

# Leaky Cups: Tinkering with Hydrofeminist Temporalities for HCI

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## Abstract

This paper offers new perspectives for More-Than-Human (MTH) design and Human-Computer-Interaction (HCI) by rethinking technoscientific logics of temporality. To do this, we draw on alternative logics such as Hydrofeminism, interlocutor and autobiographical accounts, and Leaky Cups—a set of willfully dysfunctional data-enabled artefacts that leak in response to local water data. In doing so, it repositions more-than-human agency not as a passive conduit merely mediating human experiences but as a force capable of creating change and ethics through non-progressivist care labor. By engaging with these ideas, this work critiques and disrupts normative assumptions about progress, openness, fluidity, and objectivity in MTH research and design, and presents productive tensions that challenge dominant temporal frameworks.

## CCS Concepts

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **HCI theory, concepts and models**;

## Keywords

Temporality, More-Than-Human Design, Posthuman, Care Ethics, Hydrofeminism, Temporality of Care

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## 1 Introduction

More-than-human (MTH) approaches to Human-Computer-Interaction (HCI) have proliferated in recent years [22, 26, 40, 46, 80]) to suggest new ways of living and designing with more-than-humans for more sustainable and preferable futures and presents. With the stakes of life ‘as well as possible’ [25] in mind for current and future generations, HCI is increasingly interested in MTH perspectives on temporality [10, 14, 15, 37, 67] and how ways of conceiving time affects design sensibilities. This interest is motivated by modernities’ paradigmatic association with ‘the future’ as progress and technoscientific advancement. Within this context there is an increased sensitivity to how the dominant temporal logic of technoscientific futurity effects how MTH inquiry is conceived, interpreted, and presented back to our community. Responding to this need for a paradigmatic shift in design thinking which is aware of and challenges the things, histories, and futures being produced from anthropocentric and objectifying positions we crafted a set of Leaky Cups (Figure 1 and Figure 2). The Leaky Cups are research products [63] (high fidelity apparatuses of inquiry) grounded in the methodological tradition of Research through Design (RtD).

This paper draws on two conceptual disciplines in its understanding of the Leaky Cups project. The first is feminist ethics of care. In this case, care is not the everyday sense akin to kindness but, follows Fisher and Tronto’s seminal definition of care as, “everything we do to maintain, continue, and repair our ‘world’ so we can live in at as well as possible’ [26]. As an ethic based on life sustaining webs of care labor, this theory has been employed by HCI researchers (e.g., [7, 29, 41, 42, 87]) in myriad ways to understand our world as fundamentally in relation with more-than-humans. Inspired by Mol, et al.’s emphasis on tinkering or “attentive experimentation” [52], as a primary mode of care ethics, the Leaky Cups highlight processes of ethical tinkering which challenge dominant ideas on how change occurs, who has the agency to make change, and how the ability to affect vs be affected by progress is a fundamental byproduct of our anthropocentric understanding of temporality. Tinkering, as many designers would agree, is rarely a linear process where the endpoint is focused and fixed thus highlighting how the ethics of MTH care are similarly non-linear because it unties ethics



**Figure 1: The Leaky Cups use real-time and historic data on an interlocutor’s local watershed to trigger vibrations which create a wave pattern (center) breaking surface tension and causing a leak (right).**

from a priori outcome or process. In this way, ethical phenomena can’t sidestep questions to do with which good, for whom, when, and at what cost to focus on utilitarian questions of how to achieve or stabilize a universally good, right, and moral outcome (even one such as sustainability). This is because what is good, right, and moral is contingent upon particular relations, histories, and temporalities.

In particular, this paper focuses on what Puig de la Bellacasa calls “the recalcitrance of the temporality of care to productionist rhythms” [21]. We look to how care is ethically negotiated as its priorities intersect with anthropocentric and progress-driven notions of time. Design is said to be progressional when it moves towards eventual production, further realization of itself, or its preferred future—following the “arrow-like progression of design” [20]. We argue (more fully in 6.2) that even alternative designs who embrace openness and ambiguity often follow this arrowlike progression when the anthropocentric temporalities embedded within those design positions are unexamined. As such, this work tries to examine such positions and their related outcomes by shifting attention from underlying questions in MTH HCI such as ‘how can we spend more time?’ or ‘attune to MTH time?’ to ‘what happens to our understandings of care, its labors, and ethics when we are not guided by linear progressive temporal frameworks?’ And, what implications does that hold for research and design?

Secondly this paper turns to Hydrofeminism. First proposed by Astrida Neimanis. Hydrofeminism integrates ideas of embodiment and ecofeminism to explore ethical obligations between bodies of water. Hydrofeminism radically reframes embodiment as common rather than individual in part because the water so crucial and intimate to a human body doesn’t just belong to it. Rather, it is part of a perpetual exchange with the hydrosphere (the 4-billion-year-old collective body of water on Earth) through our breathing, drinking, and leaking [57]. For Neimanis, “to begin one’s ethics and politics from the realisation that we are mostly made of water means refusing a separation between nature and culture, between an environment “out there” and a human subject “in here” [11]. Despite HCI’s interest in human fluidity as MTH (e.g., [79]), its contemporary investigation of embodiment more broadly (e.g., [4, 60, 81]), or its interest in water bodies as sites of MTH inquiry (e.g., [34])

there are few engagement with Hydrofeminism (i.e., [49]). Yet the synergies with MTH HCI are clear as they both aim to trouble humanist understandings of bodies as discrete, coherent, individual, and autonomous [58]. Despite the advances afforded by these prior works, we see unrealized potential in using Hydrofeminism as a lens to trouble humanist understandings of temporality as discrete, coherent, individual, and autonomous. We argue (in 6.4) that Hydrofeminism’s understanding of interrelation phenomena beyond the solid/fluid binary (to consider viscous and porous states in-between) allows us to better account for the ways in which MTH relations do more than merely mediate interrelation to willfully enable and resist change and progress.

This paper brings these concepts together to expose frictions between technoscientific logics of temporality and interlocutor’s experiences navigating care ethics between their bodies, their loved ones’ bodies, and the waterbody that is a leaking cup. We argue that these situated divergent expectations and expressions of care point towards a different kind of temporality that tell us something about how temporality is imagined and understood. In short, we see this project as responding to Rapp et al.’s call for future research on temporality to “*also ask ethical questions*” using “in-depth qualitative research, using e.g., diary studies and autoethnography. . . [to] reveal hidden assumptions that shape current temporal orders” (emphasis original) [1].

To that aim, this project blends research artifacts, interlocutor and autobiographical experiences, and theoretical lenses. While we understand this makes for an ambitious project, we are committed to exploring how experiences with watery bodies and data are themselves relationally bound together with our tools and theories of inquiry. The Leaky Cups are what Reed et al. would call data-enabled artefacts operating as ‘Baradian apparatuses’ because “they do not exist independently of the phenomenon they seek to measure but rather collect and co-produce observations from within their entangled state: the phenomenon and the apparatus co-constitute one another” [75]. Within this same Baradian tradition we take, what Barad would call, an ‘ethico-onto-epistemological’ [6] approach to researching MTH temporality. Ethico-onto-epistemology values the messy inseparability of ethics, ontology, and epistemology because when viewing ethics as a property of co-existence (rather

than a product of social conditions) one is automatically responsible to others (human or otherwise) through the numerous ontological entanglements that materiality entails.

## 2 Leaky Cups

One trend in HCI is to use environmental data in persuasive technologies to shape behavior in more sustainable ways (e.g., [2, 24]). However, an altogether different kind of response based on an altogether different kind of temporal (and as we will further argue tempo-ontological) orientation is also needed.

Rather than inserting themselves into a unilinear causality chain with the aim of disrupting predictably unsustainable events, the Leaky Cups are an environmental data driven technology and research product [63] concerned with ethical experimentation without advancing or even exploring preset ethical outcomes. The Leaky Cups utilize environmental data not as a technological solution to environmental problems but to consider how relationships between ecologies of human and more-than-human matter require ethical coordination and discoordination.

### 2.1 How They Work

These cups leak, but not all the time. Despite two pinhead-sized holes in the cups' sidewalls, the cups do not leak until data is received. The holes are designed so that the water's surface tension prevents leaking. When data comes in however, the cups vibrate, breaking surface tension and causing a leak. The length of the vibration, and therefore possible mess, corresponds to the flow rate of each interlocutor's nearest stream within their watershed. A watershed is an area of land that channels rainfall, snowmelt, and runoff into a common body of water. Water from hundreds, or in some cases thousands, of creeks, streams, roads and drainages flow from higher ground and eventually join a larger waterbody. Each Leaky Cup was paired to the nearest creek or stream (Figure 7) in the interlocutor's watershed. This meant that each time an interlocutor filled their Leaky Cup they were interacting with the watershed. In fact, many actions interlocutors might make can affect the watershed such as drawing a bath, using the toilet, watering plants, making tea, the shape of their roof, etc.

Using Wi-fi, cups received data on the flow rate or "discharge" from the nearest real-time surface-water monitoring station to each interlocutor's home via the United States Geological Survey's (USGS) national real-time water information database. Each cup was set to receive data once every hour during the daytime (individually defined with most choosing from about 8am-8pm). The USGS database includes real-time measurements on water temperature, air temperature, gage height, and flow rate. Flow rate measures the volume of water crossing any section of a stream for any set amount of time and is expressed in cubic feet per second. We chose to use flow rate because factors like precipitation, groundwater supply, and vegetation can all have significant effects. As can dam installation, water diversion, urban development, groundwater withdrawals, or other human-centered land-use practices.

When flow rate is high (meaning a lot of volume is passing through the station's selected area) the vibration, wave pattern, and leaking (if the cup is full) will be more evident. If the flow rate is low the vibration will be shorter and may not even last long enough

to cause a leak. The USGS has been collecting these water data for 30+ years and have made these historic data available online as part of the Open Water Data Initiative. We chose to have the Leaky Cups respond to both real-time and historic flow rates. When a Leaky Cup receives the latest flow rate data it will vibrate and leak in relation to that value (via vibration duration); in addition, that vibration will be followed by a second vibration corresponding to the flow rate for the same time, date, and location 30 years prior. Simply stated, the first vibration and potential leak is the real-time value, and the second is the historic value. This allowed interlocutors to experience data separated by decades as one side-by-side embodied experience. These data values, timestamps, and err codes were available to Key (the FA) via Adafruit IO's web-based dashboard for troubleshooting and observation.

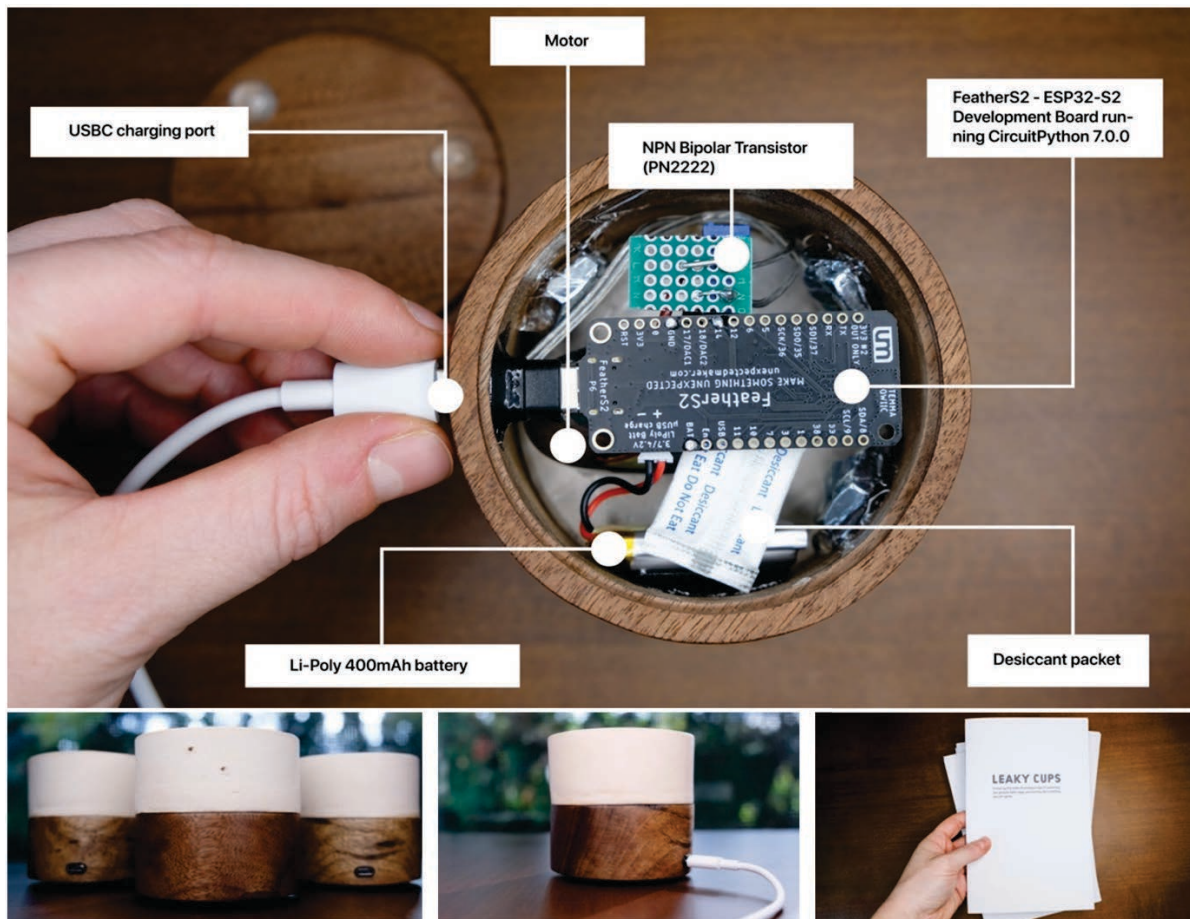
Working with collaborators Stevie (form builder/architect) and Aaron (artist/developer), the cups are hand-built terracotta ceramic attached to a walnut base which housed the hardware (Figure 2). The cups are unglazed except for the bottom underside to protect the electrical components from humidity emanating from the (otherwise intentionally) porous terracotta. The drinking portion was treated with bees wax which was baked into the terracotta to provide a partial water barrier while retaining a porosity far beyond a typical cup.

Lastly, we recognize the potential incongruity of using USGS water data in a project which promotes epistemologies outside of dominant Euro-Western models. As we hope to demonstrate (and address explicitly in Section 6 and Section 7) this paper contributes a reframing of several of HCI's sensibilities regarding how MTH design and research is conceived rather than how it is conducted. This is because we see the stickiness not so much with methods for data collection or a lack of MTH methodological variety (although those argument could be made). Rather we find troubling anthropocentrism arises when researchers (or scientists in the case of the USGS) understand data from any given method as normative, exclusionary, and objective accounts of reality. While we could have built our own water sensors, devised a new method, or looked to decentralized methods of data collection (and all of these would have interesting implications which we might explore in future studies), the existing infrastructure and open access to 30+ years of historic data would have been impossible to replicate.

## 3 Foundations

Before situating how the Leaky Cups are motivated by current discourse on time, agency, and ethics it is important to say a word about citational practices. This paper is, in part, a story of ethics and care. As such we have tried to cite scholarly discourses from outside white male dominated knowledge traditions (a non-insignificant slice of HCI) both as a matter of citational ethics and care, and because these are most relevant to understanding less anthropocentric temporal logics. As a discipline, we cannot ignore that the existential bifurcation (and environmental degradation) motivating HCI's turn towards MTH inquiry has long been voiced by non-white and queer scholars (e.g., [53, 76, 86]) whose nuances, understandings, and perspectives are vital to engage and think with.

However, as authors we are in many ways privileged beneficiaries motivated by a genuine desire to learn from and understand



**Figure 2:** (Clockwise) a) a diagram showing hardware inside the cup: USB-C charging port, motor, NPN Bipolar Transistor (PN2222), FeatherS2 – ESP32-S2 Development Board running CircuitPython 7.0.0, Li-Poly 400mAh battery, and a desiccant packet, b) diaries were printed and sewn with colored thread, c) cups charge when plugged in, d) each cup is unique and hand built.

these scholars' work without romanticizing them or claiming them as our own. Like others (e.g., [54]), we see citational practice as an opportunity to exercise more ethical relations to humans. Yet we also argue this is an opportunity for MTH HCI to recognize and account for some of its human subjectivity in ways that might begin to resist the hegemony of Enlightenment thinking about humans and more-than-humans. We admit that such attention is difficult, somewhat unidirectional, and that our treatment here is imperfect. However, we see this as a step towards decentering maleness, whiteness, and Enlightenment humanism as HCI's unspoken foundation.

We now present the foundations for this paper's questioning of human exceptionalisms embedded in notions of change (via temporal logics), who has the power to tinker and respond willfully (via agency) and how tinkering is relationally negotiated (via ethics).

### 3.1 Temporality

Temporality has always been implicated in how HCI seeks to understand relationships between technologies and the worlds around them [42]. The notion is commonplace and ever-present yet deceptively complex. Time is often thought of as an external constant and unalterable flow marching ever forward in a single direction. Yet there are many notions, understandings, frameworks, and individual experiences of time.

Over the many waves of HCI, researchers have engaged with time and temporality with ever more attention to such complexities. Looking at time and temporality across HCI (from secondary or tertiary concerns to primary dimensions of research), Wiberg and Stolterman's literature study of 529 papers [96] over 30 years indicates this is indeed a rich area of interest. Many, especially those relevant to HCI's early concerns, focused on clock time – referring to time as determinate, quantifiable and characterized by a linear progression of events that can be precisely assessed and rationally

understood. Examples include mapping or visualizing along time-lines [3, 21], achieving optimization [27], and temporal aspects of machine operations [18].

Yet time has also been understood as a critical aspect of human interaction and therefore interaction design [28, 90]. Odom et al have explored such temporal interactions in many research artifacts such as *Slow Game* [65], *Olly* [64], and more [62, 66] with a special interest in slowness (drawing on slow design [82]) and relationships over longer spans of time [61]. With these and other projects (e.g., [70]) the aim is to surface and explore temporal perceptions as they relate to daily life with the goal of encouraging reflection over time. Still others work to understanding humans' experience through the subjective role of time in social life focusing on how time is socially constructed and situated at home (e.g., [47]) at work (e.g., [39]), at play (e.g., [74]), and in societies or cultures [85], including the political power of time in these social orders [71].

As HCI enters its proposed 'fourth wave' [26] (focusing on entanglements between human conditions, other beings, matter, and environments), the need for MTH perspectives on temporality grows [14]. The explorations mentioned above have advanced our understanding of temporality from a human-to-human perspective, yet embedded within those explorations is a distinctly anthropocentric temporal logic. A temporal logic, according to Mazmanian et al, which represents and reinforces assumptions about time which manifest as societal norms, ideologies, discourses, epistemologies, technologies, even identities. They argue "it provides an understanding of time that becomes so embedded that it seems to define reality" [38]. Given this growing understanding of the importance temporal logics play in shaping words, an emerging body of work in HCI and adjacent fields point to time as relational, interconnected, multi-agentic, and not-just-human (e.g., [8, 15, 37, 73]).

Beyond understanding MTH entities or systems as 'outside' of human time, on a different scale, duration, flow, or attunement (and resisting the reflexive urge to simply slow everything down) the Leaky Cups look to how human and MTH connections shape the meanings and consequences of time [33] not as purely objective (universal) or subjective (individualistic) [9] but as emerging through relations of care and labor. Kyle Whyte argues that when conceived of through linear time, sustainability projects (i.e., technological progress, futures, or solutions to ecological degradation) can obscure effects on marginalized members of a society (human and beyond) and our responsibilities to them [95]. For Whyte, using linear time to present information in the hopes of persuading humans to change, bypasses foundational work understanding how human and more-than-human relationships have degraded. Therefore, successful, respectful, and ethical intervention would account for "how responsible relationships must first be established or restored" [ibid]. Similarly, in her critique of linear time, Carol Greenhouse describes "the affirmative power of linear time is in its ability to resolve tensions among priorities, loyalties, and accountabilities" [24]. By contrast, the Leaky Cups are concerned with complicating tensions among priorities, loyalties, and accountabilities by exploring how perceptions of change are inseparably linked to how the agency responsible for that change is distributed or amassed.

## 3.2 Temporality / Agency

In her MTH reading of *Greenhouse*, Michelle Bastian argues that "Western accounts of agency focus on the ability of a self-conscious individual to achieve a previously articulated goal, not because this simply is agency, but because the notion of time as linear guides this understanding of how change happens. . . by linear time's basis in the modification of present moments, where an idealization of 'presence' underlies the idealization of the individual and its capacity for rational decision making" [8]. In other words, 'humans' possess the agency to make change (to progress) while 'nature' simply possesses the agency to undergo change (to be affected by our progress). This understanding of Western temporal logic exemplifies the connections between time, agency, and human exceptionalism. In viewing progress as intentional change and time as linear progression towards said change, who has the power, ability, or agency to make change is reduced to exclude 'non rational' others such as more-than-humans.

This question of agency and intentionality has been an important part of HCI discourse and has been understood within theories such as actor-network theory [43], technological mediation [91] as well as other flavors of postphenomenology (e.g., [36]), etc. However, for Vanessa Watts, even in these more inclusive formulations "this type of agency is hierarchical; it is dependent on the belief that humans are different based on our ability of will and purpose. . . interconnectivity is permitted, but only insofar as distinction from the thinking human and the acting natural world" [93]. While others have attempted to equalize the playing field through further separations, i.e., by cognizing agency as separate from intention (e.g., [56]) or separate from thought (e.g., [48]) they all operate within the same temporal logic separating that which thinks and therefore makes change from that which is thoughtless and agentic but less so. We view the Leaky Cups as altogether willful and entangled and hope to contribute to HCI's evolving understanding of agency and time by opening ways of being which account for how more-than-humans make change and make ethics through non-progressivist care labor.

## 3.3 Temporality / Agency / Ethics

This paper attempts to rethink processes of tinkering with life 'as well as possible' as responsive and iterative changes made through care labor by both humans and more-than-humans. To do this we must question human exceptionalism embedded in notions of change (via temporal logics), who has the power to tinker and respond willfully (via agency) but also how tinkering with life 'as well as possible' is relationally negotiated (via ethics).

While MTH projects in HCI have looked at various ethics (e.g., [7, 12, 13, 31]), including feminist ethics of care (e.g., [29, 41, 42, 88]) to understand entangled relationships, the connection between ethics, temporality, and agency, is not always made explicit. Based on the work of Deloria Jr., Glen Coulthard describes the effects of time-oriented (and by contrast place-oriented) ways of being, thinking, and understandings ethics. According to Coulthard, a key facet of Western metaphysics is how meaning is derived through history and development which centers time rather than place [16]. Fundamentally, Coulthard is describing how logics of liner productionist time (i.e., how progress is achieved, and by whom) come to occupy

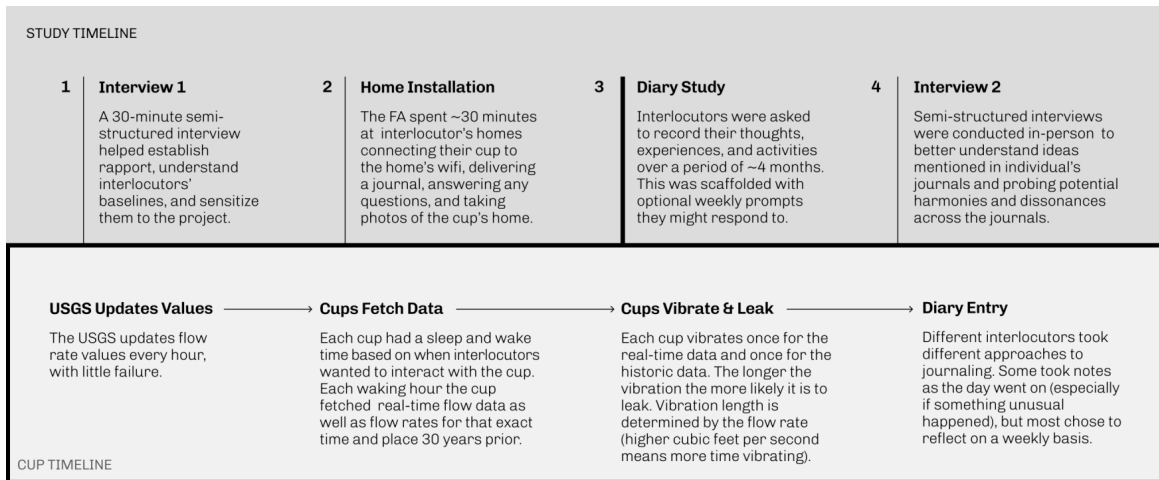


Figure 3: A diagram of study activities over time above and cup activities over time below.

“an ontological framework for understanding relationships” [ibid]. We argue that this intersection between temporality and ontology goes beyond temporal logic, which deals with societal norms and definitions. We suggest the term tempo-ontology to signify how temporal logics come to define what it means to be, to become, and to relate. Such a tempo-ontological framework for understanding relationships breeds a mentality of individual agency, dominance, and exploitation rather than an ethic of reciprocity (i.e., I am, and I become rather than we are, and we become).

Conversely, he describes how a place-based ontological framework, which views change as relational underpins a relational understanding of ethics. He explains, “within this system of relations, human beings are not the only constituent believed to embody spirit or agency. Ethically, this meant that humans held certain obligations to the land, animals, plants, and lakes in much the same way that we hold obligations to other people. And if these obligations were met, then the land, animals, plants, and lakes would reciprocate and meet their obligations to humans, thus ensuring the survival and well-being of all over time [ibid].

Looking at Fisher and Tronto’s definition of care ethics as “everything we do to maintain, continue and repair our ‘world’ so we can live in it as well as possible” [18], we can see the essential similarities of their ethic based on life sustaining webs of care, yet Coulthard, and the Leaky Cups project explicitly recognize more-than-human entities as willful participants in how ‘life as well as possible’ is negotiated. Like others in HCI [41], we build off projects using feminist ethics of care to recognize MTH participation. Care, as a feminist practice, is about attending to what, how, and when things get caring attention and come to matter and what, how, and when things don’t. Not about making more things matter or about caring more, or romanticizing care labor (e.g., [55]). Again, the Leaky Cups are not in the business of persuading humans to change their habits because now they care more about watersheds, cups, or their own ‘inevitable’ futures. The Leaky Cups attempt making legible the willfulness and tempo-ontology of human and more-than-humans which ethically tinker towards ‘as well as possible.’ Just as the Leaky Cups seek to operate from a temporal

understanding of change apart from the ‘thinking human and the acting natural world’ which privileges human agency, they also seek to operate from an understanding of ethics apart from the ‘thinking human and the acting natural world.’ In this way we see the Leaky Cups as material echoes of Tronto’s rhetorical yet salient question, “Why can’t we conceive of matter as animated toward care and justice rather than indifferent to these concerns?” [78].

## 4 Process

This study included six interlocutors as genuine users (Figure 5) and (Figure 6). Four individuals were independent to the project and were recruited through researcher and collaborator networks. In addition, Key and collaborator Stevie also experienced and documented life with a cup. All interlocutors were asked to commit to an initial 30-minute semi-structured interview, 30-minute home installation, an approximately 4-month deployment, and a final 2-hour interview (Figure 3).

Initial semi-structured interviews were conducted to get to know each interlocutor, their home and to confidently achieve informed consent for participation (as required by Northumbria University’s ethics review board). After the initial interview, Key came to each interlocutor’s home to install a cup. Exit interviews were conducted in-person and were semi-structured around participants’ diaries which Key collected and reviewed 1-2 weeks prior. Conversations centered around better understanding or evolving ideas mentioned in individual’s diaries but also probing potential harmonies and dissonances across the diaries. All interlocutors have been given pseudonyms and identifying information removed.

### 4.1 Diaries and Analysis

Each interlocutor received a Leaky Cup diary (Figure 4) with prompts such as “how has the cup settled into your life and home?” or “how do you care for the cup?” and “how does your relationship to this cup feel similar or dissimilar to your relationships with other technologies?” as well as an activity using tracing paper to layer maps of where and how care, technology, and water exchange and

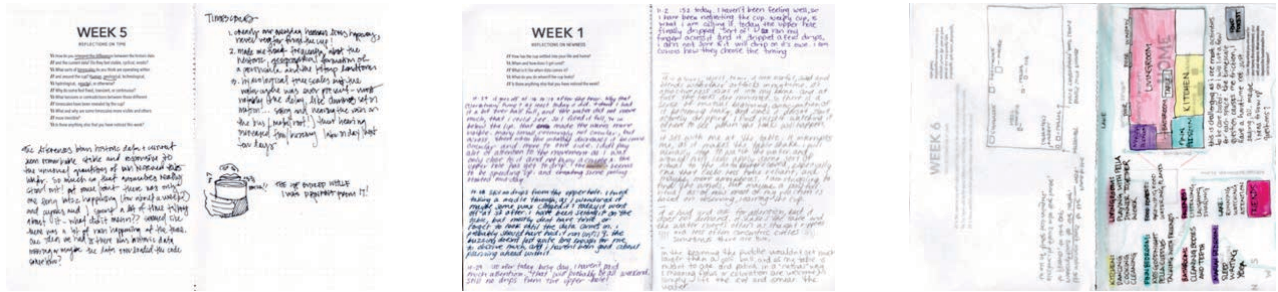


Figure 4: Pages from interlocutors’ Leaky Cup diary including writing, sketching, and layered mapping activity using tracing paper.

overlap. The diary ended with a wrapping-up section and blank pages for additional thought.

Importantly, prompts were left open-ended, often simply saying “the cup” and letting interlocutors interpret that as the water in the cup, the cup’s computation, the cup as a vessel, the data, a combination, or some other aspect. As a feminist project this was in important design decision because it reflects our understanding of data as always partial, situated, and incomplete [19] where “the telling of one story has always been told in place of another possible story” [83]. In this way, we wanted to limit prescribing to interlocutors what stories were possible or preferred (i.e., what kind of data we wanted from them). While this has the benefit of broadening the research space, it also messies the analysis process when it is difficult to pick apart what exactly interlocutors are reacting to.

However, like others in HCI [41, 45, 77, 84], this project takes a diffractive approach to analysis [6], meaning Key was not trying to uncover what participant data ‘really meant,’ but instead was interested in how those data produced differences. Diffraction is a feminist approach where sets of texts, ideas, theories, artifacts, data, etc. are read through one another to investigate the entanglements of materialities and ideas [5]. This is different from reflexive approaches where data ‘speak for themselves’ through processes of recognition, identification, and classification [38]. According to Taguchi, “to understand this we need to move, ontologically, from identifying bodies as separate entities with distinct borders to think in terms of processes of entanglements and interdependences” [83]. In other words, we didn’t want interlocutors to priori see the cups as an amalgam of distinct parts and we did not want to priori see their data that way either. Afterall, if data can be some other story, then analysis can also [38], necessitating attention to the multiple and messy lenses of data creation and its analysis.

Data from this project included interview transcripts, installation photos, diaries, images and videos captured by interlocutors, a voice memo transcript (Key’s way of reflecting at the end using the same interview questions), as well as the data logs downloaded from Adafruit IO. Analysis began with open notation (‘opening up’ the data and noting when anything sparked interest) then axial notation (identifying relationships). Finally, the data could be organized so that questions began to emerge around synergies, concurrences, discordances, contradictions, relationships of tension, and places where binaries like data and research apparatus, theory and praxis, objective and subjective were unsettled.

### 4.2 Interlocutors

As mentioned, this study included six interlocutors as genuine users4 independent, project collaborator Stevie, and the FA Key. The Leaky Cups project embraces human subjectivity, positionality, and situatedness as core starting points from which to explore objectifying positions and practices with more-than-humans. However, the need to keep sight of the humans is not motivated by a desire to keep ‘centering humans.’ Instead, it is to hold account rather than emancipate humans from the ethical imperative to account for our roles in reproducing prejudicial Anthropocene/s for humans and more-than-humans. Sympathetic to prior arguments that HCI cannot run the risk of displacing the same anthropocentrism elsewhere from a position of nowhere [41]. We argue that one way to resist displacing the same anthropocentrism elsewhere is to begin from a situated human ‘somewhere.’

Hence, Key and Stevie looked to autobiographical RtD to provide interstices between crafting and living with the cups. It is through the lived experiences that the authors have had the capacity to recognize, challenge, and even celebrate [20] some of the subjectivity, positionality, and situatedness needed to ethically account for how we generated particular knowledges with and through the Leaky Cups. We argue (more fully in section 7) that it must be, in part, through ourselves as designers, makers, and analysts that we frame this paper’s situated visitation and complication of an (rather than the) anthropocentric vision temporality.

All interlocutors in this study have made their lives amongst the waterbodies of Washington State. This land emerged as the Cordilleran Glacier retreated past the entrance to the Strait of Juan de Fuca ~14,000 years ago. Having been contoured by the retreating glacier, Washington State has a varied and diverse landscape where waterbodies are ubiquitous and omnipresent (Figure 6).

Waterbodies are integral to life in this region both through the histories they have enabled and the presents they create. Neimans’ hydrofeminist notion of ethical obligations between bodies of water where water “entangles our bodies in relations of gift, debt, theft, complicity, differentiation, relation” [16] is woven into the daily lives of the residents here. Since its colonization (these are the occupied ancestral lands of the Coast SalishDuwamish, Puyallup, Suquamish, Tulalip and Muckleshoot nations), these waterbodies have been manipulated, corralled, and harmed in the name of ‘progress’ for some and detriment of others [17].

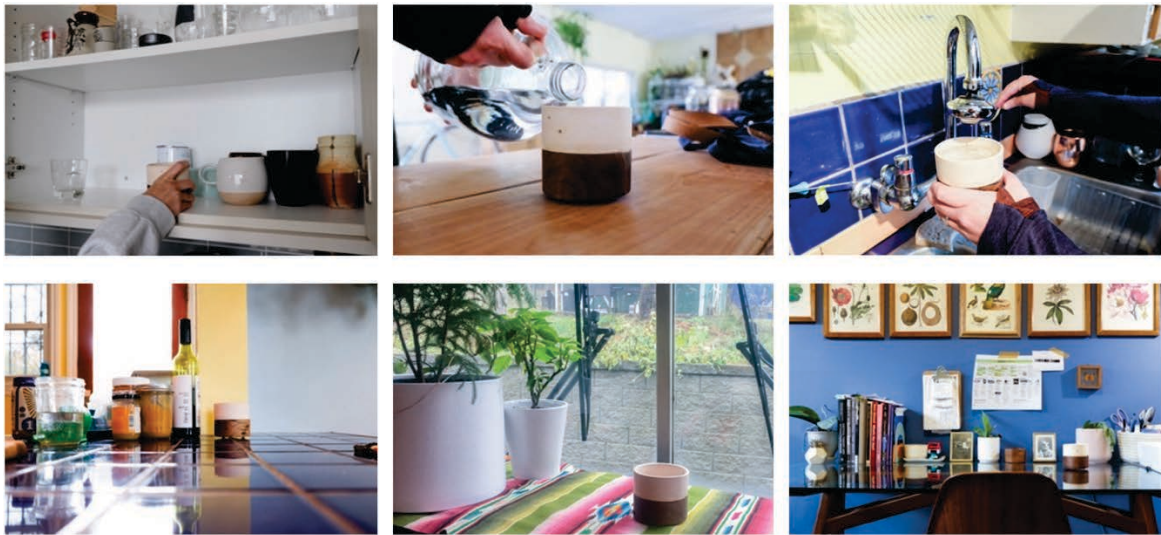


Figure 5: (Clockwise) Billie, Nico, Lou, Hazel, Stevie, and Key during home installation.

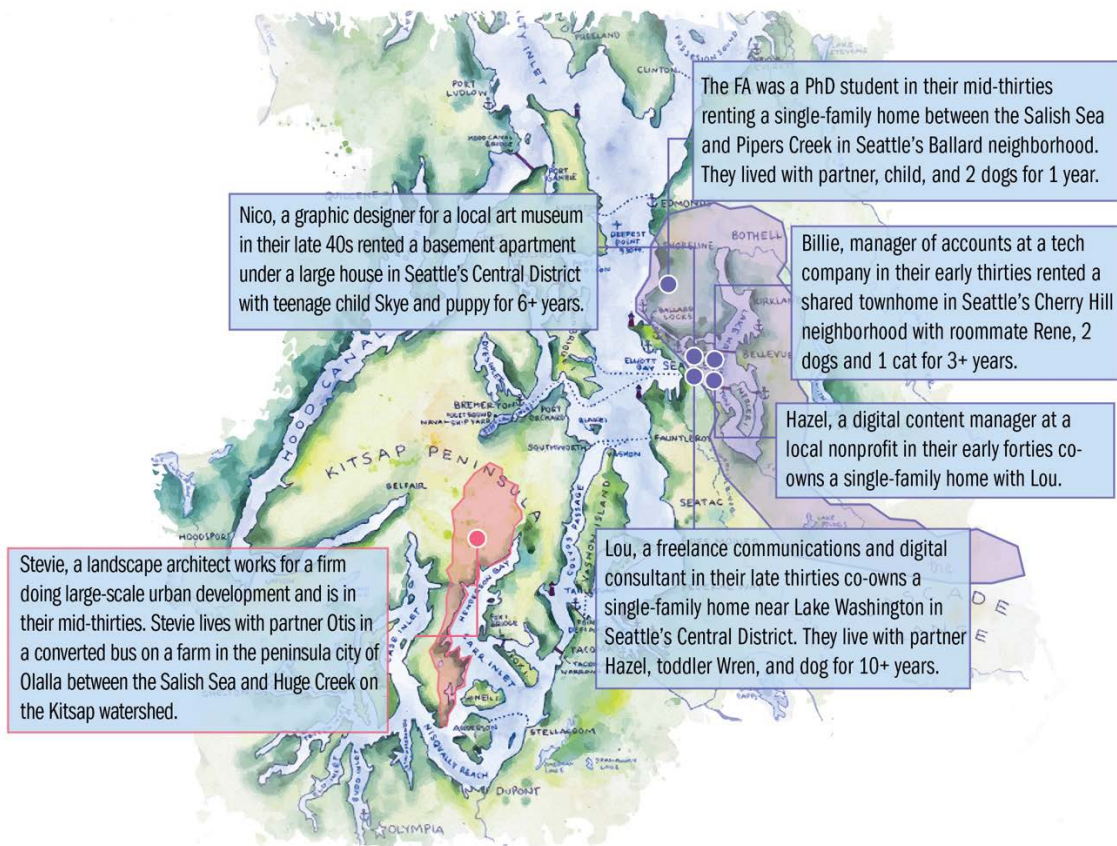


Figure 6: A map of interlocutors' homes within the Cedar-Sammamish Watershed (purple) and Kitsap Watershed (orange) among a landscape intermixed by waterbodies. Map used and modified with permission of the artist Elizabeth Person [68].





**Figure 7: (Left to right) Stevie’s cup having just vibrated on the now water-soaked tablecloth, Key’s weepy cup pooling on the windowsill, and Nico’s cup stained with water marks after months of use.**

Yet, they are also how we recreate (according to some with the highest boat-per-capita in the US), dwell (Lake Union is home to approximately 500 floating homes), and commute (with a ferry system that services 30+ islands in the Salish Sea). It is also how some define our founding (as descendants of loggers, fishermen, and commercial port workers). And it is what makes us unique (as residents of “the rainy city,” we are made of stern stuff and will adventure no matter how wet it is).

Washington State’s waterbodies are beautiful and iconic, yet omnipresent reminders of how modes of living and relating to watery bodies means being enmeshed in agentic material reciprocity and obligation. In the map below we introduce each interlocutor, showing where they live in a landscape punctuated by water.

## 5 To Tinker. To Trouble. To time

Below we present two themes and four subthemes. Our themes explore how humans and more-than-humans tinker, trouble, and temporalize (i.e., make change and make ethics through non-progressivist care labor) which productively contradicts, discords, and holds tension for some enduringly normative conceptions around temporality and openness.

*“Change doesn’t always happen in linearity. Change isn’t a time. Change is not a clock. ... I feel like we’ve done a disservice by being like: This. Is. Time.” – Nico*

### 5.1 “This. Is. Time”

For some interlocutors, the lingering COVID-19 pandemic meant that questions with time’s singularity and authority were not far from their thoughts. In a diary entry Lou wrote, “What is time? It’s something I’ve thought + said often during the pandemic. ... my sense of time has shrunk / changed. This cup seems like it has been here forever!” Nico echoed this saying, “I think that our perception of time shifted a lot through the [pandemic] because we just had an expectation that it was running on our time—and it’s not running on our time. But I don’t know whose time it’s running on. Are all times happening simultaneously? I don’t know.” For many, the pandemic rapidly brought a new set of relations to the fore that meant a very different ‘as well as possible’ entailing very different modes

of care labor (where absences thereof were intensely devastating). For many, this was a challenging and humbling period where the agentic powers of more-than-humans rippled across scales causing quotidian reorientations of time, care, and their interlocking bonds. Being mindful not to equate the two, we find it salient that the cups disruptive and unrelenting presence reminded some interlocutors of this temporal phenomenon.

Although difficult to pin-down, Nico explores how the cup shifted, reoriented, or destabilized their preexisting idea of time by bringing together seemingly divergent temporalities.

“I think that although the cup is dealing with multiple time scales it is hard to grapple with much outside human scale. And the cup resides firmly in human scale, as evidenced by its breaking. But as it exists, all the scales are affecting it. The geological, technological, and hydrological are visible through its function. I think one of the biggest indicators of time comes from the interruptions, overnight, or when it wasn’t working. Although there is continual data coming during the day it still doesn’t feel like a timer / clock. Maybe because it changes daily but the data coming in on the hour creates a fixity. There is a tension in that which places it, in some ways, outside of time.”

For Nico, time (i.e., Euro-Western temporal logic) is linear, non-distributed, constructed rather than emergent, and absolute. So, when the cups sketched out a temporality of change emergent from the synchronicities and asynchronicities of its relations—which are in constant negotiation and at times contestation—it displaced the cup from linear time altogether.

Although Nico did not elaborate further on the cup breaking (i.e., the cup came loose from the base several months into the study), this also happened to Hazel and Key, who reflected on the event saying,

“the way the water is so strong that over just a matter of weeks it breaks through the epoxy and glass glaze. How nuts that it happened so fast, yet the terracotta will last so long. The porosity so harmful to its function as a cup makes it perfect for a planter (all the

previous versions are now planters for my starts and propagations).”

Although the bases of the cups were glazed to protect the electronics from moisture, the side walls were left unglazed to allow some wicking through its open pores. This allowed water to seep into the edges where epoxy held the wooden base to the ceramic cup. Coupled with frequent vibration, the water degraded the epoxy enough to eventually separate the base from the cup.

According to Howell et al, material breakages in research are opportunities to look beyond functional evaluations of design artifacts towards nuanced attention to surrounding lifeworlds [35]. For Nico and Key, their cups’ breaking prompted consideration of the powerful non-human effects within the cupNico focusing on the tensions between geological, technological, and hydrological materials and timescales and Key frankly awestruck by the sheer power of water. For Hazel however, whose diary entry on the event simply stated, “different object, lost meaning,” the consideration was personal. The breakage was upsetting for Hazel because they were very fond of the cup and had developed some meaningful rituals (see 5.2). In one last example, Stevie preemptively considered surrounding lifeworlds and avoided their cup breaking by taking care not to leave it full for too long fearing “it would become earth” again. These breakages (and breakage avoidance) are poignant examples of when willful and contemporaneous dynamics and care relations drive change through unmaking relations (i.e., literally separating materials), limiting relations (i.e., keeping materials from transforming), and altering what matters (i.e., when changing form changes meaning). In this way, the Leaky Cups were not about highlighting this time over that time, this pace over that pace, or any other temporal dichotomy but with how change emerges through the conditional agencies and care practices between interdependent things.

**5.1.1 Capacious Presents.** The Leaky Cups are concerned with what we might call the speculative here-and-now, where mechanisms and capacities to make change are iteratively reconfigured via tinkering with life ‘as well as possible.’ However, here-and-now is not such a simple notion, as the cups revealed to interlocutors while living and negotiating with them. When discussing the cup’s temporality in relation to the “weirdest thing about the way we try to organize time,” Nico describes how the notion of past, present, and future as distinct temporalities easily breaks down when thinking of their son Skye. They explain, “when I think about Skye, I perceive Skye through all of history. He’s my baby and he’s my 18-year-old. Not because I see a baby in him or anything, but I just mean my care for him and my love for him. It has grown over so long. We have all this rich history, but when I think about time as years, I’m like, God, that was so long ago that he was a baby.” Linear time — that is, time in years which are sequentially organized — dictates that Skye is 0 then 1, 2, 3 and so on. Yet for Nico, with whom he has been in a care relationship the longest, that relationship cannot be represented through a linear tempo-ontology. Skye, and the care relationship he has with Nico, is both 0 and 18 and all the moments in-between all at once. And those histories constitute and reconstitute present reciprocities, agencies, care, and other ways of being and relating.

11.22	:40	12.20	:03	12.27	:34
11.23	:36	12.21	:58	12.28	:30
11.24	:32	12.22	:55	12.29	:26
11.25	:29	12.23	:51	12.30	
11.26	:27	12.24	:47	12.31	
11.27	:25	12.25	:43	1.1	:16
11.28	:23	12.26	:39	1.2	:13 am
1.3	:11				
1.4	:07				

**Figure 8:** A page from Nico’s diary where they tried to track the ‘drift’ of when the cup’s data came in.

Although the cup and Nico could never have such a history, the cup found a way in through the richer histories of things surrounding it as a window to other histories and care practices. For example, Nico explained that the cup is “another part or another view in, and I guess that’s maybe why it feels like a dimension. It’s like another window into the relationship with the table.” For Nico, “flaws or coloration are welcome” signs of use which build up over time on the table whose visual history has been developing for over the many years the family has had it. Through integrating the cup into some of those care processes it folded itself into that historical narrative and brought up similar feelings of experiencing seemingly distinct temporalities (past, present, future, mine, yours, human, more-than-human, etc.) inextricably. This idea that the present can hold more than just a progressivist notion of here-and-now resonated with Key, as a fellow parent but also as a crafter of the cups. Key’s richer history with the cups led to a similar phenomenon; they journaled, “well, this is entry 1 rather than week 1. It feels like I have had my cup for ages. . . This cup has slowly morphed into being alongside me for 6+ months. . . There has been so much work / engagement I’ve had other than just living with it.” For Key, although the cup was entering a new phase of research engagement it carried with it a history of designing, making, testing, caring, living with, and connection to the thought and work which preceded it. On the day of deployment, the cup’s preexisting care reciprocities meant that its integration felt like it had just begun yet already established—all at once.

**5.1.2 Time in Patches.** The Leaky Cups temporalized their surroundings by calling attention to themselves irregularly yet somewhat steadily — like a drawn-out metronome in need of repair. Data would come in (audibly, visually, messily), vibrate for a few seconds and reset to vibrate again later. This (plus a few unforeseen skips in vibration when the cup could not reach the USGS servers) meant the time of day when data would come in drifted (figure 8).

The fixed unpredictability of the watershed data was central to many interlocutors experience living with the cups. Nico explained, “I do think that it is something that’s really poignant, that’s pointed. You want to pay attention to it. It means something or it feels something. It is an odd way to have information come at you. Typically, it makes sense and it’s linear and the clock says one and so it’s one, or it’s so random that you’re not dependent on it for anything. It’s interesting that it straddles both those things. You couldn’t set your clock. . . there’s a lot of variations, but they’re tiny.”

This odd way of having watershed information and temporal marking ‘come at you’ does not yield itself to being ignored or utilized in any conventional way. In Stevie’s diary they explain that this irregular, but fixed marking of time in relation to other interactions was the primary way they and partner Otis experience the cup. Stevie and Otis live in a small, converted bus where the cup was perhaps more omnipresent than with larger homes. In this way, the passing of Stevie’s day (waking, sleeping, socializing, working, etc.) was always connected to and pronounced by the cup. So much so that when the cup was inactive at night Stevie noticed how that changed their perception of time, saying

“Honestly, it felt like a time-keeping device-like-thing. I’d hear it when I woke up and I’d be like, oh, it’s 8.30. I notice I’m missing the buzzes that night, before bed, but after 10:00 PM. Because some nights I go to bed at sh\*\*ty hours with architecture world. I’ll be like 1:00 AM and I’m just like, ‘Oh, it’s been three hours since I’ve heard the cup.’ I think that’s something I forgot — that there was time without the cup.”

Because the cup embedded itself in this way, marking and connecting rituals and routines erratically rather than predictably it more obviously participated in the creation of a relational or patchy experience of time. And when the cup was silent, that uncannily shifted Stevie’s perception out of patch time (which is not about universally fixed hours and minutes, but about unhealthy job demands, partners wanting to sleep in, and the inescapable connectivity of having 200ft<sup>2</sup> of living space) and back to linear or clock time.

For other interlocutors, their cup patched together rhythms, routines, and histories not just from the metronome-like vibrations but also from what the varied duration of those vibration meant (i.e., real-time and historic flow-rate data on the nearest waterbody within their watershed). According to Stevie,

“The differences between historic data and current seem remarkably stable and responsive to the unusual quantities of rain received this winter. So much so that anomalies really stood out! . . . If I couldn’t really see outside, I don’t know that it would speak as much to me without that noticing of the rain, then noticing the stream. That triangulation, I think was pretty critical to my experience. . . . Our bus is a space that has windows on all sides and the roof is made of metal. When it rains you see it, you hear it, you probably feel it because there’s not great humidity control. And then [the watershed data] would be on a delay from our experience of the rain in real-time because it was actually when rain was getting to the streams.”

Stevie’s experience of triangulation is significant because the waterbody data was not considered as discrete and meaningful in-and-of-itself. Instead, it was understood in relation to time and materiality. It was understood through the delay it takes water to reach a stream and for that to reach the cup, and through comparing current flow rate data to historic data, allowing anomalies to emerge. And it was understood through materiality such as metal’s acoustics, window’s transparency, and bus’s humidity.

As we have discussed, designs can and often do temporalize the world (i.e., shaping temporal logics and tempo-ontologies) by

assuming unilinear causality, hierarchical agency, and human-only willfulness. However, these experiences with the Leaky Cups represent frictions between such temporal logics and the messier co-constructed temporal logics exposed through an attention to the ethical negotiations between bodies of water (their materialities, capacities, durations, histories, data, etc.) Through experiences of breakage, interweaving histories of care, and the unfixed marking of situated rhythms and happenings, the cups worked to temporalize the world through ethical coordination or discoordination arising from MTH assemblages rather than outside authority.

In highlighting how the Leaky Cups made and were not merely affected by time, they suggest a tempo-ontology which is not about cup-time, ecological-time, or any other more-than-human-time but about patches of relational change and agency. This is a consequential departure for MTH design projects because change (including homeostasis, return, etc.) relationally become, materialize, and can be made legible “differentially and contemporaneously” [30] through endless iterations of MTH care labor. Just as a MTH design agenda seeks to non-universalize through centering relations rather than categories, so to must be done for anthropocentric logics of time. Time is not universal but patchy chunks of happenings colliding with other chunks of happenings, making change and ethics through their bumping and avoiding.

## 5.2 “Change is Not a Clock.”

We know that humans filter personal experiences of change, progress, and the making of meaning through the dominant temporal logic at hand [51] and have demonstrated above how the Leaky Cups surfaced a different temporal logic (that of patch time) which shifted interlocutors experiences of time itself towards something more relational. In the section below we look at examples where the Leaky Cups were experienced as open (but also not), meaningful (but also not), and ambiguous (but also not). Importantly, these shifting states were always trace-back-able to care conditions between things that make change (i.e., recognizing these contradictions means recognizing temporal logics outside the anthropocentric norm). We see these examples of how interlocutors iteratively tinker with meaning and interpretation of watershed data in response to MTH agencies as expanding our understanding of the contingent, sticky, and pluralistic role of temporality in design and technology.

*5.2.1 Open (but also not).* The Leaky Cups are part of a design research tradition which embraces ambiguity, openness, and undetermined functionality. Although such designs remain open to situated interpretation, that openness is often employed and valued for their ability to generate specific outcomes such as critique, reflection, novel interactions, or new design ideas. The cups, by contrast, were not concerned with embodying environmental information for a predefined purpose (i.e., critique, reflection, etc.). They are concerned with the process of how human and more-than-human agency, temporality, and care labor shape the conditions from which such critical, reflective, and generative responses might arise. In this way the Leaky Cups were perceived as relatively open-ended, and interlocutors did respond with imagination, playfulness,

and creativity. Importantly however, we also see situations involving avoidance, earnestness, and resistance in ways that suggest they were also experiences as didactic, explicit, and banal.

For Nico, the cup seemed to arrive with this sense of willfulness but not purpose. The cup leaks on its own terms, but how Nico attends to it, how that will affect the other relations in the home, etc. felt mutually up for grabs between themselves and the cup. Nico describes this when explaining, “its attractiveness eases it into my home and at first the leaks are minimal. So, there was a sense of mutual beginning.” This ‘mutual beginning’ leaves room for conscious tinkering on what purpose the cups might have as well as what care practices and associated reciprocities might evolve. For example, soon after receiving a cup the seasons changed and rainfall dramatically increased. Increased stream flow across the watershed meant leaking on the table and surrounding objects wasn’t so minimal. Nico began anticipating leaks out of obligation and preservation saying, “a large amount of water on the table is never a good idea, so it falls into that lineage of, ‘Okay, this is another thing that may or may not drip on the table, and so we should be aware of that.’”

The cup started out mutually settling into Nico’s life in a way that felt open. However, over time, as care reciprocities changed, so too did that sense of open-endedness as the cup closed some possibilities (the cup was not going to be as care-free as Nico thought) and opened others (being a part of that tables ‘lineage’ or history opened up the care relationship mentioned in Section 5.1.1). In focusing on the shifting reciprocities of care within this example (where Nico still gets something valuable from the cup but at a higher cost) we get to see how the primary driver of that change was the increased saturation of the watershed and the permeable wooden table that Nico who is no passive bystander but also not ‘in control.’

Further into the deployment Nico had a second experience which exemplifies how the cup’s willfulness, or ability to make change, effected its open-ness / closed-ness. As Nico grew to understand the cup and its rhythms, they imagined an ideal interaction with the water data that was ultimately thwarted. Nico explains,

“because of the fixity but also nonlinear temporality this felt playful and lent itself to a playful use of that fixity. I think that it was playful for me because it is all over the place, because the data was chaotic to me, it wasn’t perfectly linear, because every day it changed (and I did keep a list in the back [of the diary]). I think that there was a playfulness to that. I thought that was an interesting way to — you couldn’t gauge time by it. It wasn’t that linear. It only really lends itself to something that’s morphable, which is playful to me. It’s what I wanted to do. . . apply some playful ritual to the data as it’s being perceived. . . but it was also my projection. I don’t know if it ever established itself in that way. I did it a couple of times, but it never became a thing that I did over and over.”

As the cup tinkered with and amongst the web of other things in the home, it rarely cooperated with Nico’s playful vision. The cup didn’t always go off when Nico had the time or desire to do those ritualistic things and when the cup would go off during Nico’s free time it required attention in other ways such as wiping up a leak

before it soaked into the wooden table, watering plants with the leftovers, or moving it to a different area so Skye could work on a project, etc. Nico’s playful ‘as well as possible’ bumped up against many others highlighting how more-than-human factors can resist or deny change, progress, and forms of care. In a way, the cup along with the other things around it, were not always open to Nico’s preferred possibility.

These examples show us that even something which seems so solidly belonging to the human like ‘purpose’ might only appear that way because we default to thinking that humans are the only ones willful enough to truly affect what something means. However, Nico was made to respond to reciprocities emergent from material properties and preexisting care relationships not because they alone chose to, but because ethics as a fundamental property of matter.

*5.2.2 Meaningful (but also not).* For Key, water data felt meaningful when the cup received stream flow metrics, vibrated, and leaked but more so when the cup started visibly changing. At some point Key became focused on the marks building up along the sides of the cup as a form of beautiful and meaningful analogue data emerging on the cup itself (Figure 6). Key journaled,

“On the cup, is that pinkness from my water? The bees wax? Microorganisms? Minerals? Oils from my skin? I think about how the cup interacts with the water as it always seeps inside, and you can see it in the patina on the outside of the cup. The stain pools more at the leaky holes and along the seam between the wood and ceramic.”

According to Aryn Martin, “care is a selective mode of attention: it circumscribes and cherishes some things, lives, or phenomena as its objects. In the process, it excludes others” [50]. For Key, cherishing or caring about this aspect of the cup was not predetermined or static but malleable and emergent processes of tinkering where human and more-than-human agencies shaped the conditions from which those responses arose. For example, the markings along Key’s cup quickly became prominent in a way that invited attention. This was due to many factors such as position in the oven when the wax was baking (affecting porosity), having been used in testing for months prior to deployment, frequently leaving water in it when getting distracted by their young child, the large tree in the yard casting long shadows on the windowsill where the cup often sat, and many more. Although the processes of circumscribing, cherishing, and excluding might seem to be the sole labor and will of humans, this example points to how more-than-human labor, will, and care is mutually involved in how caring attention and meaning is allocated and changed over time.

*5.2.3 Ambiguous (but also not).* Although interlocutors found meaning as they interpreted their cups’ presence in their lives, those interpretations changed over time as they experienced the cups and water data as more or less ambiguous. Stevie, for example, fluctuated between engaging in detailed musings about the watershed and utter confusion as to what the data was supposed to do. In one instance they said they thought “frequently about the historic, geological formations of the peninsula and the \*Anonymized\* landform.” On another occasion however, they said they thought the cup’s leaking prompted “maybe. . . engagement, I guess. Like, a tool

for some sort of engagement?” Over time Stevie tinkered with the ambiguousness—unambiguousness of the data at any given moment as they responded to shifting tensions and complex ambivalence with the cups and surrounding environments.

## 6 Hydrofeminist Shifts

Having explored the patchy, non-linear, and at times, less anthropocentric temporal logic of the Leaky Cups we refract those learnings through the logics of Hydrofeminism to highlight related concerns relevant MTH HCI. Our themes around porosity, viscosity, and objectivity illuminate and trouble how the dominant temporal logic of technoscientific futurity effects how MTH inquiry is understood, analyzed, and reported.

### 6.1 Rethinking Openness in MTH design

As indicated in Section 5.2, the Leaky Cups were experienced as open-ended, incomplete, and provisional artifacts. In design research (in particular, speculative and critically oriented projects), openness to interpretation and ambiguity are valuable features which, according to Bill Gaver, “makes them evocative rather than didactic, and mysterious rather than explicit” [32], thus potentially yielding more novel or interesting results. However, in the context of MTH inquiry, we find that ambiguity is an all too human concept [75]. As a result, in this section we examine the anthropocentric temporality that underpins ambiguity and openness to uncover how it can obscure or deny the agency of MTHseven as it remains generative for humans.

To begin we first must examine the assumed chain of events at play in the encounter with an ambiguous research artefact. For Gaver, “the artifact or situation sets the scene for meaning making but doesn’t prescribe the result. . . the work of making an ambiguous situation comprehensible belongs to the person” [32]. This sequence of events follows the assumed pattern of all communication theory [94]: a human creates a ‘signal’ (in the form of an artefact or situation) which then is interpreted by another human. However, work that is deliberately ambiguous or open-ended aims for a different end point (or telos) than work that is closed. For a closed work, the purpose is to successfully communicate the author’s intended message with as little interference or noise as possible. For an open work, the purpose is to allow readers to produce variety and richness in their interpretations [23].

Yet Gaver unknowingly describes a fundamental limitation of normatively open design within a MTH agenda. Given a human-centered paradigm, the intersubjective generation of multiple meanings is a valuable feature even though the agency involved in reaching that end point (be that open or closed) is humans’ alone. For MTH design however, this formulation shifts focus to all the wrong places; it emphasizes how open work fluidly mediates human interpretations. Assuming artefacts have a fluid role in the meaning-making process obscures the way that non-humans can also willfully resist, oppose, alter, and create.

While it is well understood that no design can prescribe its reception in a totalizing way, because designs are not static, it is worth remembering that designs don’t just set the scene and then cease to create change. In other words, when only humans can alter a scene or make sense of a situation and more-than-humans are—at

best—conduits, or mediations from the designer’s composition to the rationale of the human receiver we lose important nuance. As discussed in Section 3, foundational to all MTH research paradigms is the understanding that more-than-humans have agency. Further, these perspectives understand agency as relational (i.e. not a property of individual actors but of relationships). Given this perspective, can we give a different temporal account of ambiguity? To make this concrete, recall Nico’s experience feeling a sense of mutual beginning, then failing to cement a playful ritual, and finally found meaning in-part through care labor between themselves, the cup, and the table. Using Nico’s experience, we might reimagine Gaver’s design sensibility through the temporal logic of the Leaky Cups as: the artifact or situation is one part of a persistently iterative process of making an ambiguous situation more and less comprehensible where all things in the relationship tinker via care labor.

To develop our argument that the current agential and temporal logics underpinning notions of openness must better align with MTH design principles, we turn to alternative logics offered by Hydrofeminism.

### 6.2 Viscous Porosity

As discussed in the introduction, Hydrofeminism integrates ideas of embodiment and ecological ethics to explore obligations between bodies of water. Having identified that resistances show up in interactions between the waterbodies in this study (interlocutors and cups) we use Hydrofeminism to explore how the metaphor of fluidity can obscure MTH’s agency and willfulness. We see particular value in adopting Hydrofeminism’s notion of ‘viscous porosity’ as a counter metaphor to think differently about MTH resistance or opposition which is missing in design’s current conception of openness as a form of fluidity.

Viscous porosity encourages us to understand how friction coexists with flow. For Nancy Tuana, “viscosity is neither fluid nor solid, but intermediate between them. . . ‘viscosity’ retains an emphasis on resistance to changing form, thereby a more helpful image than ‘fluidity,’ which is too likely to promote a notion of open possibilities and to overlook sites of resistance and opposition or attention to the complex ways in which material agency is often involved in interactions, including, but not limited to, human agency” [89]. Working in tandem, porosity allows us to think about how membranes alter and constrain the movement of fluids across boundaries in a way that “helps to undermine the notion that distinctions, as important as they might be in particular contexts, signify a natural or unchanging boundary, a natural kind” [ibid].

Taken together, viscous porosity offers a way to think differently about more-than-human participation. Rather than viewing open-ness as ‘fluid’ mediation that enables possibilities of human communication, we can also use open-ness to focus on how not-just-humans alter and constrain ambiguity through porous interrelations and viscous material resistances. Such a view would highlight the willfulness and labor needed to move across those resistances within the continuums of ambiguous—didactic and open—teleological. In moving away from valuing designs as open to all possibilities after the scene is set, we might resist the position where designs are understood as mere conduits to the meaning-making of

human users. The Leaky Cups are our first step towards a porously viscous design which unsettles the who of careful ethical tinkering through expanding the process of meaning-making to all entities and the how through understanding that such processes are not fluid, unencumbered, or limitless.

Beyond enabling us to complicate our understanding of MTHs role in ambiguity, viscous porosity also offers a way to reframe the baseline temporal logics of anthropocentric accounts of ambiguity. As discussed in Section 3.1, linear time “can obscure effects on marginalized members of a society (human and beyond)” [95]. In the next section, we argue that a temporal logic attentive to design’s limitations and resistances offers potential for recognizing those effects.

### 6.3 Telic, Atelic and In-Between

Having introduced the metaphor porous viscosity to expands our ability to attend to how MTH agencies enable and resist open-ended tinkering, we turn our attention to how the Leaky Cups disrupted anthropocentric temporalities (where progress is understood as linear, fluid, and rationalistic advancement). Lauren Wagner’s viscous understanding of progression “requires describing movement through exponential rates of change rather than describing it as linear unfolding: ‘infusing’, ‘coagulating’, ‘dissipating’, or demonstrating ‘surface tension’ instead of linearly ‘flowing’ or ‘connecting’” [92]. In this way we might think of the Leaky Cups as, what James Pierce calls, ‘in tension with progression’ [69].

In Pierce’s account, design is progression when it moves “arrow-like” towards production or realization [69]. This teleological structure could be said to underpin the majority of design activity and artefacts; however, Pierce also describes designs which are in tension with progression. These designs embody various frictional tendencies on their way to places other than production or realization. Importantly, he describes these designs as atelic, meaning not motivated by purpose or endpoint and open to virtually limitless possibilities and potentialities. While concerning to treat telic and atelic design as binary opposites (and we have previously troubled the agentic erasure of conceiving of designs as open to limitless possibilities) importantly, frictional designs are teleologically ambiguous.

Viewed through a MTH lens, this teleological ambivalence takes on greater significance. According to Elaine Gan, “telos segregates those who make history and futurity from those who fall behind, mute, in a timeless background. Being as a manifold of becoming and borderings flourishes in excess of unidirectional telos.” [30]. For Gan, it is damaging to view telos as a binary (telic or atelic) which has the tendency to segregate along the lines of thinking human (who makes history and futurity) vs acting more-than-human (mute and timeless). Rather, we suggest conceiving of a design as we do care ethics as holding together emergent and relational telos in the multiple and multidirectional while also negating or undoing multiple others.

This idea is made legible when forces converged causing some cups to break but was resisted and negated by others. The breakages (and lack thereof) illuminate the multiple and multidirectional telos of the clay, epoxy, interlocutors, pets and families, every drop of water, etc. coming together. Viewed through the progressive

design lens, one could write this off as a design failure. Viewed multi-telically however, the break down wasn’t a break down but a neutral event that closed and opened interpretations, meanings, and possibilities.

However, adopting plural and multidirectional telos without also changing our understanding of temporality and progress is not enough. Anthropocentric tempo-ontologies where what something is remains separated from how it becomes that way only allow more-than-human matter be changed and be affected by progress or purpose. In that paradigm, non-human matter does not produce change, purpose, or progress. To move beyond this, it is also vital to understand that progress is not contingent on rational decision making. We must understand that all matter, living and non-living, thinking and non-thinking can make change happen.

Without this, we inevitably revert to the fluid logic of teleological design and meaning-making. This can be seen in the way that even critical and speculative designs are often framed. Although they are not meant to represent immediate or preferable proposals, they are intended to contribute to human ‘progress’ via public debate and discourse on what might be, what should be, or will be if we do not get our act together. The result is while these objects are given some immediate agency to infuse, coagulate or dissipate futures and by extension temporalities, their ultimate purpose/telos is as mediators to human-centric discourse.

In this section we showed how feminist Hydro-logics have helped us appreciate design artifacts beyond mediators of human meaning and progress. As we found with the Leaky Cups, design artifacts themselves make meaning through viscously and willfully effecting their surroundings. We see the Leaky Cups as membranes with “a material fecundity that rejects an ontological separation between ‘thing’ and ‘transition,’ between ‘body’ and ‘vector’” [59]. It is through this tempo-ontology orientated towards material agency that the Leaky Cups are committed to telos in the plural—not without purpose but joining, cutting, reordering, and iterating on many different purposes simultaneously. This is because their meanings and purposes are not based on humanist progressive frameworks which require a commitment to stabilizing telos in the singular—flattening resistances through separating things from their transitions. In other words, the Leaky Cups’ richness comes not from independent humans thinking about possible or different ways we might settle into a future external world. As we will develop in the next section, instead they require and create an ontological dissolve between body’ and ‘vector’ which we might also see as the tempo-ontological softening between ‘speculating’ possibilities and ‘being’ possibilities.

## 7 Muddying the Waters

In the preceding sections, we have advocated for a shift in how HCI approaches MTH design and research, focusing on conceptualization over, say, inventing new methodology. Like John Law, we believe a fundamental challenge lies not in the structure of methods per se, but how they are understood and presented as singular and objective,

“Such stories help to sustain a strong perspectival and singular version of out-therness *even as they manufacture multiple realities*. They assume, and at

the same time help to enact, the standard version of Euro-American metaphysics while also crafting something different. . . In this way Euro-American metaphysics preserves itself in Keyce of possible contradictions” [44] (emphasis added).

In other words, our situated analytical selves are also semi-permeable membranes from which ideas pass through. For Neimanis, such a bodily membrane “is no passive prop for the ontologically weightier bodies that traverse it” [59]. Therefore, we argue it is through our conception or metaphysical reading of how change occurs throughout such ‘open,’ ‘ambiguous,’ and ‘atelic’ MTH projects we see the greater risk of displacing the same anthropocentrism elsewhere. Of course, this is also where we see potential because this highlights how the work of designing with a different tempo-ontology lies not in our methods but in ourselves as ‘Baradian apparatuses’ [75] which, like the cups do not exist separate from the phenomenon we wish to understand. Researchers collect and co-produce observations from within.

As an example, we draw from Key’s experience analyzing Leaky Cup data and choosing which data to focus attention on (i.e., which data to circumscribe, cherish, and exclude). When first analyzing Leaky Cup data, Key found themselves drawn to examples like where the cup brought Hazel’s family together for an act of noticing and appreciating. Hazel explains,

“there is this great moment when it buzzes — still happens. We all stop and look at each other and kind of wait / listen for the actual distribution data. It’s become part of our routines as a family (and our dog has adjusted — so no stressed-out dog). I love this moment, this intentional pause and I have come to appreciate how unscripted it is, how unexpected. It is such a contrast to Facebook memories. This feels like something positive, and it adds to our experience of place. It pulls us from the flow of our day, but in doing so, brings moments of collective awareness that are kind of amazing.”

Traditionally speaking, that’s MTH gold right there! But taking a step back Key realized they were falling back on some preordained temporal frameworks of action—reflection and present—speculation. Instead, we find there is value for MTH research in attending to those instances where outcomes fail to meet researcher’s didactic or teleological aims (i.e., when multiple heterogeneous interpretations are permitted if they represent active engagement that is based on the normatively valued characteristics of curiosity, contemplation, play, and exploration). We must not look only at data which demonstrate creativity, reflection, defamiliarization, or romanticized care. These are didactic and teleological readings which might limit more substantial and discursive findings.

Contrastingly, our commitment diffractive analysis, where one is encouraged to open up data “and to imagine what newness might be incited from it” [83] urged a second look at experiences like Nico’s—where their goal of experiencing the cup creatively, ritualistically, and with intentionality failed. Key admits that, at first, this experience was going to go unreported; if it had succeeded it would be more of that research gold. In hindsight we recognize this way of engaging data is itself viscous porose as it focuses on sites

of resistance and opposition where distinctions signify no natural or unchanging boundary.

Much MTH scholarship is rooted in a tradition of epistemological values that favors objectivity and objectification to establish legitimacy and clarity. This tradition demands clear and precise definitions of contributions (what truths are revealed) and rigorous explanations of how these contributions were discovered (were the appropriate methods employed). While this framing might make sense for some inquiries, for MTH inquiry it is problematic. The baseline assumption is that methods offering new ‘outsider’ perspectives on definitive phenomena will somehow produce new relationships and possibilities. The issue is that HCIs rationalistic tradition translates the experiences it observes into an objective reality (i.e., the thinking human reporting on the acting natural world). In other words, when our analysis of what MTH research means focuses purely outward towards the world (i.e., when what is remains separated from how it became that way), we deny tempo-ontological multiplicity. For Roseik et al., it is a truly problematic when a MTH project “involves framing the goal of inquiry as producing an improved description of our objects of inquiry, while leaving unchanged the construction of the inquirer as a spectator subject. [Especially because] the very being of inquirers are also multiple and transformed in the entanglement of inquiry” [76].

## 8 Conclusion

This work took inspiration from the willful, divergent, intermittent, and contradictory pathways that watery bodies take to join up with other bodies of water. Always leaking from and to somewhere, water is a conduit mostly back to itself. We let our cups leak and followed the mess. What emerged were the messy, liminal spaces that exist between open and closed, clear and opaque, now and then.

Through a set of data-enabled artifacts, the Leaky Cups, we (a) provide situated explorations on how processes of ethical tinkering, where the ability to make change requires no rationality, challenges anthropocentric temporalities underpinning most techno-futures and design activities (b) bridged prior literature on temporality, agency, and ethics to offer the term tempo-ontology to signify how temporal logics come to define what it means to be, to become, and to relate, advancing HCIs understanding of temporality (c) provide an introduction of hydrofeminism and its logics to HCI which we utilize in critiques of openness, ambiguity, and objectivity in MTH research and design.

Lastly, we add it is important to personally challenge these anthropocentrism through our work where researcher subjectivity, positionality, and situatedness are never separated from the subject of inquiry. We argue that until HCI embraces tempo-ontological multiplicity within MTH inquiry, when confronted with the pressure to legitimize outcomes and contributions as referential and ostensive we run the risk of falling into didactic and teleological traps which focus on ‘matters of fact’ (what matters of fact are) versus ‘matters of care’ (engaging with matters to create more ethical relationships) [72]. Rather than trying to design more ethical relationships from linear conceptions of progress and time we suggest viscosly porous approaches such as feminist diffractive reading (focusing on difference), and autobiographical engagement

(accounting for human subjectivity). We advocate for study designs which document and embrace breakage or failure and analytic processes which linger in the unease when outcomes fall short of researcher's and HCI's deep-seeded teleological goals. In short, we call on MTH researchers to embrace the multiple, contradictory, messy and banal over the circular, unidirectional, tidy, and normative. It is in looking beyond these propensities and proprieties that an alternative MTH gold might be found.

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