Pheno-data

Pheno-data: Using Tomatoes to Rethink Data and Data Practice for Ecological Worlds

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Notions of data increasingly revolve around digital representations prioritizing the efficiency and productivity of global economic-systems, often side-lining tangible and local information that is crucial for 'more-than-human' worlds. To challenge this, we propose the concept of, "Pheno-data," which aims to embody the livingness of the lifeworld through the evolving characteristics and responses of organisms. We also introduce, "Pheno-fication", as a means to access Pheno-data, and use tomatoes to exemplify the process. Through a fabulation workshop, we integrate these concepts into design practice in order to tangibly explore their potential for shifting perspectives from an anthropocentric to an ecological viewpoint.

Keywords: Pheno-data, Living organism, Livingness, Fabulation, More-than-Human, Ecologies

Subject classification codes: include these here if the journal requires them

1. Introduction

Data science has been criticised for its reductionist, dichotomous and oversimplified methods of collecting, sharing, and storing vast amounts of data in an attempt to understand, control, and predict (Boyd and Crawford, 2012; Kitchin, 2014; McQuillan, 2018; Loukissas, 2019) the complex world, while raising cultural and ecological challenges through concepts such as data colonialism, data capitalism (Sadowski, 2019), dataveillance (van Dijck, 2014), and data extractivism (Crawford, 2021). In his book,

the Data Revolution, social scientist Rob Kitchin (2014) addresses that the meaning and role of "data" in digital society have become quite the opposite of its etymology:

> "The word data is derived from the Latin *dare,* meaning 'to give'. In this sense, data are raw elements that *can be* abstracted from (given by) phenomena – measured and recorded in various ways. However, in general use, data refers to those elements that *are* taken; extracted through observations, computations, experiments, and record keeping." (p.3)

The nature of data has become inherently socio-political through specific data practices that involve *taking* data with certain purposes and intentions. Daniel Rosenberg (2013) has explored the etymological history of data and explained how we ended up thinking that data is "the result of an investigation rather than its premise". In the chapter, *Data before the fact,* he insists:

> "From the beginning, data was a rhetorical concept. Data means—and has meant for a very long time—that which is given prior to argument. As a consequence, the meaning of data must always shift with argumentative strategy and context—and with the history of both." (p.35)

The need to reclaim concepts of data, data science, and technology, is equally increasingly reflected in Science and Technology Studies (STS), where researchers have been advocating for reconsidering the ontology and epistemology of data to recognise the relational, situated, embodied, and entangled nature of the physical world, where humans and nonhumans co-exist (Latour,1999; Suchman, 2007; Barad, 2007; Braidotti, 2019). In this paper, we bring together these two lines of research: the critique of recent data science approaches and the motivation to situate data in the world, in order to reconfigure data as *given not taken*, allowing us to notice, make sense of, and derive meaning with humans, nonhumans, relationships and situated environments. In

other words, we seek to reconfigure data to answer the questions: How can we regain a sense of being situated and embodied in our surroundings, which is necessary to recognise the *active* participation of other beings in the real world? How can we build responsibility, appreciation, care, common sense, and wisdom *from/with/for* diverse species in the coexisting world?

By introducing the concept of "Pheno-data" as a provocation to account for the complexity and richness of the natural world, this paper aims to expand perceptions of data, from conventional *taken* records and information to improve human life, to contextual features (i.e., colours, shapes, movements, rhythms, and cycles) *given* by entities, and which ultimately draw attention to the autonomy, agency, and livingness of other beings and the environment.

The paper contributes to HCI to reconceptualise data from an ecological perspective in three ways: 1) by introducing the concept of Pheno-data as a shift of perspective towards more-than-human worlds, 2) by exploring how the new concept of data can be accessed through a practice of Pheno-fication and 3) by expanding how these concepts can be applied, through a fabulation workshop, that focuses on resensitising, recontextualising and reimagining the relationships between humans, non-humans and the environment.

2. Background

In this section, we highlight the challenges and limitations of a digitalised society from an ecological perspective and explore the concepts of ecofeminism and posthumanism

in order to find ways to restore appreciation, responsibility, connection, and care for both human and nonhuman entities.

2.1 Critiquing tendencies towards a "datafied" world

A significant amount of academic discourse among sociologists and social scientists has observed and criticised "Datafication" and "Big data" trends (Boyd and Crawford, 2012; Mattern, 2013; Cukier & Mayer-Schönberger, 2013; van Dijck, 2014; Dourish & Gómez Cruz, 2018; Sadowski, 2019). To explain the term "Datafication", Van Dijck (2014) adopts the concept from Cukier and Mayer-Schönberger (2013), describing it as "the transformation of social action into online quantified data, thus allowing for real-time tracking and predictive analysis." Kitchin (2014) defines "Big data," as a process to capture large volumes of data with high velocity, variety, scope, and resolution. He claims that both concepts are prone to lead to an "ecological fallacy" (Kitchin, 2014), due to assumptions, biases, and errors. Rosenberg (2013) insists that "when a fact is proven false, it ceases to be a fact" but "false data is data nonetheless." Furthermore, such concepts also tend to interpret the physical world through the lenses of specific human-centric (and capitalist) worldviews, making use of quantified data, optimisation, control, and prediction in economic, political and technological contexts (Boyd and Crawford, 2012).

Such practices can in turn seriously obscure *situational* (Haraway, 1988), *causal* (Cukier & Mayer-Schönberger, 2013), and *contextual* (Boyd and Crawford, 2012) values, facts, truths, and meanings that do not align with the capitalist aims or human-centric views.

2.2 Being and becoming in the real world

In contrast to the abstract and rational approaches of data science, scholars of ecofeminism and posthumanism have advocated for embodied and intrinsic ways of being in, relating to, and interpreting the natural world through concepts of “situated knowledge” (Haraway, 1988), recontextualisation and reconnection of humans, bodies, and nature (Plumwood, 1991), and “the art of noticing” local and situated changes (Tsing, 2015). These approaches seek to decenter humans, which are seen as narrowly defined throughout history, and to move towards a more-than-human worldview that includes misrepresented and misplaced humans, plants, animals, land, and other beings.

Donna Haraway (1988) introduces the concept of "situated knowledge" to counter various forms of knowledge that are "unlocatable", "irresponsible" (unable to be called into account), and based on fetishised "relativism and totalism", which are both ‘god tricks’ promising visions from everywhere and nowhere *equally* and *fully*, common myths in rhetorics surrounding Science”. She argues that situated knowledge, which is "partial, embodied, locatable, critical," can bring *accountability, responsibility, solidarity, and resonance*.

From an ecofeminist perspective, Val Plumwood (1991) criticises the "human/nature dualism," (i.e., mind/body, reason/emotion, and masculine/feminine) which she sees as the result of a rationalist tradition. She asserts that this dualism results in "a masculine concept of the human" that excludes and inferiorises women, bodies, and nature, as well as "disembedded and individualist accounts of the self." Through the lenses of “feminist ethics”, she argues that we need to reconfigure "the conception of the human, the conception of self, and the conception of nature" to reclaim human qualities such as "reproductivity, sensuality, and emotionality" which provide *continuity, connectedness*, and *care* with nature within ourselves.

In her book, *The Mushroom at the End of the World*, Anna Tsing (2015) introduces the concept of "arts of noticing." She problematises the Anthropocene era, which is seen as geared towards capitalism and industrialism, through assumptions of growth, of turning humans and nonhumans into resources, eventually producing ecological ruination. She insists that we need to regain our ability to "notice" possible *multispecies histories and stories* that are created by the "interplay of temporal rhythms and scales in the divergent life ways that gather" for collaborative survival.

Building upon the ideas of thinkers in Science and Technology Studies mentioned earlier, Braidotti (2019) strongly criticises the profit-oriented approach that underlies data technologies, which generate scientific and economic information from living matter (such as genetic codes and bio-data). Braidotti emphasises the importance of a "zoe (non-human life)-geo centered approach" with living matter as the core of Posthumanism, aiming to resist over-codification of life and move towards the coexisting lifeworld of both humans and nonhumans.

Our work aligns with these theories in its motivation to elicit *situated* knowledge, restore human qualities to *be connected* to other beings and nature, and create new practices of *noticing* lifeworlds that multispecies make. We aim to reconceptualise data onto-epistemologically in line with Braidotti and posthumanist HCI researchers, introduced in the next section, and to bring new concepts of data and data practice that enable HCI designers to explore these ideas through design practice for the more-than-human world.

3. Related work

Some recent studies in Human-Computer Interaction (HCI) have embraced the concepts of posthumanism, focusing on reconceptualising data from humans and non-

humans to shift our perspectives and capabilities towards a more-than-human world (Lupton, 2021; D'Ignazio & Klein, 2020; Biggs et al., 2021; Lee et al., 2022). These researchers have proposed various notions related to data. For example, Lupton (2021) introduces the concept of "lively" data to rethink our relationship with personal digital data. D'Ignazio & Klein (2020) discuss data "visceralisation" to elevate the emotion and embodiment of data from minorised human groups. Lee et al. (2022) explore the idea of "becoming" data, which rethinks economic and scientific concepts of non-human data through design principles. Biggs (2023) proposes the notion of "posthuman" data for planetary sustainability, involving humans, nonhumans, and land.

Through their research, they explore more situated, embodied and nuanced understandings of the entanglement of humans, non-humans, and the physical world through the reconceptualisation of data and design practice. Such approaches emphasise experiences and meanings of *life* and *vitality*, focusing on the pursuit of the "good life" for the entire ecosystem rather than the "enhancement" of humankind (Light et al., 2017). For example, in the paper "Alternatives to agrilogistics", Biggs et al. (2021) explain the potential for the reconceptualisation of data for a more-than-human understanding of "soil":

> "As soil health is an established way to combat the effects of climate change, taking the abstract notions of soil "data" and translating them into tangible, visceral imaginaries and understandings might be critical for encouraging more farmers to adopt posthuman agricultural ontologies. This reconceptualization of data can be seen as a larger project within HCI to make data's ambiguity visceral and embodied."

Biggs et al. (2021) highlight the significance of acknowledging the "livingness" or health of soil by reconceptualising data. This is because the vitality of non-humans

supports our planetary good life and raises awareness about the detrimental effects of human activities on climate change.

In relation to the approaches of HCI researchers, we deeply reflect on the ontology and epistemology of data , in a multispecies context, using tomatoes to situate these reflections. We introduce a new concept of data, "Pheno-data," which allows us to explore the contingent and emergent aspects of living beings *becoming with* the lifeworld. Additionally, we propose a new approach of "Pheno-fication", to working with this data, which embraces the relational, situated, and embodied attributes of the lifeworld. Using Fabulation as a design method (Rosner, 2019), we integrate these ideas to reveal the entanglements between humans, non-humans, and the lifeworld and provide a tangible experience of the tensions between anthropocentric and more-than-human worldviews and knowledges.

4. Pheno-data for tomatoes and world's becoming

4.1 Pheno-data for the livingness of our planet

Various forms of life and death exist in this planet that interdepend, interact, and respond to each other to sustain the complex web of *living* systems. Within these systems, microbes, plants, animals, and humans, each possesses their own bodies, agency, and rhythms, continually reshapingand being reshaped by interaction with an array of species and non-living matters—viruses, land, water, and machines.

As observed by Karana et al. (2020), living organisms exhibit a range of biological processes, from growth and metabolism to response to stimuli and reproduction, that are all deeply connected to their physical *bodies*. Moreover, they establish intricate ecological *relationships* that encompass cohabitation, intra/interspecies interaction, and engagement with non-living elements. Within specific

contexts, organisms display adaptability to changes and respond to the contingency of times and spaces.

The unique nature of living organisms catalyses the emergence of embodied, ecological, and more-than-human knowledge across geological, biological, and social spheres of the Earth. As explained by Karen Barad (2007), living organisms, as agential apparatus, create a momentary "cut" to distinguish between what matters, which strongly relates to life and death, and is excluded from mattering. In the Earth where everything is interconnected, humans and non-humans create temporal separation through "boundary-drawing practices" to bodily experience specific *phenomena* or events as “part of the world’s dynamic engagement in practices of knowing”. In her book, *Meeting the Universe Halfway,* Karen Barad (2007) provides an example of brittle stars—brainless and eyeless creatures—as agential beings:

> “A brittlestar can recognize a predator and successfully negotiate its environment to elude capture despite the fact that it has no brain. A brittlestar is not some ideal Caresian subject, but through specific practices of intra-active engagement, it differentially responds (not simply in the sense of responding differently to different things that are out there but) in ways that matter. There are stakes—life-and-death stakes—in getting it wrong.” (p.398)

We have discussed the importance of the living, lived, and life aspects of organisms, which enable them to bodily *become with* the living and nonliving elements of the Earth in matters of life and death. The exceptional capability of living beings enables them to evolve into a multitude of *phenotypes*, that is, into observable traits that result from the interaction of the organisms’ genes and environment (*Britannica*, 2023, July 27). This intricate process allows organisms to develop structures, behaviours, and

products that enhance their survival in diverse environments, even changing their DNA and passing such traits down through genetic inheritance.

Similarly, in our concept, data is seen as tangible, relational and becoming with the environment, which we refer to as "Pheno-data". Pheno-data combines the prefix “Pheno” derived from *phenomena* and *phenotype*, with “data”, representing the entanglement of lifeworld. Pheno-data therefore represents the livingness of the world tangibly, through evolving characteristics (colours, forms, movements, and rhythms) and responses (participation and engagement) of organisms which are equally shaped by and in turn shape the environment (other organisms, non-living matter, etc.).

The concept of phenotype has been applied diversely in different disciplines and has become controversial. For instance, in genetics, the technique of "(DNA) phenotyping" has been developed for healthcare and plant breeding. These techniques often view genes as "blueprints" that provide significant data for predicting and even controlling variations in phenotype. In computing, researchers have extrapolated these genetic approaches into the world. They have used the term to refer to methods of unobtrusively capturing daily behavioural data that can potentilly indicate traits of an individual, their state of health and illness for instance, all based on ubiquitous usage of smartphones.

Such methods are known as "moment-by-moment quantification of the individual-level human phenotype in situ using data from personal digital devices, particularly smartphones" (Onnela, 2021), and have been used particularly in the context of healthcare, Some HCI researchers, however, express concerns about potential technical and ethical challenges related to data collection and analysis (Rooksby et al., 2019). These challenges include an excessive focus on individual behaviours rather than

considering broader contexts and situations, diagnosing an individual's well-being based solely on collected daily data without considering their autonomy and dignity, and concerns about the privacy of sensitive personal health data (Rooksby et al., 2019). Ultimately, these various "Phenotyping" techniques in multidisciplinary fields aim to monitor and predict the physical and mental well-being of humans, animals, and plants by considering behavioural data, their “phenotype” and a particular blueprint, their “genotype” without taking into account the flow of environmental factors and possible changes to the format and interpretation of the blueprint.

Therefore, our approach and focus on the concept of “pheno”s significantly as it places emphasis on flows of change in situational and environmental factors. We acknowledge the significance of understanding the phenotype of organisms as a way of knowing the evolving world. In line with the argument presented by Oyama (2000), we consider the phenotype of organisms as a contingent and unpredictable manifestation of the lifeworld influenced by various causal factors. Rather than attempting to predict the development of a particular being, let’s say a tomato, into a narrow future state, we focus on embracing the contingency and wildness of the lifeworld, using it as evidence of its interaction and being in the world, while striving to connect with ever-evolving phenomena around towards what truly matters for multispecies survival, which is particularly relevant with unpredictable patterns presented by climate change.

Although humans have been historically familiar with “Pheno-data”, through practices of attending to and caring for other beings and nature (through farming, gardening, and child rearing), such familiarity has been subsumed by objectified notions of data, information and predefined trajectories of progress, which work in ways to quantify, decontextualise and finally demote these practices. In the following sections,

we use tomatoes as a provocation to move from this tendency towards “Datafication” to a form of “Pheno-fication" of data.

4.2 Datafied tomatoes and lack of “livingness”

Data has been used to optimise the commercialization of tomatoes on a global scale. This includes the collection of quantifiable and measurable data on tomato plants (e.g., genes, colours, shapes, and sizes), and controlling environmental factors (e.g., pollination, temperature, humidity, and biotic stress) as well as the monitoring of logistics to transport and store tomatoes without damage or bruising (e.g., firmness, weight, timing, and temperature). Data on food labels for commodified tomatoes include producer brands, country of origin, nutrition facts, and shelf life (Heuvelink, 2005). The excessive focus on specific types of data for the productivity and efficiency of tomatoes has obscured our embodied experience, memories, stories, and imaginations associated with the life and livingness of tomatoes and the world.

These types of data have been used not only to support distribution but also to change the very physical characteristics of tomatoes. Humans have engineered, grown, and consumed tomatoes as a commodity through different levels of domestication. Breeders and bio-scientists have engineered more than 10,000 cultivars of a species of tomatoes to optimise quality, quantity, and durability. Tomatoes also serve as a “model crop” in the biotechnology industry due to their short life cycle and easy manipulation (Heuvelink, 2005). Production systems typically involve highly controlled greenhouses with modern technology for high-yield fresh tomatoes, open fields for processing, and plastic-covered structures for fresh consumption. Additionally, vertical farming is becoming increasingly available, allowing tomatoes to be grown in even more controlled indoor systems (BBC, n.d).

Despite the range of tomato species bred and cultivated, the highly controlled environments and production systems work towards reducing differences. In Western industrialised societies, a bag of tomatoes can be easily purchased in a supermarket. However, their shape, taste, and colour do not reflect any particular context. In other words, there is little chance that such tomatoes will elicit any stories, connections, or imaginations about the lives of tomatoes, insects, animals, labourers, and the environment where they grew as living plants, often because there is indeed little variability in environments geared towards large tomato production. The highly controlled conditions that dismiss any ecological livingness around these tomatoes, combined with the large scale of production can lead to perfect-looking red tomatoes, often from a single species, which lack differences in flavour, form, and resilience, exploiting tomato farm workers, and endangering bees and other insects (Alexander, 2022).

In contrast, gardeners and local farmers are preserving and growing open-pollinated heirloom tomatoes to "connect us to our ancestors, the land, and our history," as William Alexander (2022) notes in his book. It would be important to investigate their approaches and practices, actively engaging with other beings' participation and collaboration, to overcome the ecological challenges of the datafied living world, and to appreciate and respond to the “harmonious rhythm of life” (Bennett, 2010).

4.3 Power of Pheno-data in the context of tomatoes

In the context of tomatoes, Pheno-data refers to *situated, embodied, and given* characteristics and responses that can be interpreted as information and knowledge by all beings, as well as connect to human imagination enabling us to pay attention to the ecological livingness of tomatoes, our own livingness, and that of other beings and the environment more broadly. Considering the pheno-data of tomatoes would invite us to

pay attention to tomatoes' tangible bodies and movements, their engagement and configuration in a polyphonic rhythm of the lifeworld, as well as to unknown and known local, geographical, and evolutionary stories of them. In other words, as a human (self), *accessing* Pheno-data in the context of tomatoes would mean:

1) Resensitising physicality and materiality of tomatoes entangled with surroundings. The material bodies and movements of tomatoes and their surroundings allow us to fully engage with them through our senses of sight, sound, taste, touch, and smell. Through the sense-making practice (Lupton, 2018), we can notice subtle and nuanced Pheno-data about the livingness of lively situations, which often *provokes* powerful emotions, memories, and imaginations (Ingold, 2000; Bennett, 2010; Tantia, 2020).

2) Recontextualising happenings and meanings of their interaction and participation taking place within a particular context. By observing Pheno-data in a given context, we can perceive the *thick* presence of both humans and non-humans as well as the environment that surrounds them (Haraway, 2016). As a tomato plant grows, it undergoes continuous changes in size, colour, structure, and rhythm while interacting with the diverse visible and invisible beings in its environment. This reveals the tangible meanings and implications of entangled, situated, and localised relationships between the plant and its environment. As a note, humans have explicitly led to singular and dominant meanings and implications through economic, political, and technological contexts of domesticated tomatoes.

3) Reimagining possible evolutions of tomatoes and multispecies world-makings embracing emerging happenings, phenomena, situated knowledge and stories from multispecies. In some of the wilder and less-human touched places in the world, such as

the Galápagos, wild tomatoes have undergone evolutionary adaptations to thrive in the unpredictable and untamed wildness of nature. Consequently, these tomato plants have developed various phenotypic traits. Their green bodies, flowers and fruits have different colours, shapes and flavours while encountering multispecies and attracting some of them that aid in the dispersal of their seeds. Their Pheno-data carries all these relationships, fuelling ecological imagination.

As one of the multispecies, humans also have cultivated certain (hi)stories of tomatoes. Domesticated tomatoes, once deemed perilous and labelled the "Devil's fruit" until the 16th century, have become a globally ubiquitous culinary ingredient. Facilitated by colonial and trading histories, tomatoes are named "Pomodoro" (golden fruit) in Italy, "Pomme d'amour" (love apple) in France, and "番茄" (foreign eggplant) in China. They also are linked to social and cultural histories such as “German feminism”, owing to a tomato-throwing incident involving a feminist activist and “La Tomatina”, a tomato fight festival in Spain. Even in the realm of entertainment, the movie "Attack of the Killer Tomatoes" is about a fictional story that tomatoes becoming sentient by unknown means and revolting against humanity.

How do these (hi)stories affect their bodies and vice-versa? Could the consideration of their bodily attributes through the notion of Pheno-data change the way we tell these (hi)stories and relate to tomatoes? What if we saw tomatoes through a phenomenon of “Pheno-fication” rather than “Datafication”? By resensitising, recontextualising, and reimagining Pheno-data in the context of tomatoes, Pheno-fication could help us recognise a broader and connected ecological world that embraces what matters to all beings—one that involves not only humans and technology but also other living and non-living beings and nature. As a result, we would regain and

enhance our curiosity, appreciation, and responsibility towards the more-than-human world, which involves more living, vibrant and meaningful participation of multispecies.

5. Method

In order to leverage these concepts, we have developed a fabulation workshop that provides a hands-on experience to explore the potential of Pheno-data and Pheno-fication. In this workshop, we employ Fabulation as a design method to enact the concepts of Pheno-data, lived experiences, beliefs, and values into an imagined world. It allows both designers and non-designers to tangibly explore the potential of Pheno-data and Pheno-fication in the context of "data practice through design" (Lee et al., 2022)—a practice to embrace ecological uncertainty and complexity of data, people and the world.

As shown in Figure 1, this exploration aims to engage in the process of reconnecting with the lifeworld and fabulate a more-than-human world. This involves revealing tensions between more-than-human knowledge and anthropocentric knowledge in imagined alternative lifeworlds that exist not only in the future but also "in the past, present, and future, or extend from the past to the present and then into the future" (Sødergaard, et al., 2023). We provide details regarding the preparation, structure, and process of the fabulation workshop, which was conducted with 32 post-graduate design students.

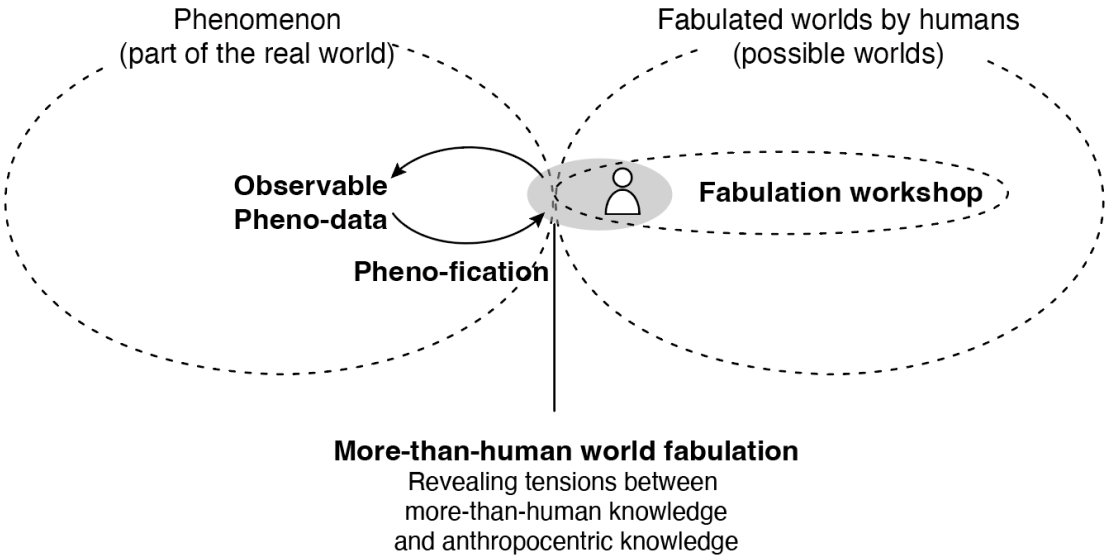

Figure 1. Visualised relations between Pheno-data, Pheno-fication and Fabulation for a more-than-human world-making process

5.1 Fabulation for reconfiguring and reimaging pasts, presents and futures of the world

Feminist and posthumanist HCI scholars (Rosner 2018, Nijs et al., 2020, Sødergaard, et al., 2023) have been advocating for fabulation as a powerful tool to help designers and researchers de-center humans, reconstruct ecological temporalities beyond narrow human timescales, and reconfigure the meanings and relationships between humans and nonhumans from a more-than-human perspective. Donna Haraway, who is one of the key scholars working on fabulation as a renewal means of multispecies storytelling, introduces Speculative Fabulation in her book, *Staying with the Trouble (2016)*.

> "Neither the critters nor the people could have existed or could endure without each other in ongoing, curious practices. Attached to ongoing pasts, they bring each other

forward in thick presents and still possible futures; they stay with the trouble in speculative fabulation." (p.133)

In her paper, contemporary philosopher Aline Wiame (2018) examines the concept of fabulation as developed by Bergson, Deleuze, and Haraway and explains the potential of fabulation to overcome dualistic thoughts (true/false, human/nonhuman, abstract/affective) and to enable us to "develop life stories making room for an ambulatory approach to beings characterised by multilevel precarity and co-dependency" to move forward towards a co-living world. In HCI, the concept of fabulation has been adapted as a new design practice within the critical and speculative design and explored to acknowledge subjugated, invisible, and marginalised labours and women while criticising conventional norms and systems of capitalism and technological determinism (Rosner, 2018), empower feminine and nonhuman bodies (Sødergaard, et al., 2023), and to decenter humans and focus on more-than-humans in an urban environment (Nijs et al., 2020).

The practice-based studies demonstrate that fabulation brings "lost or unacknowledged situations into the present and rework the margins of design by remaking the stories that get told with the stories we neglect to tell" (Rosner, 2018), offers "a shift in temporalities across pasts, presents and futures, by troubling linear narratives and a human temporal stance" (Sødergaard, et al., 2023), and allows us to "imagine more modest, down-to-earth, terrestrial tales in a less techno-heroic reading" (Nijs et al., 2020).

In our workshop, we start with Pheno-data as a means of shifting away from our anthropocentric perception of living and non-living as commodities or objects. Next, we use fabulation as a scaffold to experience alternative world-makings through Pheno-

fication and help us reveal tensions between our anthropocentric knowledge and more-than-human knowledge. By adopting this approach, we can recognise our limited and dualistic perception of "natureculture" (Haraway, 2003) in the reimagined stories. This, in turn, empowers us to pay more attention to other beings and nature and to create more diverse stories for all beings.

5.2 Workshop structure

We organised a two-part workshop with a week in between, engaging a group of 32 post-graduate design students. The first part of the workshop was a 90-minute in-class session that introduced the concept of Pheno-data, involved design activities for fabulating alternative worlds and ended with a short reflection on the notion of data by asking students to write about how the meanings of data have changed for them. The second part consisted of an individual reflective assignment to fully focus on a process of Pheno-fication to access Pheno-data. It gave students the chance to delve deeper into Pheno-data with sufficient time by reflecting on the insights gained from the fabulation activity. After one week, the students shared representative images and descriptions of their work on a Miro board.

Both parts of the workshop were conducted with students' consent and ethical approval from the University (Ethical approval number: 193402-193395-104313792). The presentation of results from the fabulation activity in the first part of the workshop was audio recorded and photographed.

5.3 Workshop Part I: Resensitising, Recontextualisation and Reimagining

The workshop began with the question "What is data?" and students used sticky notes to write down their thoughts on the question. This was followed by a short introduction

about why rethinking the notion of data is significant for imagining alternative ecological worlds and what Pheno-data would mean in the context of tomatoes. Next, they were divided into 8 small groups and selected one species to carry out the design exercise consisting of resensitising, recontextualising and reimagining (Pheno-fication) as part of fabulating alternative lifeworld stories as shown in Figure 2.a.

1) Resensitising to chosen organisms and their surroundings. In this workshop, we included a variety of living organisms, including chickens, cows, butterflies, bees, snails, birds, as well as tomatoes in order to gain new insights and outcomes from multispecies storytelling (Haraway, 2016). Each group selected different organisms and specified types of living organisms (e.g. mockingbirds) or locations where they inhabit (e.g. butterflies in Red River Butterfly Valley, China and snails in an urban area).

During the workshop, students also conducted research through visual images, videos, and texts about the organisms' biological bodies, habits, and life cycles. The specification helped them to evoke feelings, memories, and imagination with the specific organisms, drawing from both their lived experiences and newly acquired information which was more focused on the livingness of the organism which we would later discuss in the context of Pheno-data.

2) Recontextualising meanings of its interaction and participation taking place within a particular context. Students contextualised the living organism by mapping out their meanings and relationships with human and non-human entities from social, economic, political and environmental perspectives (Springgay & Truman, 2017) on a large sheet of paper. To begin this phase, students were provided with a set of questions to guide their thinking to do the mapping exercise. These questions such as:

- Where is the living organism located?

- Who and what interacts with the living organism? How and why?
- What are the meanings and impacts of the different relationships?

This phase aimed to build upon the resensitising phase and encourage students to recognise the entangled web of relationships among multispecies, symbolic and functional meanings of the living organism's participation, and even the power of humans in deconstructing the existence and relationships of more-than-human lives (e.g. tourism of wild butterflies and mechanised milking from cows)

3) Reimagining possible evolutionary stories of chosen organisms and multispecies world-makings. In this phase, students were asked to imagine alternative lifeworlds based on facts, fiction, and trends from a contextualised map of an organism. Each group fabulated a short narrative about a world, including the broader entanglement of symbiotic beings (e.g. parasites, companions, and predators), social, technological, and environmental trends (e.g. gene editing and climate change), existing stories and histories, and evolutionary facts and fiction of the organism. Before concluding the workshop, we briefly asked them to consider how this new approach to data (Pheno-data) differs from conventional concepts of data and write down their thoughts on sticky notes as shown in Figure 2.b.

Figure 2. Snapshots of a) students' in-class activity and b) collected definitions of data

5.4 Workshop part II: Reflection

In the second part, students did an individual exercise to explore Pheno-data and Pheno-fication. In the first part of the workshop, students naturally brought diverse data that combines their lived experience, knowledge, beliefs, and Pheno-data to fabulate alternative lifeworlds. This second phase was crucial in our workshop as it provided an opportunity to iterate the practice of "Pheno-fication," experienced through the fabulation exercise, with a focus on "Pheno-data" in an ecological context.

Students explored their own surroundings to find Pheno-data and elaborated on the meaning or interpretation this data elicited to them. As design researchers, we analysed their outputs to undertand the potential relation of Pheno-data and Pheno-fication in the context of data practice (and knowledge production), to regain a sense of the livingness of the natural world. The exercise was carried out on a collective Miro board, where we added the following guidelines:

> "*While we might think of data as something living in a computer, there are many other ways in which data can be considered as manifesting around us. For instance, an archaeologist would consider fossils or remains of previous times as data… Now we would like you to do the detective work and look for representations or data in nature, beyond what is captured in databases. Please look for 2-4 representations of data in the world and include at least one that differs from traditional notions of data as in databases."*

One week later, we analysed their assignment results (Figure 3). It helped us uncover tendencies in their practice to move towards Pheno-fication, or the interpretation of the co-inhabitant world through Pheno-data.

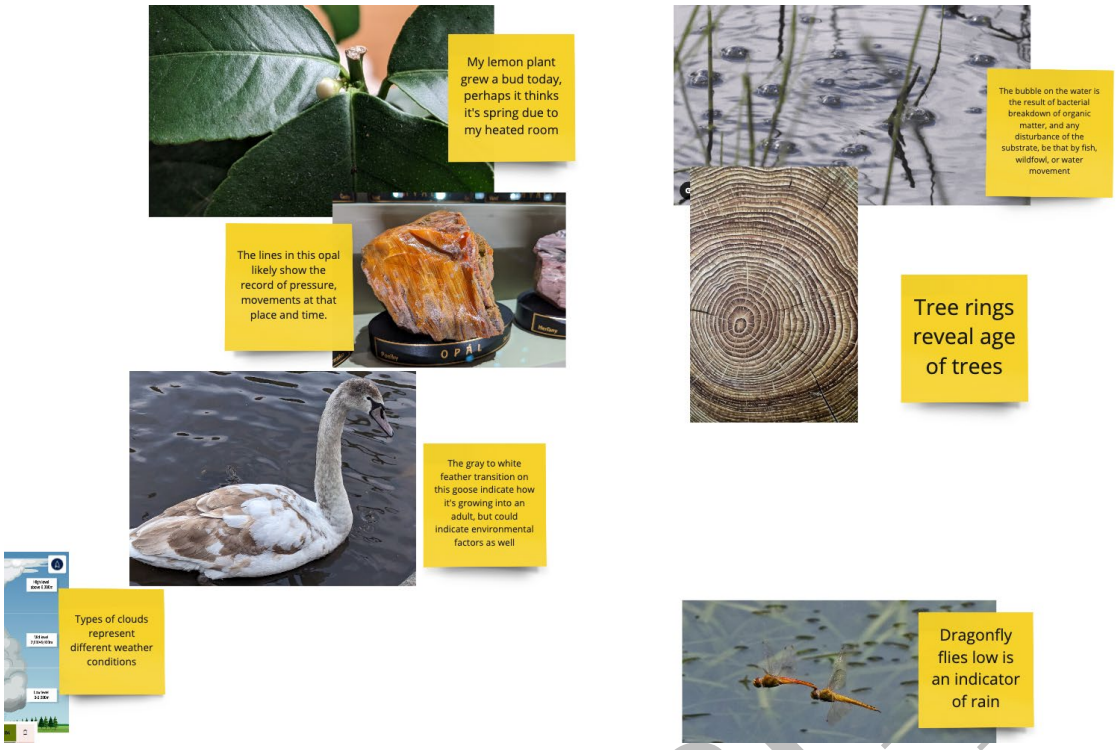

Figure 3. A snapshot of students' assignment shared on Miro board

5.5 Data collection and analysis

In the first part (in-class exercise), written texts and sketched drawings (from each contextualised map and imagined story) were collected from the corresponding student group's large sheets of paper. Data was also collected in the form of post-it observations gathered at the start and end of the workshop. Students' presentations were audio-recorded and transcribed. In the second part (individual online assignment), data was collected through images and notes posted on a Miro board. To analyse data from both parts, the lead author identified keywords to create clustered themes.

Meanings of texts and images of the first part were interpreted based on students' presentations about fabulated stories and short conversations with student groups during the workshop. The interpreted data further classified under social and cultural (general perception), technological (rationalistic and dualistic approach), economic (commodification and datafication), biological (livingness of the world), and

environmental (other beings and nature) categories related to the chosen organism, humans, and surroundings. These were clustered to create potential themes that summarise design challenges and opportunities for fostering an ecological perception to a more-than-human world.

Furthermore, two authors analyzed texts, notes, and visual images of students' answers on what data and Pheno-data are from both parts of the workshop under the categories of conventional data and Pheno-data. Notes of students' thoughts on Pheno-data from the individual assignment were further analysed and interpreted to gain insights into their new tendencies and approaches towards the Pheno-data. This analysis revealed the potential of Pheno-data and Pheno-fication. The processes and outcomes of both data analyses were shared and discussed with the two co-authors and improved accordingly.

6. Outcomes

6.1 Workshop Part I: Fabulating alternative world stories

The students explored the complex relationship between living and non-living entities through nuanced written texts and sketches in the forms of facts, histories, beliefs, ideas, and norms from diverse perspectives (social and cultural, economic, technological, biological, and environmental). They fabulated narratives to imagine alternative human and nonhuman worlds by involving Pheno-data in the mapped context.

Generated themes. We collected keywords based on the categories of social, cultural, economic, technological, biological and environmental factors. Clearly, while keywords in social, cultural, economic, technological categories tended to refer to a human-centered perspective—e.g by describing chosen organisms as commodities, pests, objects for scientific, cultural, and creative motivation, keywords in biological

and environmental categories referred to the life and ability to live of the chosen organisms within their ecologies and surroundings (other beings and geographical locations).

By analysing these different tendencies of factors around living organisms and seeing how these tendencies are influenced to create fictional narratives, we generated three themes through the three representative narratives: 1) Noticing and appreciating livingness and resilience of non-humans 2) Care for non-humans 3) Humans and non-humans' polyphonic lifeworlds.

Selected results of fabulation. In this paper, we present the results of three groups as representative examples of the themes above, as shown in Table 1, they are: Future Snail as an Indicator of the Heat Island Effect, Butterfly Religion, and Tind-bird. These results explicitly elaborate how the livingness or evolving characteristics (Pheno-data) of the chosen organisms could influence and be influenced by anthropocentric knowledge in the imagined alternative world in their narratives.

Title	Elements	
Group A: Future Snail- Indicator of the Heat Island Effect	Living organism	Snail in a city
	Contextual factors	- Biological: dentritivore, tentacle (long: eyes/ short: smell) - Environmental: food chain (firefly, chicken, duck, plants, crops, wastepaper, dead worms, fruits, squirrels, humans, birds, small mammals), tree, land, garden - Social, cultural, economic, technological: wild and farmed snail, slime (skin care ingredient), a symbol of laziness, food, pet, pest for crops, parasitic dieases
	Fabulated narrative	Snails can absorb thermal radiation with their shell, so future snails may have lighter-coloured and simpler patterned shells. These shell changes could indicate the heat of a city.
Group B: Butterfly Religion	Living organism	Butterflies in Red River Butterfly Valley, China
	Contextual factors	- Biological: egg, larva, pupa, imago, attracted to light (instinct) - Environmental: bugs, ants, flowers, bees (competitor), lighting, parks, streams, farm yard, seeds, microbe, temperature, weather, water, rain, soil, trees, bamboos, cities and buildings, season - Social, cultural, economic, technological: commodity (honey, silk, make ups, paintings, specimen, perfumes, food, medicine), factory, hunt (with a butterfly net), religion, spiritual, curt, song, poem, science research (indicator species), education
	Fabulated narrative	To protect endangered butterflies, create a religion that worships butterflies.
Group C: Tind-bird	Living organism	Mocking birds
	Contextual factors	- Biological: mate for life, copying bird/insect sounds, incubation (12-16 days) for 2-6 eggs, breeding early summer/spring, living in forests, nest construction, seeds dispersal, female and male sizes, good eye sight - Environmental: food chain (squirrels, owls, cats, eagles, predator, berries, insects, worms, grasshoppers, fruits), forests, disease, habitat (North America, Canada, Mexico), - Social, cultural: Eminem song 'Mocking bird', book 'how to kill a mocking bird, symbolism, scientists, culture song, farmer, music, bird watcher (fool them with mimicking sounds), carry disease
	Fabulated narrative	The mimicking sound ability of domestic mockingbirds can be used for matching couples, similar to Tinder.

Table 1. Summary of chosen living organisms, contextual relationship mappings and fabulated narratives by three groups in the workshop

Snail in an urban city in theme 1) Noticing and appreciating livingness and resilience of non-humans. The A group chose to focus on snails that inhabit cities. From the beginning, the group identified economic, social, and cultural factors related to snails based on their experiences. For example, they considered how snails are used (food, skincare ingredients, pets), how they are perceived generally (parasitic diseases, pests), and how they are symbolised due to their slow movement (laziness). They also explored biological and environmental factors, such as snails' position in the food chain,

their diet, and how they interact through their tentacles. The group researched further on snails' biological information and found a scientific research paper (Kerstes et al., 2019) that reveals how urban heat can affect snail shell colour evolution as shown in Figure 4.a.

They then fabulated how the heat island effect could influence colour of snail shell in near future and drew the imagined snails as show in Figure 4.b. They said that "the temperature of the city will be warmer [...] It means the snails' shell with less colour on the top and darker colour on the bottom, as the darker colour helps with thermoregulation." To create this narrative, they realised the ability of snails to adapt to certain heating conditions with their shell colour transitions and used the colour of snail shells as Pheno-data, imagining a world in which the evolutionary changes of snails can indicate the temperature conditions of our shared environment.

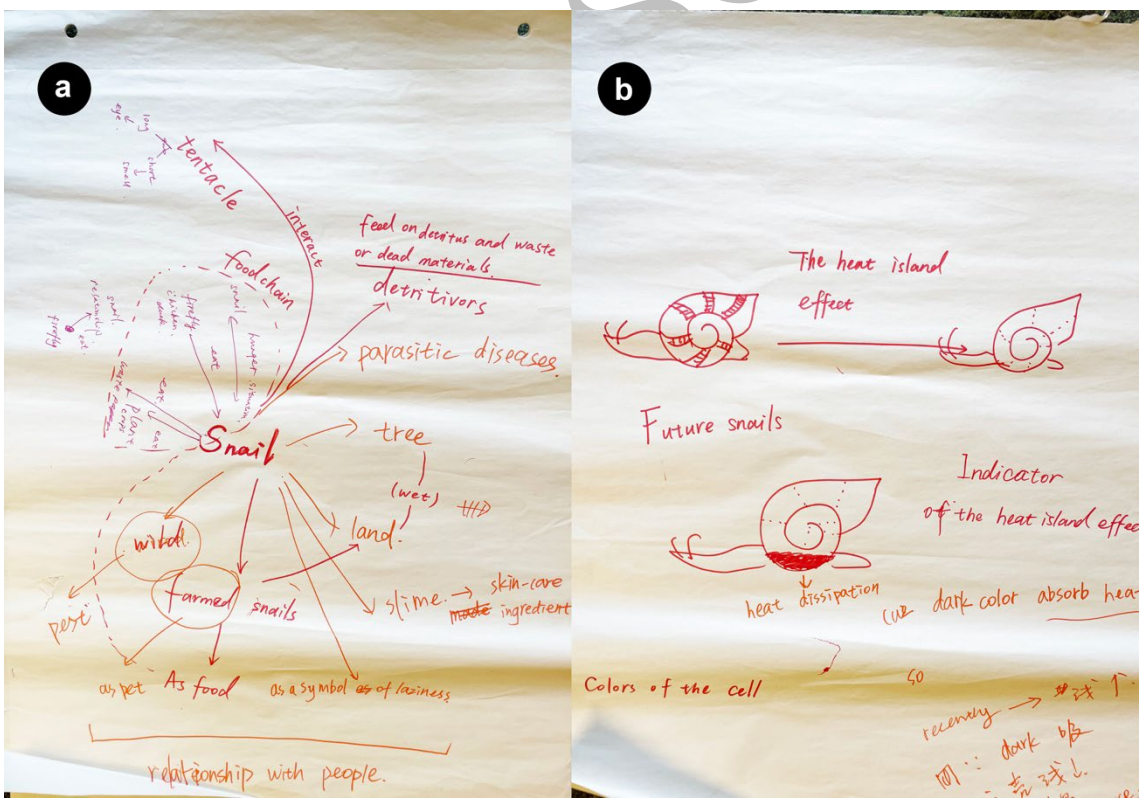

Figure 4. a) Contextual relationship mapping results of group A b) drawings for the fabulated narrative

Butterfly Religion in the theme 2) Care for non-humans. The B group began by choosing a specific location, Red River Butterfly Valley, to develop a contextual relationship map of butterflies as shown in Figure 5.a. The valley is a popular tourist attraction known for its numerous red Chinese butterflies, beautiful mountains and streams, and local activities. The natural and local aspects of the location led the group to explore diverse environmental factors such as bugs, ants, flowers, bees, parks, streams, bamboos and cities, as well as cultural factors such as the symbolic, religious, artistic meanings of butterflies. They also considered the biological factors of butterflies related to their life cycle (egg, larval, pupa, imago) and temporality, which was seen as interconnected with nature-based tourism. Considering tourism, environmental, and biological factors, they found recent news reported on the decline of butterfly populations due to climate change and pollution.

The B group created an elaborate speculative narrative that considers climate change as a crucial trend and drew some sketches on a large sheet of paper as show in Figure 5.b. They imagined an alternative world where people worship endangered butterflies as a religion and had therefore developed religious and cultural systems to celebrate these divine creatures globally. In the narrative the UN would dedicate a day to commemorate butterflies, and various organisations, bibles, poems, and songs would emerge to support this new religion. Furthermore, the narrative shows how this new form of worship would influence our economy and create a new technology.

> *"Our topic is about the butterflies. With more people caring about the ecology and butterflies, we actually established a butterfly religion. Here is our butterfly bible.*
>
> *[this comes with] some restrictions to the public, like factories and farms for butterflies are forbidden since they are sacred to our religion. We actually provide more parks and green spaces in the cities for them to have natural environments and*

the residents. We have asked the restaurants to provide more butterfly-related foods [...]. McDonald's has changed its logo into a butterfly shape to meet the trend, new developed chips, fries, in McDonald's is named as the butterfly chips. We also have a huge museum which exhibits the life stages of the butterflies and we also have a trained butterfly group for the circus play. Another cultural fact we're developing is about the poems. Actually, we are using European technology to edit previous poems and replacing key items in them with butterflies. For example, there's one line in the USA that goes like "In God we trust." After the European program editing, we will change it into "In butterflies we trust." That's the future of the butterfly religion."

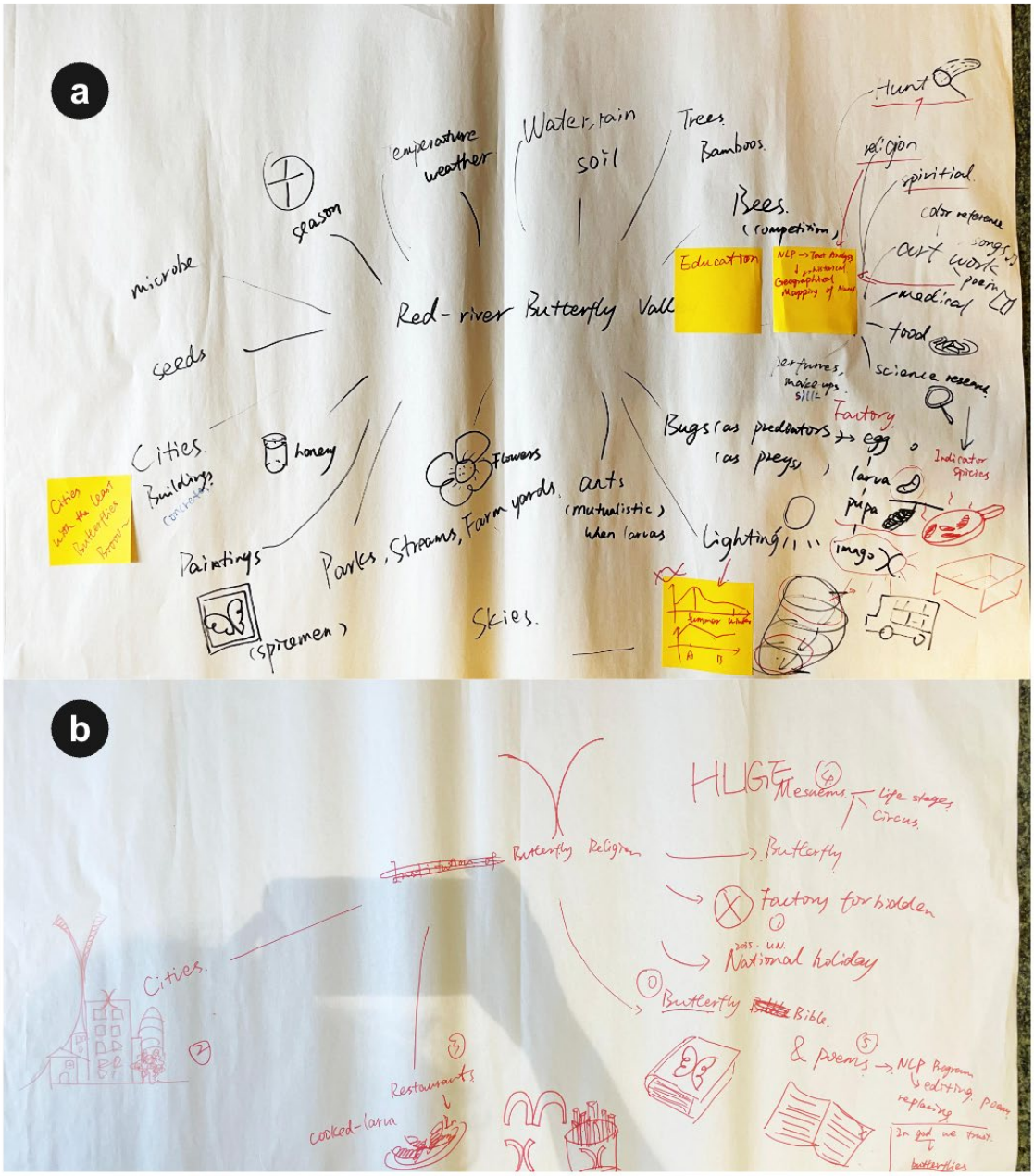

Figure 5. a) Contextual relationship mapping results of group B b) drawings for the fabulated narrative

Tind-bird 3) Humans and non-humans' polyphonic lifeworld. The C group chose mockingbirds for their contextual relationship mapping exercise. Compared to the other groups, this group spent most of the time understanding the wild birds, which were unfamiliar to us. This led them to concentrate more on the biological and ecological factors. They delved into mockingbirds' biological functions, behaviours and

life cycle, such as their unique ability to mimic other animal sounds and their skills for building a nest as shown in Figure 6. Additionally, they investigated the environmental factors such as their geographical habitats and how food chains look like around the bird.

The C group focused on social and cultural trends, such as the increasing number of social media users, people living isolated lives, and the number of pet owners. They developed a speculative narrative based on mockingbirds' ability to mimic other animal sounds. In the narrative, the birds would replace Tinder, a popular dating application, by delivering courteous messages between humans (and even non-humans). The group explained how this ability could be influential in solving social isolation challenges. Furthermore, they showed how the power of mockingbirds' ability to mimic sounds could inspire and help humans connect with nature, blurring the boundary between nature and culture, despite the human-oriented perspective.

> *"While humans can play the instruments, the birds can sing in the background. They can [...] inspire musicians by letting the bird go outside and picking up different sounds, different music, different from nature, and inspiring the musicians with their different musical abilities."*

Overall, the fabulation exercises revealed that the time spent researching living organisms, the contextual factors mapped, and the functions and meanings of the relationships between living organisms and humans, varied depending on the degree of familiarity or domestication of the organisms. The three groups' fabulated narratives were also diverse, with different ways to integrate livingness of organisms, environmental contexts, and human-oriented factors together in anthropocentric contexts (urban city, tourism, social media). The students unwittingly tended to imagine ecologies in which humans played an active role, by indirectly modifying, giving

visibility, symbolising, and domesticating living organisms (snails, butterfly religion, and Tind-birds) to alleviate challenges such as environmental depletion, endangered species, and social isolation. However, humans were also deeply affected by these species, with their cultures and lives being changed by the butterflies, or mediated by the mockingbirds.

Figure 6. Contextual relationship mapping results of group C

6.2 Workshop Part II: Reconsideration of data for a more-than-human world

Prior to starting the first phase of the workshop, we asked participants for their understanding of the term "data." Responses were written on sticky notes as follows: numbers, words, quantitative and qualitative information, pictures, visible and invisible materials, tables, data visualizations, measurement, and calculation. After the first phase, we gave the assignment of finding Pheno-data in nature (and explaining why they considered it as Pheno-data) to encourage them to collectively expand on the initial

notions of data and explore the implications of this expanded notion on the ecological world, through a reflection-in-action process (Schön, 1992).

The results of the assignment (Table 2) indicate the potential of Pheno-data and Pheno-fication in nudging mindsets towards an ecological understanding of the world. In their results, Pheno-data were derived from a wide range of living organisms, from the *evolving bodies and rhythms* of lemon trees and geese to responses of dragonflies, octopuses, corals, and fireflies, to *responses* to weather, enemies, and pollution, and even *productions* from microorganisms (such as lights and gas bubbles) and birds (such as sounds). Students also recognised Pheno-data from non-living entities, such as lines and layers of opal, changes in the position of the sun, tide and stars, waves created in the desert by wind, and the movement of fish and winds created by ocean currents, as crucial for retaining the livingness of our planet. To gain deeper insights into our concepts focusing on the power of livingness, we selected examples of Pheno-data derived from living organisms and interpreted students' notes based on the form of Pheno-fication (sensitising, contextualising, imagining).

Through a series of workshops, we found that different focuses and practices of data can lead to expanded ecological perceptions, centered on situatedness, locality, different nuances, responses, rhythms, entanglement, and evolution of multispecies and the environment. At the end of the in-class workshop, one participant shared her sticky notes by saying that *"I used to believe that data was what we could get from the real world, but now I consider that data is how we can understand the real world."* This quote highlights the potential of expanding our understanding of data beyond "datafication" trends. Through this workshop, we were able to encourage participants to consider the richness of data expressions in the world and the complexity of relationships between humans and non-humans.

Texts from participants	Pheno-data	Pheno-fication
My lemon plant grew a bud today, perhaps it thinks it's spring due to my heated room	A growing bud from the lemon plant	- Sensitising: movement, temperature - Contextualising: Bud, lemon plant, heated room - Imagining: the plant might think it's spring
The gray to white feather transition on this goose indicate how it's growing into an adult, but could indicate environmental factors as well	Colour change of the goose's feather	- Sensitising: color transition of the feather - Contextualising: colors of feathers, aging goose - Imagining: a possibility of environmental influence on the feather
The bubble on the water is the result of bacterial breakdown of organic matter, and any disturbance of the substrate, be that by fish, wildfowl, or water movement	Bubbles from the water surface	- Sensitising: upcoming bubbles on the water - Contextualising: bacterial breakdown of organic matter, disturbance of the substrate - Imagining: thinking specific possibilities such as fish, wildfowl, or water movement
Bioluminescence in shores show the presence and location of certain microorganisms	Bioluminescence from microorganisms	- Sensitising: color and movement of bioluminescence - Contextualising: shores, presence and location of certain microorganisms - Imagining: conjecturing the existance of invisible microorganisms
Coral species and growth conditions reflect the water temperature, the condition of sediments, the degree of pollution of of a certain sea.	Coral species and growth	- Sensitising: species and growth - Contextualising: sea water temperature, sediements, pollutions - Imagining: conjecturing temperature and health conditions of sea)
Dragonfly flies low is an indicator of rain	Dragonfly flies low	- Sensitising: movement of the dragonfly - Contextualising: dragonfly, the weather - Imaginging: conjecturing rainy weather
Mosses must live in damp areas where there is moisture readily available for them to take in. So they are a sign that this area is wet and moisture.	Mosses' life in damp	- Sensitising: mosses' bodies and health - Contextualising: mosses, moisture, damp area - Imaginging: conjecturing if the area is wet or not
Fireflies have high requirements on the living environment and are very sensitive to environmental changes, so they can be used as the most intuitive environmental indicator insects. The number of fireflies is a measure of the quality of the local environment. The living environment of fireflies is an ideal living environment for human beings.	Presence and life of fireflies	- Sensitising: presence of fireflies - Contextualising: sensitive bodies of fireflies, quality of life, local environment, human-beings - Imaginging: conjecturing if the local environment is ideal for living
Migration of animals can be used to perceive the change of seasons	Migration of animals	- Sensitising: migration rhythm of animals - Contextualising: animals, climate, seansons - Imaginging: conjecturing what season is coming through a specific pattern of specific animals' migration
The different forms of mimic octopuses imply that they are in different environments, imitating poisonous animals to scare away predators	Forms of mimic octopuse	- Sensitising: different forms of octopuses - Contextualising: octopuses, predators, poisonous animals, an environment - Imaginging: conjecturing octopuses imitating poisonous animals to scare away predators
The songs of various bird species can reflect information such as the location of the forest and the season at that time.	Songs of birds	- Sensitising: different songs from specific birds - Contextualising: birds, sounds, location of the forest, seasonal time - Imaginging: guessing which forest and season we are in.

Table 2. the relation of Pheno-data and Pheno-fication from the results of students' assignment

7. Discussion

7.1 Role of fabulation for Pheno-data, Pheno-fication and a more-than-human world

Through the workshop, we attempted to actualise an alternative world involving livingess of multiple species. To achieve this, we incorporated Pheno-data to reveal tensions of a more-than-human knowledge and anthropocentric knowledge and find a potential where there is "a niche space" for multispecies becoming-with (Haraway, 2013) using the fabulation design method. We especially focused on the Pheno-data of other beings, including their evolving bodies and active participation in the world. Additionally, we sought to tangibly experience the meaning and significance of "in-between" narratives that don't lead to unrealistic utopian or dystopian fictions but help us to feel and imagine confusions, fears and hopes as we move towards more-than-human worlds. For example, the workshop's findings uncovered unsettling truths that humans are interacting with other beings and nature in a too-humanly way. To create an alternative world, mockingbirds were shaped as Tind-birds, butterflies were revered as a religion, and snails were appreciated as heat indicators.

> "Fabulation happens in-between; it does not occur as the myth of a past people, and it certainly does not occur as a positivist assessment. Fabulation refuses both fatalism and escapism in pure fiction. Fabulation is an addition to the reality it deals with – it makes potentialities appear and gives strength to the potentialities it develops."

Recent works in Feminist and Posthumanist HCI have focused on creating spaces and worlds that emphasise the presence of marginalised women's bodies (Sødergaard et al., 2023) and other beings in a city (Nijs et al., 2020). In addition, our work attempts to revitalise the autonomy, agency, and livingness of other beings in our perception. It is important to focus on their evolving characteristics and active participation because these are real happenings, evidence, facts, and stories that keep all beings and our planet alive. This method will encourage us to observe the tangible tensions between more-than-human knowledge and anthropocentric knowledge. As a

result, it will encourage us to keep reshaping minds, histories, imaginations, and even possible worlds. This approach helps us move away from an anthropocentric worldview and become part of the *evolving* and *real* lifeworld, enabling nonhumans and humans to confront the climate change.

In this sense, we identified three key learnings with our fabulation workshop:

"Curiosity" and "appreciation" for non-humans we take for granted. By introducing the Pheno-data concept and fabulating narratives that scaffolds Pheno-fication approach to focus on non-human organisms and their "livingness," we found that students expanded their understanding of the context to include more biological, geographical, and ecological aspects. The in-class exercise nudged them to consider living organisms beyond commodities or objects, and instead appreciate the power of their livingness, including their existence (butterfly), adaptation (snail), and active participation (Tind-bird).

Through exploring the tensions from the power dynamics of non-humans and humans, as well as anthropocentric data and Pheno-data (by writing them down as texts and information for the workshop activities), students generated intriguing narratives that provide a glimpse of the complex and extensive coexistence and interdependence of multispecies on the planet. This shift in perspective fostered curiosity and motivation to learn more about matters and meanings of the alternative world that supports the existence of both humans and non-humans.

Furthermore, their assignment focusing on a reflexive approach led students to notice the changing bodies and rhythms of living organisms, as well as the responses of microorganisms, insects, trees, and animals. It even sparked their imaginations and helped the process of Pheno-fication to think about how and why living organisms were

changing in a given context and vice versa, such as the effect of room temperature on lemon tree buds, the bubbles on the water surface and the life of microorganisms, and the change in movement of dragonflies as a forecast for rain.

Revealing an "in-between" and "blurry" world with non-humans' active engagement. Contextualization with both human- and nonhuman-oriented factors helped us understand hidden and intangible elements, conditions, and relationships in the "status quo" within a broader ecology (Bryant, 2014). This design process enabled us to experience what an "in-between" world would look like by blurring the boundaries of our dualistic thoughts (human/nonhuman, true/false, fact/fiction, abstract/affective) through fabulated stories, as Wiame (2018) addresses.

For instance, students created stories about snails as urban heat indicators (replacing scientific measurement), butterfly religion (replacing gods), and Tind-bird (replacing technology). These cases showed the power and capability of living organisms as more-than-human knowledge. It prompted us to revisit our anthropocentric perspectives, which students and we have developed throughout our lives. Additionally, we could better reflect on the ecological considerations by retaining both the "reality" that the vitality of the organisms holds and the "possibilities" that humans imagine by visualising contextual factors and relationships with living organisms.

Manifesting anthropocentric mindsets and skills. While this design approach encourages us to consider the agency and temporal ecology of living organisms (Tsing, 2014; DeLoughrey, 2015) with Pheno-data and Pheno-fication, upon analysing students' speculative narratives, we also noticed that their imagined stories often embedded social, political, and technological attitudes and decisions towards nonhumans relying

on anthropocentric norms, values and knowledge. It strongly influenced students to imagine an alternative world within human societal boundaries and systems (city, religion and tourism, digital society), and consider how their livingness could influence human society for benefit of humans (see organisms as a heat indicator, commercialised god and a digital messenger).

As a result, there was limited consideration of natural context to engage the livingness of the chosen organisms and other beings. By tangibly seeing the tendencies of students' results, we could recognise the ecological challenges and limitations of anthropocentric mindsets and skills developed throughout our entire life. For example, how would changes affect the food chain (predators, prey, and symbionts) and vibrant wildlife of mockingbirds and butterflies, and evolutionary stories from them? By comparing the "status quo" of the contextual relationship maps with speculative narratives, we could vividly witness a tendency to human-oriented solutionist approaches and recognise the need to regain a sense of appreciation and responsibility is required to avoid unintended consequences for ecological worlds.

Additionally, the results of the assignments revealed glimpses of their shifted focus and attitude towards a greater attention on the natural world. Based on the results of two parts of the workshop, we discovered that practicing Pheno-data and Pheno-fication before engaging in a fabulation workshop could potentially enable us to envision more dynamic worlds that reveal the tensions and entanglement between more-than-human knowledge and anthropocentric knowledge.

7.2 What if we start seeing the world through Pheno-data in the natural context of living organisms?

Living organisms possess bodies and agencies that enable them to interact and evolve to adapt to the evolving world. By considering attributes of their agentic bodies as data, we can extend current theoretical discourses on the materiality (D'Ignazio & Klein, 2020; Lee et al., 2022), relationality (Leonelli & Tempini, 2020) and plurality of data (Loukissas, 2019) to embrace other species and the world as active participants in the data-design practices.

Firstly, the situated and embodied nature of Pheno-data provides a tangible way to understand the fluidity of information beyond human-centric data sets. The living and evolving world allow us to experience "data" with our senses, perceive their contextual relationships with specific attention, and access rich information in matters, relationships, and contexts of them. Data here is "given" by nature and the world rather than "taken" by humans from the world. From the results of the assignment, it is evident that students attempted to identify unseen influences, causalities, relationships, and flows that exist in the natural world through Pheno-data (of lemon tree, goose, dragonfly, mosses, corals, fireflies, octopuses, bubbles, and bioluminescence). As Pheno-fication, this entire process for accessing the Pheno-data provides a starting point to pay attention to non-human lives, behaviours, and participations becoming with the lifeworld in meaningful ways for all.

Secondly, it allows us to acknowledge the role of ecologies in defining the plurality and locality of "data" based on different times, spaces, and scales. Despite the temptation to look at genes and DNA as the "data" blueprint that defines life (Kim et al., 2022), their phenotypical attributes reveal much more about their roles, preferences, and unknown capabilities. It is what situate them in the world and allow us to understand the ecological context bind us together. Depending on when, how, and what comes together, the same organisms may present different shapes, movements, rhythms,

colours (lemon plants, dragonflies, octopuses and mosses) creating plural and resilient worlds. As Bennett (2010) notes, "In a world of lively matter, we see that biochemical and biochemical-social systems can sometimes unexpectedly bifurcate or choose developmental paths that could not have been foreseen, for they are governed by an emergent rather than a linear or deterministic causality."

Finally, this perspective can result in unexpected encounters and a new realm of questions, many of which are unlikely to be asked otherwise through conventional data and data practices. For example, it is important to understand phenotypes of organisms to acknowledge the entangled becoming of an environment and their bodies components beyond genes. This allows us to embrace the uncertainty and continuity of the natural world. Regarding this, Oyama et al., (2003) says,

> "information “in the genes” or “in the environment” is not biologically relevant until it participates in the phenotypic processes. It becomes meaningful in the organism only as it is constituted as “information” by its developmental system. The result is not more information but significant information."

This can lead to greater curiosity and appreciation for the living organisms that let us encounter unknown unknowns of the co-living world (Tsing, 2014).

9. Conclusion

In this work, we explore the significance of reimagining data as attributes of the living world, emphasizing the importance of broadening our understanding of data to include the intricate interdependence between humans, animals, plants, and other entities within ecological frameworks. With a focus on livingness of organisms, and the specific example of tomatoes, we introduce the new onto-epistemological concepts of Pheno-data and Pheno-fication in a tangible and grounded way, discussing the significance of

these concepts to move towards more-than-human worlds that matter to both humans and non-humans.

Our focus on differential Pheno-data of tomatoes in various locations offers opportunities to resensitise, recontextualise, and reimagine the entangled relations between humans and nonhumans across geological, biological, and social spheres. For example, tomatoes harness energy from sunlight, the exchange of molecules, nurturing soil, and interactions with viruses, microbiomes, animals, and humans. These relationships enable the Pheno-data of tomatoes to surface, revealing the intricate connections across time and space. Their capability to refigure and embody living processes and nonliving entities of Earth inspires us to explore the imperceptible, long-term-paced, and unknown aspects of the natural world.

By looking at diverse Pheno-data from various types of tomatoes, e.g. wild tomatoes in Galapagos, heirloom tomatoes on a local farm, and commercial tomatoes on an industrial farm, we can start to answer the questions, raised in the introduction, of the necessity of regain a sense of being situated and embodied in our surroundings to notice, respond to, and care for other beings and nature, while critically reviewing our current activities to better relate to, rather than detach from, environmental changes, which is particularly relevant in the context of climate change.

We envision the concept of Pheno-data and Pheno-fication to be explored in diverse ways, including through fabulation, in order to help designers, scientists and civil servants engage in discussions and practices that critically reimagine our relationships with the world as well as with data for ecological worlds. These concepts can foster responsibility, care, and appreciation by repositioning the human, exploring different temporalities of multispecies, and more varied interactions in these various

contexts. They can also provide a space to imagine more-than-human worlds, which are not necessarily human-led. We hope that this paper will inspire further research and experimentation in HCI, which extend the endeavour to reconcile the human and more-than-human worlds.

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