nonhumans and made her acknowledge Juniper as a living being that can receive and respond to care.

Watchful decision making

The decision-making aspect of care was defined by participants making choices on whether to care that were either voluntary or involuntary, active or inactive, or instrumental. In Jordan's case, caring for his plant is intricately linked to a voluntary decision: "I care for it because it feels like it is a special plant. [...] If I let it die, it would be symbolically bad, and I wouldn't feel good ruining it. [...] It was not random. It was meticulously chosen." When Olivia received a plant as a gift, the choice was rather involuntary: "I started having plants because I received one as a gift, and it was something nice to receive. But then I didn't choose that plant, so I felt like I want to choose the plant carefully." Jordan expresses how decisions on plants can be either active or passive. The caregiving is active with his plants and passive with the plants outdoors: "I recently got a plant that I care for explicitly at home. That relationship is different from other plants since I don't explicitly care for them or build them, so to speak. Like I try not to hurt them by not making their environment bad." Jordan's decision not to actively engage with plants by avoiding harming them is what Puig de la Bellacasa (2017) calls conscious neglect. Decisions can also be instrumental when they primarily focus on the need of the human. For example, Olivia grows herbs in a hydroponic system for cooking and Ivy grows Aloe Vera for use in skincare. Thus, care can stem from an active and free individual choice of whom to care for and how we should engage, forming reciprocal and considerate relations of care. At other times, it is a necessary decision, such as receiving an object of care. We can actively engage in care while consciously neglecting others and caring for those most beneficial. Thus, how we have decided to care is part of caring.

New instrumental acts of care emerged with the added feature of energy supply. Participant Jade reflected on the energy aspect of the probe by speculating on how the probe could be used in remote areas when camping or being outdoors for extended periods. Additionally, a monetary aspect would have encouraged Jade to be more engaged with the caregiving, given that such an artefact would be a cheaper electricity source for him. Thus, active engagement stems from the potential benefit gained from caring.

Response-able care

In the pre-probe interview, we have seen the responsibility aspect of care develop when April receives plants as gifts: "When someone gives me a plant, even if it is someone that we don't have that big of a relationship, [...] then I kill this flower, then I feel bad. [...] It feels like I want to take care of it because that is kind of a symbol." Caring has a moral implication that the caretaker can experience as a commitment, which differs from the experience of hedonic pleasure. For Jordan, this responsibility is heightened because of the symbolism behind the plant he cares for. He protects it because it has meaning for him and his loved ones. When a plant is a proxy for a loved one, the sense of duty is more significant, as its symbolism fuels the care.

While fostering the probe, participants felt responsible for it and the study. They felt the need to ensure they maintained the probe, as another participant in the study would later use it. They wanted to provide sufficient nurturing for the plant to keep it alive and actively engaged

with Juniper and in the interview sessions. Ivy describes how Juniper gave her a "personal feeling to it, made it more special in a sense." This account points back to the work of Toombs et al. (2017) on researcher–participant relations and how care is intrinsically entangled in them. Care here was exhibited through the sense of responsibility rather than the ability to respond.

Emotional care

Participants attributed emotions of various kinds, such as aesthetic, empathic, and worrying. A strong reason for participants' care for plants, in general, was to have aesthetic experiences. They mentioned how plants, while being beautiful, also create a cosy atmosphere. They bring aliveness and a natural feeling to an indoor space. As Olivia states, it is an aesthetic visual experience. For April, the act of maintenance brought out empathic emotions. When she sees the plants grow, it makes her think they are "happy," which in return makes her happy. She thinks of her plants as her "babies" and that she takes care of them "as if they are human." Olivia gets concerned if she sees signs of worry in the plants and wonders what could be done to improve their overall livelihood.

With Juniper, feelings of concern and enjoyment increased. The participants who commuted with the probe (Olivia, Ivy, and Jordan) were more considerate of the plant's well-being. Olivia mentioned how she made sure to bike more carefully, while Ivy felt distressed with the need to transport the probe: "It was slightly annoying to carry her from one place to another because I was afraid of damaging her." Fostering the probe created a different experience than the usual plant interaction for the participants. Thus, we see more acknowledgements of vulnerabilities within the human-nonhuman relation by introducing new functionalities or requirements to a plant. However, it also generates new ways of being with plant others and aids in speculating what other care worlds might be.

Discussion

Increased engagement with nonhumans in various forms of human–computer interaction will require increased human care and a better understanding of nonhuman needs. Our study set out to answer the question of what forms of care are enacted by humans in human–plant relations, and how does care shift when digital technology is embedded in the assemblage? It was thus intended as a stepping stone to the analysis of how human engagement in care affects the lives of nonhumans. Given the study at hand, we will discuss how the care framework revealed certain aspects of humans interacting with plants within cultural and socio-technical contexts and how care manifested differently towards plants in general life and the plant in a technology context.

Human forms of care for nonhumans

Altogether, we see that the notions of care formulated in the framework were present in our more-than-human study. Our study recognised six forms of human care occurring when engaging with nonhumans (practice, relations, noticing, decision making, response-ability, and emotion). We have described the care practices as the maintenance that goes into nurturing plants and the adjustments needed when transporting the probe. The socially-situated care relations were derived from a custom or proxy, with physical limitations and some plants becoming embodiments of human relations. The noticing aspect of care manifested through attuned attentiveness, primarily by visual perceptions of the plant's well-being or an attuning to the rhythms of plants that created opportunities to reflect on the future. With care as

decision making, we observed how it stemmed from personal choice forming a reciprocal and considerate relationship, such as choosing the object of care, or through obligation, such as receiving a plant as a gift. Additionally, we can consciously choose to neglect or practice care towards plants that are useful to us. With care as response-ability, we observed the quality of being responsible and committed to maintaining a nonhuman through and from care. While with care as emotion, it was reflected through various emotions, acknowledging the vulnerabilities of nonhumans, nurturing empathy through the practice of maintenance, and experiencing aesthetic enjoyment.

However, new understandings of care were conceptualised, such as the various forms of care as relations, e.g., customary, symbolic, and proximal, and the aspect of conscious neglect in care as decision making. Thus, rather than setting the care framework as normative, we created it as more of a blueprint in which there is space for further additions and modifications.

Expressions of care towards plants and the probe

Participants commented on their previous interaction with plants and their interaction with the plant–technology prototype. Comparing these accounts makes it possible to identify similarities and differences. First, we identified several similarities between how participants described their care for plants and their care for Juniper. There were no differences between a plant and Juniper regarding watering or ensuring sunlight. The type of symbolic anthropomorphic relation discussed by the interviewees also occurred in both cases. For example, Jordan described how a plant could be a proxy for kin while caring for Juniper extended to care for the research per se. This refers to how researchers and participants switched between caring for themselves, caring for the research project, or caring for research participants (Toombs et al., 2017).

Second, we identified cases where participants' forms of care differed between plants and Juniper. Transporting Juniper to and from work added a new care practice referring to the adjustments needed to practice care. However, the energy aspect brought forward new forms of caring relations, such as April suggesting having it in a library and sharing the power between students. The new utility seems to divert participants' care focus away from the plant. According to April's accounts, the lights became a representation of the plant as a living being. While an interesting aspect of care as noticing, we cannot say that this new understanding changed her ways of caring. Generally, we learn that the technical system overshadows the plant, implying that instead of paying attention to the plant, the user attunes to the added technology. Even as a speculative artefact, Juniper shows how easily the main focus can switch from the plant to the technology and how the technology becomes a potent agent in the more-than-human power relation. Thus, researchers need to consider how conditions change for better or worse by introducing technology to the biotic.

Care for nonhumans in a human context

The care framework includes previous findings on forms of care for both humans and nonhumans. We suggest that forms of care between humans are relevant when caring for nonhumans, as caring for nonhumans occurs in a social context. In the following, we discuss this suggestion and how it revealed social and cultural aspects of care when engaging with plants. By applying the framework, we identified three ways the social context became relevant: the plant as human utility, human proxy, and human per se.

Plants as human utility: articulating care as decision making revealed how participants came to see both plants and Juniper as a utility. Our design of Juniper's functionality as an energy producer seemed to have directed participants' attention to energy production in general.

Plants as human proxy: articulating care as relations and response-ability revealed how participants came to see plants as human proxy. Care occurred when participants seemingly treated the nonhuman as a human or as a symbol of a human. While care usually flows between a caregiver and a care receiver, we noticed that the plant, while benefitting from various forms of care, is only a proxy for a human. That is to say, while the plant does receive care, such as watering, the caring intention is directed towards someone else. It is a form of symbolic anthropomorphism (Kant, 1950, 105-106) where the plant stands in for someone else.

Plants as human: the application of care as relations and emotion brought forward how the participants saw the plant as having human characteristics. Examples include April's descriptions of her plants as "babies" or when Juniper became part of April's "family" and Olivia's account of Juniper as having "friends." Whether the sentience attributed to plants is real or imagined, it seems to encourage caring practices. Regarding plants as humans, this could also be seen as a form of empathy, an attempt to understand these plant others, or a projection of one's beliefs and values, clearly seen in the Instagram posts where plants were represented as thinking and speaking through human language.

As discussed above, the forms of care applied to participants' accounts revealed who was actually being cared for. As technology is increasingly introduced to the biotic, we identified a need to become aware of how this affects human-nonhuman relations. We thus aim to avoid designed contexts in which care is leaning towards the needs of one part more than another, for instance, forms of care that harm or instrumentalise, rather than improve, the life of nonhumans. As a first step toward avoiding these frictions, we suggest the need to account for how humans care. Furthermore, taking a speculative approach to this intricate topic allowed us to identify the three aforementioned more-than-human frictional dynamics without having the context as a set reality. We were able to observe how care for the plant and probe was enabled throughout the study with the help of participants' engagement in speculation. In addition to being a design probe, Juniper was grounding the speculation into a device that the participants were able to touch, see, and engage with, co-creating with the probe the possible future of the interaction. In the following, we permit ourselves to discuss how embedding care in a "human" and social context might influence plants and, more generally, nonhumans.

When formulating care as decision making, we saw a certain tension between seeing plants as objects and plants as subjects. Following Robin Wall Kimmerer's (2013) ideas about gift-giving, Juniper's power supply can be interpreted as either a commodity from an object or a gift from a nonhuman subject. While gifts build community and interdependence, commodities are signs of individualism and loss of power, as there is no inherent obligation to care for a commodified object (Kimmerer, 2013). Thus, as a commodity, the plant is merely a means for obtaining energy. In contrast, if we see the energy provided as a gift, Juniper becomes a subject, namely the gift giver, which creates an "ongoing relationship," a bond where gifts have value beyond the monetary economy (Kimmerer, 2013). We see this difference between participants Jade and April. In Jade's descriptions, Juniper is a cheaper source of electricity, a means of obtaining what is needed for his well-being. With April,

however, Juniper is considered a living being brought into her "plant family" and cared for the same way, with the added bonus of being an energy supply. Kimmerer's perspective is relevant in social settings as it is considered harmful to treat people as objects rather than subjects and use them as a means to an end, especially when they depend on a caregiver. Similarly, if we do not see the plant as another self with its own value, there is a higher risk that by making it part of a technical system, the technology will overshadow the caring of the plant in itself.

When the plant is considered a human, it is not understood in its own terms either. However, we cannot directly point out whether such anthropomorphism is harmful to a plant. In order to understand the consequences of such forms of care, we need either an empirical evaluation of the plant's condition or a theory on plants from biology, for instance (Pollan, 2001), or bodies of work that build on critical plant studies (Charlston & Charlston, 2021). Aspling et al. (2016) encourage a design direction that aims to increase plant dissemination by improving hedonic human-plant engagement rather than supporting abstract contemplation. Such understanding is aligned with seeing plants as utility or symbol for a human, provided that they contribute to disseminating the species. Equally, a misconception of the nonhuman as a human could be beneficial for their species in terms of the care they are given.

Conclusion

This article presented a care framework based on investigations in feminist studies, STS, and HCI. It is composed of six forms of care: practice, relations, noticing, decision making, response-ability, and emotion, which we then applied to a design study of a human–plant–technology interaction. The study investigated what forms of care are enacted by humans in human–plant relations, and how does care shift when digital technology is embedded in the assemblage? Through the different articulations of care and a speculative approach, we were able to reveal three hidden dynamics between humans and nonhumans and how these progressed once technology became part of it. The first dynamic of viewing a plant as human utility was reinforced within IT-supported interactions when plants were seen as a commodity from the outset as participants focused on the energy aspect of the probe. With the second dynamic of plants as human proxy, we observed how a symbolic anthropomorphism formed, the plant proxying the intended subject of care. Lastly, the third dynamic considered a plant as human, which would need further evaluations to identify whether caring within this type of more-than-human relation is harmful or beneficial for the nonhuman. We thus took a speculative approach to investigate this human-plant-technology interaction that could be part of a possible future. The speculative thinking was grounded by a material device and enabled an embodied experience for the participants. Given the difficulty of understanding other-than-human needs, we as humans require ways to critically unpack actions that are considered caring and have good intent. Humans are innately part of sociotechnical and cultural settings that include nonhumans. Whether in the design, use, or evaluation of a technology, we cannot disregard humans' involvement, even if the intent is to design for nonhumans or to understand nonhuman needs. Embedded in a culture of care, we argue for the need to unpack how humans care for nonhumans and what forms of care are prioritised. Our proposed care framework does not offer a course of action. Instead, it stands as a first measure to build a critical and speculative perspective of what other, more sustainable and symbiotic worlds could be. Further investigations could include outlining how the forms of care build on each other and how they present in other sociotechnical interactions with plants or other

nonhumans. Our choice of a speculative design probe has an inherent utilitarian perspective which revealed itself through the framework. Thus, the exploration through care would reveal new implications by taking a different design intent, such as hedonic, which is more aligned with a human relation to plants.

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