Decomposition as Design:
Co-Creating (with) Natureculture

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ABSTRACT

HCI in recent years has shown an increasing interest in decentering humans in design. This decentering is a response to concerns about environmental sustainability, technology obsolescence, and consumerism. Scholars have introduced theoretical notions such as natureculture from feminist technoscience. Yet how such theories translate into material design practices remains an open question. This research seeks to broaden the repertoire of nonanthropocentric design practices in HCI. Specifically, it draws on the natural processes of decomposition as a creative approach to develop and test design tactics. To do so, we curate and critique hundreds of examples of decomposition in architecture, design, textile, crafting, and food making. We observe that decomposition often depends on what we call a "scaffold," and we further propose four variants of it as design tactics: fragmenting, aging, liberating, and tracing. We then tested the tactics over a period of four months in a ceramics studio using diverse materials, with a mixture of successes and failures. We conclude by reflecting on how the design tactics might be deployed in nonanthropocentric HCI/design.

Author Keywords

Natureculture; decomposition; nonanthropocentric HCI; decentering humans; research through design; ceramics.

CCS Concepts

• Human-centered computing → Interaction design • Social and professional topics → Sustainability

INTRODUCTION

Humans are not the only but one of the entities on the planet, living alongside with other nonhumans actors such as plants, animals, and microorganisms. In the past decade, researchers in Human-Computer Interaction (HCI) have argued the need to move from a human-centric design agenda to one that encompasses a multispecies worldview [24,25,38]. This body of research not only provides insights to design for multispecies interaction and cohabitation [3,29,38], but also reflects on how interspecies collaboration opens new opportunities to environmental sustainability, collaborative survival, and aesthetic interaction [3,24,25,27]. This is an exciting step in HCI toward nurturing a mutualistic relationship between humans and other-than-human actors with and through technology.

However, the philosophy of de-centering humans in design remains quite abstract and theoretical to date. Except for a few examples [7,19,20,25,38], little research has been done to translate nonanthropocentric theories into actual design practices. With an interest in designing with nonhumans in mind, we ask, what exactly can designers do once we get out of the realm of high-flying theories and get our hands dirty? In this paper, we draw from the theory of natureculture—a concept that resists a human-centric perspective by "dis-objectify[ing] nonhuman worlds by exposing their liveliness and agency" [33:7]—and engage in design activities to explore concrete ways of co-creating with nature.

Under the theory of natureculture, we look into the process of winemaking. In turning grapes into wine, a series of collaborations between humans (e.g., grape farmers, wine producers) and nonhuman agencies (e.g., soil, grapevine, yeast) are involved. For example, wine makers provide yeast with sugary grape juice and an oxygen free environment, within which yeast drives the fermentation process and converts sugar into alcohol and carbon dioxide [1]. We are particularly inspired by the idea of human actors cultivating a space of co-creation that invites nonhumans to participate, sometimes even to take over the original composition. A similar concept, decomposition—breaking down organic matters to smaller particles—is yet another process of destruction and reconfiguration driven by nonhuman agencies such as earthworms and fungi. Although the term decomposition is often associated with negative connotations such as decay, rotting, aging, and death, it also opens new pathways to growth, renewal, transformation, and rebirth [6]. We consider decomposition as a creative process through which nonhuman others bring their own form of agency into the creative process and add value, character, function, aesthetics, and sustainability into design.

Within HCI, nonanthropocentric perspectives have become increasing popular in addressing and overcoming the present sociotechnical challenges. For example, sustainable HCI researchers have explored ways of urban farming and

foraging in response to issues over food safety, scarcity, and environmental sustainability. Scholars in urban informatics have suggested integrating ideas such as hybridity [9,43], coproduction [8], cohabitation [38], organic sensing [21], collaborative citymaking [10,12], and collaborative survival [25] to expand the current landscape of interactive technologies. We situate our work in nonanthropocentric HCI to contribute to the growing interest in building collaborative kinship with other species. In this paper, we build on the natural process of decomposition and explore through design curation, analysis, and making the concrete ways of designing with nature. We propose the notion of decomposition as a tangible and actionable design tactic in incorporating nature into design.

Our contribution to HCI is multi-fold. First, we present the natural process of decomposition as a way of natureculture co-creating with humans though actions of destruction. Such a provocation has the potential to spark the imagination of what designers can do to engage in creative activities with nonhuman actors. Second, we concretize the theoretical concept of natureculture and decomposition by curating and analyzing the physical representation of natureculture in design works, and experimenting with materials and objects to produce our own representations. And finally, we propose the concept of "scaffolding" and conclude by presenting fragmenting, aging, liberating, and tracing as actionable design tactics for those who are interested in experimenting with nonanthropocentric approaches to design.

NATURECULTURE AND DECOMPOSITION

This work departs from the provocation of decentering the human in design. For [33], such an attempt requires a shift in perspectives that considers "the social as a tissue of associations between humans, nonhumans, and objects working in the realization of new relational formations." Central to our theoretical foundation is the concept of natureculture, which advocates for humans to (re-)connect with nonhumans and move away from the perspective of species isolation and superiority [14,23]. Anthropologist Anna Tsing describes this raise in awareness as the "arts of noticing" [41]; constituted in these arts is cultivating our ability to notice, appreciate, respond, and imagine outside of anthropocentric norms [25]. When applying the concept of natureculture into design, we are better positioned to understand design activities not as a pure cultural practice but as a creative space where humans "can be both actively involved and passively fascinated" [16:376]. Within the context of natureculture design, we are particularly inspired by Light et al.'s recent call to "embrace the rhythms of life and death around us" with and through design [24]. She writes, "the radical act of paying attention to things that we do not wish to see and that make us uncomfortable can be aided by design if it takes up the challenge of resisting smoothness and self-centeredness" [24]. We build upon this invitation to explore moments of vulnerability once we get out of the realm of human exceptionalism and come to interact with the nonhuman lifeworld.

In the context of this paper, we focus our inquiry of natureculture design on the notion of decomposition—a natural phenomenon that implies a constant process of "death and rebirth", "loss and renewal" [6]—as well as its analogous concepts such as decay, aging, corruption, destruction, decline, obsolescence, and death. As much as we try to avoid these unpleasant encounters, they are simply natural and inevitable during the course of life—for humans, animals, plants, artifacts, and technologies alike. In response to the call of "staying with the trouble" [15], HCI researchers have explored ways of adding value to design through deconstructive actions; they have also argued that designers might intervene into deconstructive processes, which often are beyond human capacity to control. For example, work on breakdown and repair investigates how forms of meaning, care, and creativity can be enacted through the limits of engineering-centered infrastructure design [17,19,28,36,39]. Rosner et al. [18,37] and Giaccardi et al. [13] experiment through material forms and reveal how traces of use present a quality that is aesthetically pleasing and emotionally meaningful in constructing relationships with technologies. Murer and colleagues [31] go further by suggesting "un-crafting" and other deconstructive practices as an initial and essential part of creating interactive artifacts. This body of work resonates with the theoretical foundation that we aim to emphasize in this work: the notion of decomposition and its synonyms provide an alternative trajectory of adding value (e.g., durability, sustainability, function, personality, aesthetics) to design through a course of destruction and reconfiguration unfolding across humans and nonhuman agencies.

DESIGN PROCESS & METHODS

We consider decomposition not as a form of degradation but as a pathway towards transformation and as such, a potentially creative process. Such a process can be driven by a collaborative effort between humans and nonhuman agencies through and manifested in material forms. In this paper, we ask, how can designers draw from the process of decomposition to cultivate a space of natureculture co-creation? A primary goal of this paper is to concretize the notion of decomposition by moving it from an abstract theoretical argument towards actionable design tactics. To gain insights to this inquiry, our methods are twofold, involving design analysis and research through design.

Curating and Analyzing Design: Design Tactics

In the first phase of the research, we aim to illustrate through actual design exemplars the physical manifestations of decomposition and explore tactics of designing with nature through destructive actions. We build a design inventory with more than 100 cases in analogous fields such as product design, architecture, textile, interaction design, and crafting. We searched popular design websites, blogs, competitions, and magazines to curate exemplars that suggested the involvement of natural forces, actors, and courses such as destruction and decay in the design-making process. To make sense of the emerging collection, help shape its growth,

and discover patterns and clusters within it, we turned to interaction criticism. According to [4], interaction criticism entails "rigorous interpretive interrogations of the complex relationships between (a) the interface, including its material and perceptual qualities as well as its broader situatedness in visual languages and culture and (b) the user experience, including the meanings, behaviors, perceptions, affects, insights, and social sensibilities that arise in the context of interaction and its outcomes" [4:604].

In practice, this part of the research involved iteratively identifying design exemplars and producing critical discourse about them; two separate activities are involved: aesthetic description and aesthetic interpretation. *Aesthetic description* refers to an attempt to characterize the exemplars in question, to articulate their qualities, materials, and forms in a language both rich and relatively objective. It is rich in that it makes use of associations and metaphors to capture subtle nuances and qualities, and it is objective in that its purpose is to characterize the object in a way that most qualified viewers would agree to. Aesthetic description responds to questions such as the following: what is it? what is the broader context of creating? how is it made? And it results in a set of annotations that characterize the form, function, material, and medium of the design. *Aesthetic interpretation* refers to our take, that is, our own efforts after meaning. An interpretation is more subjective than the description, that is, dependent on the perception, imagination, literacy, and deepening understanding of an individual interpreter (or, in this case, small team of them). An interpretation also reflects an intellectual purpose; in our case, it was to perceive and appreciate diverse ways that processes of decomposition contribute to design by accounting for the nonhuman actors, what is there to be decomposed, what drives the process, and what forms of interaction it entails. We iteratively compared and contrasted the exemplars and their qualities to discover patterns and to identify possible categorizations, leading to a set of possible processes that designers might be able to emulate—what we would come to think of as design tactics.

As an outcome of this work, we identified four design tactics of decomposition: fragmenting, aging, liberating, and tracing. These four tactics diversely demonstrate how the notion of decomposition can (co-)create material forms. We also note that the tactics are not mutually exclusive but complement one another. We describe each tactic through actual design cases and reflect on how different modes of working with nature can be promoted and perceived through material forms. Our aim is not to develop an exhaustive list of design strategies; rather, it is intended to help us move from promising yet vague, toward something that is actionable enough to develop design experiments that could be tested.

Fragmenting
Fragmenting is a tactic focusing on material fabrication. It breaks, combines, and repurposes the original materials to create a new composite that displays qualities of one-off products, manifested in patterns, textures, and aesthetics.
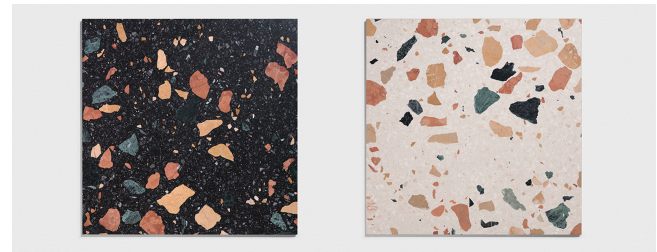

Figure 1. Marmoreal (2014). ©Dzek and Max Lamb.

Decomposition is a natural process when organic composites break down to simpler particles through physical, chemical, or organic means. We observed that this natural process has inspired designers to create new material composites by first fragmenting and then reassembling the original constituents through pressure, heat, and adhesives. The notion of decomposition in this case involves the physical breakdown of materials, the process then opens up a space for material re-composition and rearrangement, which often results in unique, unexpected, even enchanting and decorative patterns and embellishments.

For example, Marmoreal is an engineered marble designed by Max Lamb and produced by Dzek (figure 1) [45]. Composed of different types of classic Italian marbles from the Verona region, Marmoreal can be used for various interior applications ranging from tiles to furniture. The production process celebrates the sustainable root of terrazzo, sourcing waste stones from local Italian quarries. Combining together approximately 95% marble mix and 5% polyester resin, the material is casted in molds using a mixture of pressure, vibration, and vacuum. The new composite is stronger and more durable than natural marbles because the small batch of polyester resin fills the porous structure in the original stones. Max Lamb considers this material exploration as one that "celebrates the individual qualities of these stones while acknowledging that the sum of its parts makes for something far more compelling [22]."

Through the example of Marmoreal, we can see that fragmenting as a design tactic envisions a new form of natureculture co-creation, which is particularly useful in fabricating novel materials. Through a process of recycling, smashing, shuffling, and reassembling, the original ingredients remain visible while the new composite offers a wider possibility in aesthetics, function, and durability. The tactic of fragmenting can be easily integrated into the highly controlled mass production processes to add ambiguity and uniqueness to standardized products.

Aging
Aging is a material exploration tactic, which incorporates materials that are sensitive to the passage of time, manifested in physical transformations such as form, texture, and color.

Figure 2. The Rust Collection (2015). ©Ariane Prin.

Aging is a natural phenomenon that amplifies the inevitable passage of life—carried through a course of "death and rebirth", "loss and renewal" [6]. The tactic of aging addresses the beauty of ephemeral presentation and continual evolution. Such appreciation of decay is coined in literature as "graceful aging" [35] and "aesthetic obsolescence" [5]. Aging as design tactic tends to emphasize the process of rotting and deteriorating by including materials that are sensitive and responsive to their surroundings. This tactic is closely related to the aesthetic of Wabi-Sabi, which aims to manifest the beauty that is imperfect, impermanent, and incomplete by capturing the inherently unstable, fleeting moments of deterioration [26,30]. A common design approach to aging is to mix metal powders (e.g., copper, brass, iron) with resin composites to create a marble-like finish. The color and texture of the object changes over time as the metal oxidizes to signify the process of aging.

For example, for Rust Collection (figure 2), designer Ariane Prin recycles leftover metal dusts and mixes them with plaster and Jesmonite to create containers that change the color and texture overtime as the metal oxidizes [32]. "Every time I go to my studio I'm excited to see the objects' changing textures. It's like each one of them was alive and mutating with time," she explains [32]. The corrosion of metal powders is then stopped with a layer of water-resistant coating, so one can safely use them as regular pots, trays, vases and jewelry boxes. In the process of creating, the designer lets the materials take their own life to develop patterns and colors that are unique and unpredictable.

Regardless of the form or material of an object, all surfaces inevitably display changes of their original qualities through time, reflecting the use context, the nature of material, and the environment. Though most products focus on enhancing the durability and stability while preventing deteriorating and ruining of artifacts, aging as a design tactic harnesses the passage of decay to develop a natural, un-replicable look and feel of objects. It refuses to treat objects as static substances but allows materials take on their own life. Means of human intervention include using heat, humidity, and chemical erosion to catalyze the transformation. Aging as a design tactic explores and utilizes the natural process of material degradation and deconstruction to entail the uniqueness of objects. In this making, human intervention presumably constructs the overall aesthetic qualities, but as nature takes part in the creative process, no finished products will be exactly the same.

Liberating

Liberating is a production tactic that resists posing physical controls and constraints during the course of forming. It encourages an honest presentation of materials and often results in objects of fluidity and randomness.

Figure 3. Ripple (2013). ©Poetic Lab.

Here, we focus on how the notion of decomposition arrests the temporality, sensitivity, and resiliency of materials during the formation of an object. Liberating as a design tactic rejects standardization. Specifically, thinking about mass-produced products, we are likely to picture artifacts that are precisely engineered, well-defined, and perfectly polished. To achieve this, molds are combined with matrixes of control to regulate the manufacturing process. The result is products of uniformity, where traces of manual labor are nowhere to be found [35]. On the contrary, the tactic of liberating strives to capture the material properties during the course of design production. When standardized molds and manufacturing formulas are removed, the tactic of liberating facilitates the creation of one-off products that display different qualities in forms, textures, and finishes.

The design tactic of liberating celebrates the beauty of craftsmanship through a poetic encounter between the craftsman, the environment, and the material. For example, Ripple (figure 3) purposefully incorporates a mouth-blowing technique to create an uneven glass dome that resembles the ever-changing ripple pattern. Molds and jigs were still used to assist forming and measuring, but they did not define the final look of the product. Designers Hanhsi Chen and Shikai Tseng state, "the process starts with this hot tube of [glass] material, and interacts with the air, gravity, and movements of the blower. […] Time and memory is frozen […] and with a small pinch of light, you can extract that moment" and "it's about the experience and the emotion that is created by this moving light" [44]. Indeed, designers or crafters do not have full control over the finishing look; it is the entangled correlation between material properties, human movements, and environmental conditions that co-create the product.

In industrial manufacturing, defects occur due to inaccurate control. The notion of decomposition pictures imperfections as aesthetic and desirable. Liberating as a design tactic deliberately seeks to release the subject from rigid human interventions and machine control during the phase of forming. It amplifies the properties of materials and conditions of environment by intentionally adding anomalies to create uniqueness—passages of making are inscribed in imperfections (e.g., bubbles, dimensional changes, uneven surfaces) to add value to the product.

Tracing

Tracing is the tactic of foregrounding traces of force, use, and repair. The history of an artifact is objectified and synthesized in terms of forms, textures, patterns, or breakages.
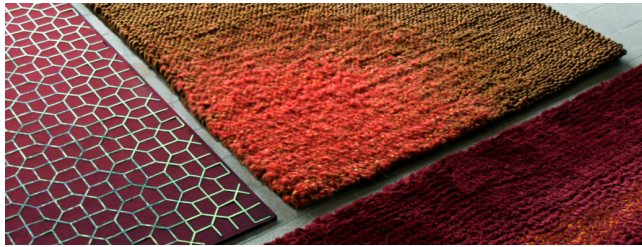

Figure 4. Ripening Rugs (2015). ©Adrianus Kundert.

The predominate production technology has been driven by the pursuit of perfection and endurance, aiming to produce objects in their pristine states. However, while scratches, breakages, and blemishes are often considered as defects, traces of use and repair inscribe the relations between an artifact and its user, adding a value that goes beyond the functional significance, and moves towards becoming an extension of the user [18,19,34]. Tracing as a design tactic not only calls attention to the entanglement between the object and its user, but also raises questions about durability, fragility, and resilience. Here, a common design tactic is to highlight the degradations with contrasting materials.

For instance, designer Adrianus Kundert believes that the durability of an object increases through use. The beauty of wear and tear is captured in his Ripening Rugs collection: the rugs gradually change their colors, patterns, and texture as the outer layer of the yarn is worn and the inner weave is revealed through use (figure 4). Kundert says, "the gradual erosion is what makes these floor coverings gain in attractiveness, each in its own way, instead of rendering them valueless and ending their lifetime." In this case, traces mark the identity of a product and signify its evolution. Another strategy of strengthening the emotional resonance to an artifact is through actions of repair. For example, Kintsugi— a Japanese crafting practice of restoring broken ceramic potteries mixing powers of gold, silver, or platinum with lacquer [11]—captures the notion of tracing through repairing. Kintsugi shows no attempt to hide the damages but to appreciate and illuminate the traces of use with contrasting color and material.

Tracing can be considered a creative practice emerging from the course of use and repair. Whether deliberate or accidental, every crack inscribes and manifests the story behind an artifact. As a design tactic, tracing appreciates and harnesses the use traces (e.g., breakage, wear, and tear) and material imperfections (e.g., impurity, asymmetry, and roughness) of an artifact; in other words, it shows no attempt to hide the damages or touches of repair, but to illuminate them as an aesthetic existence and the signature of an object. Here, decomposition is treated as both the process and result

of justification and identification. At an objective level, designers can utilize the tactic of tracing to produce un-replicable objects and foreground signs of break and repair by presenting them as decorative arts. At a subjective level, end users are empowered to create unique products and express emotional resonance through marks of use and decay. Eventually, the tactic of tracing constructs personal memories and shared experiences over time, making an object one of a kind both on a physical and emotional level— a long-lasting relationship triggered and sustained by the imperfection of materiality.

Section Conclusion: To Decompose Is to Scaffold

From curating and analyzing design exemplars, we arrived at four decomposition-inspired design tactics—fragmenting, aging, liberating, and tracing—that all might be understood to fall under the broader umbrella of "scaffolding." In architectural practice, a scaffold is a temporary structure that supports construction efforts (e.g., holds materials or workers). In the context of this paper, we define a scaffold as a *soft structure*, a *transient composition* that is intentionally built to invite natural entities to build upon and eventually take over the original cultural construct. In a scaffold, both time and space are constructive media of the design.

The notion of scaffolding we propose here differs from anthropocentric design approaches: whereas in traditional design processes, phenomena outside of human control are avoided to reduce rates of product deficiency or slow down technology obsolescence, in scaffolding co-creation with nature, they are intentionally incorporated and celebrated as part of the design practice. In other words, we consider decomposition as a creative process through which nonhumans bring their own form of agency into design to add value, character, function, aesthetics, and sustainability. To further illustrate, let us compare a scaffold to the mold, a common manufacturing tool in mass production process that gives standardized shapes to materials. With precise environmental and material control, a mold can produce up to a million pieces of product with exact, pre-defined shapes within its life expectancy [42]. If we describe an industrial mold as a "hard structure" that foregrounds regulation, standardization, and efficiency, then a scaffold can be considered a "soft structure" that loosens human control, brings nonhuman agency into design, and celebrates the in-expectancy and un-replicability of the final outcome.

To further unpack the notion of scaffolding, we look into the concept of structure-preserving transformations, proposed by architect and design theorist Christopher Alexander as the way nature constructs and evolves the environment. He writes, "throughout nature, we see a continuous smooth unfolding of the wholeness, which preserves structure at every moment, even when it seems to be introducing new structure" [2:56]. We consider the natural process of decomposition as a structure-preserving transformation though which decaying organic matter is broken down to smaller particles, culturing new forms of lives. Through the

course of decomposition, "nothing entirely new has been injected—the newness has been created by intensification of what exists" [2:53]. The design framing of scaffolding (as opposed to molding) we propose here, then, is a result of translating and leveraging the natural process of decomposition into actionable design tactics, further consolidated as design actions including fragmenting, aging, liberating, and tracing.

We are aware that the cases we select to present here are not interaction design exemplars but instances of product design; this reflects the training of the lead author. We have described earlier in the methods section that interpretation is an important means of knowledge production; as a result, we turn to our own expertise as a resource for translating nonanthropocentric theories into material design practices. In addition, every interaction design is also a product, with a specific form, function, aesthetic, material, character, and value orientation. We believe that the lessons learned from curating and analyzing product design examples are applicable to tangible and interactive interfaces. Finally, and perhaps most importantly, issues of consumerism, obsolescence, and sustainability, have long been explored and addressed in realm of product design; we believe it is important for HCI researchers and practitioners to learn and leverage what has been done in this analogous field.

Research through Design: Creating "Scaffolds"
So far, we have concluded four design tactics and proposed scaffolding as an overarching strategy in co-creating with natureculture. Next, we experiment the tactics by embodying them through material forms. To do so, we first generated twelve design concepts, entailing a wide selection of materials in its execution: ceramics, glass, papers, silicone, metals (e.g., brass, copper, nickel, silver), fabrics (e.g., cotton, silk, denim, wool), foods (e.g., chocolate, tea, coffee, breakfast cereal), resins (e.g., epoxy, Jesmonite), and organic matters (e.g., mushroom, chia, moss, flower, sponge). All of our concepts were built directly from the tactics to reflect the different ways of engaging in the notion of decomposition through design. With the goal to actually engage in activities of making, we presented our conceptual sketches to three different studio coordinators to discuss the feasibility of execution, including ceramics and printing, metalsmithing, and digital fabrication. We considered factors such as material availability, facility accessibility, time flexibility, and financial feasibility. Since our goal was to experiment with the tactics through material forms, we were not very picky about what type of material or process we wanted to focus on; we decided to initiate our experiment in the ceramic studio, where we were generously granted a personal working space and the accessibility to all tool, facilities, and materials within the studio.

DESIGN THROUGH DECOMPOSITION WITH CERAMICS
The design experiments presented in the following sections were led by Liu; the execution was supported by Wei Tseng, a senior undergraduate student, a novice in design and crafting. All authors had little experiences in ceramics making, so we turned to Chase Gamblin, the ceramics studio coordinator who has over 20 years of experiences. He showed us how to properly use the facilities and tools in the studio, but he encouraged us to engage in trial and error ourselves. Every little adjustment in the ceramics making process can lead to dramatic changes in the outcomes, "you might fail, you might succeed," he always said.

We started by getting our hands dirty, playing with clay and ceramic slip. Probably not surprising, many of our concepts failed—in a sense that the design outcomes did not follow our expectations. From an analytical perspective, the designs failed because we were not familiar with the material properties to the point that many of our designs cracked and fell apart during the course of drying. However, from a research through design perspective, the decomposed ceramics served quite well in manifesting and materializing the notion of decomposition. For instance, we were inspired by the tactic of tracing and had an idea of creating cracks on the surface of the clay body by leaving it outside in the snow during the course of drying. Our plan was to then use resins to fill the cracks to trace and foreground nature's force. Within this experiment, the scaffold is the clay bowl we made, which is considered as a soft structure because the material is still pliable with external forces. The nonhuman factor is the natural environment, filled with unpredictable weather conditions. Our hypothesis was that through fast freezing and drying, the surface of the clay might decompose and result in distinct patterns. However, the clay bowl become slushy and eventually fell apart as the snow melted.

We started to obtain some basic understanding of the clay's material properties after a few failures: it cracks during fast-drying, becomes sloppy when it meets water, and shrinks significantly while drying. In what follows, we present our design iteration on the tactic of liberating using slip. Slip is a liquid state of clay made by suspending clay particles in water. Slip is often used to create sophisticated shapes by casting it with molds or using it to paint the surface of wet clay bodies to make decorative patterns. In testing the tactic of liberating through slip, we resisted using molds but employed different types of scaffolds for slip to build upon. Here, the notion of decomposition takes place during two different stages of making: when the original scaffolds are covered and obscured with slip and when the scaffolds are eventually brunt away during the firing process.

Experiment 1: Waxed Paper Cups + Slip

Figure 5. Forces acting with the shrinking, drying slip left surprising polygonal patterns in the paper cups.

In our first experiment, testing the tactic of liberating, we used waxed paper cups as the scaffold and slip as the natural entity whose performance is defined by multiple factors in the environment (e.g., gravity, temperature, humidity). By free dripping slip onto the paper cups we turned the cups into soft structures which allow slip to cover, alter, and take over the original surface with different shapes and patterns. In this process, we as designers still exerted a certain degree of control to reach our desired aesthetics. For example, we can choose, to a certain degree, where on the cups we want to pour the slip, how much slip we want to pour, how fast we want to pour, and even how fast we want the slip to dry (we used the heat gun to facilitate the drying process for some). However, the outcomes of the design remains ambiguous because there are many constraints to how much the we can actually control. For instance, a paper cup can only hold slip up to a certain amount; once it exceeds the capability of friction, the slip falls. However, we have also noticed that the slip poured onto the paper cups need to maintain a certain thickness or the design will soon crack and fall apart when it starts drying.

We envisioned applying the tactic of liberating to capture through slip an intricate interaction between slip, gravity, paper cups, and friction. However, the final result is again against our expectation. Specifically, slip shrinks when it dries but the wax layer on the paper cups prevents the slip from shrinking; the pressure got accumulated and eventually cracked the slip when it hardened. The ceramic master predicted the crack but he still encouraged us to try because "you might succeed, since the wax inside the cup is not too thick." The final result reveals the unruly and unpredictable quality of slip and the fact that if we want to "work with" (including understanding and experimenting in our case) this unruly material, we need to find alternative scaffold materials.

What is surprising and completely unexpected is that the pressure from the shrinking clay has imprinted polygonal patterns onto the waxed paper cups, leaving a unique trace of natureculture co-creation (figure 5). This experiment has challenged and pushed forward our previous analysis. Specifically, we pictured a scaffold as the foundation for natureculture co-creation to build upon and something to be discarded afterwards (e.g., burnt away during firing). We did not foresee the scaffold turning into a beautiful design object itself. Through this ceramic making activity, we discovered that a scaffold is not only "soft" in the way that it loosens factors of human control; it is also "soft" and malleable in itself, allowing force to leave unique marks and traces onto the scaffold. Such a process seems to resemble the tactic of *tracing* more than *liberating*, suggesting from this experiment that the tactics we concluded in the previous section are not mutually exclusive to one another. Indeed, natureculture co-creation is a space where designers "can [be] both actively involved and passively fascinated" [16:376].

Experiment 2: Kitchen Towels + Slip

Figure 6. (Left) removing paper cups to prevent the slip from cracking. (Right) the final result displays a hybrid materiality.

With the goal of capturing and displaying through clay the negotiation between the cultured scaffold and the natural environment, we iterated on the material selection of the scaffold. We learned from experiences that the scaffold needed to be hard enough to maintain its shape while holding the weight of slip, and yet the scaffold also needed to be soft enough to allow the slip to shrink during the course of drying. We decided to use two different versions of scaffold in our next experiment. In execution, we first wrapped or taped kitchen towels onto the waxed paper cups and free dripped slip onto their surfaces. We then let the slip sit and dry for about 30 minutes when its surface became hard enough to sustain the shape without actually having a cup underneath it. Next, we carefully removed the waxed paper cups and set the slip covered kitchen towels on the drying rack for two days.

This time our ceramic work did not crack; instead, the final result displayed a hybrid materiality of all materials involved in the process of making (figure 6). Specifically, paper cups scaffolded the slip to display a certain unity and hardness of the pre-made containers, the texture and layers of the kitchen towels were inscribed onto the design as unique patterns, and the ceramic slip managed to visualize its own fluidity and stickiness when it came to interact with force (e.g., gravity and friction) in the environment. After firing, the kitchen towels dissolved while the clay body converted into bisque: a durable, much more permanent state of the clay. In this experiment, both the scaffolds and the nonhuman factors deformed to a degree by taking shape of one another. This hybridity almost obscures what is there to be changed and what is there to initiate the transformation. What can be observed through the material forms is that the process of decomposition transforms the soft, temporal, and invisible into something much harder, permanent, and physical.

Experiment 3: Fabrics + Slip

Figure 7. (Left) slip dried on the fabric scaffold. (Right) the flaky edge on the bisque resembles the texture of the fabric.

In the following experiment, we stitched and folded fabrics to create three-dimensional objects to replace the pre-made paper cups. We did so to gain more freedom in determining what our design may look like by not restricting it to ready-made industrial goods. In other words, we as designers tried to soften the scaffold even further so that nonhuman entities can have more voice in the co-creation process.

We used denim to make the scaffolds by cutting, layering, folding, and loosely stitching the fabrics together. We selected denim because it has enough firmness to hold the slip without collapsing; the fabric is also soft enough for the slip to shape and dry without cracking. In execution, we put our hands inside the fabrics and dipped them into a bucket of slip. The items were placed on the shelf to dry and then sent to the kiln for firing. In figure 7, we can see that the denim scaffold was brunt away during firing, leaving a thin layer of clay in the state of bisque. The final result displays a mixed property of fabric and clay. On the one hand, it has flaky edges that resemble the threads on the brink of the denim, with wrinkles and folds that capture the softness and thinness of fabrics. On the other hand, the wrinkles and folds are permanent: they no longer deform with gentle touches.

CONCLUDING DISCSSION: DESIGNING [WITH/THROUGH] DECOMPOSITION

This research responds to a recent call in HCI that proposes shifting from a human-centric agenda towards one that integrates a multispecies worldview. This paper draws from the theoretical concept of natureculture to transgress the boundary between nature and culture and explore how this shift in perspective might reorient our design practices. In writing about natureculture, Anna Tsing describes her excitement about mushroom foraging, "these mushrooms are not the product of my labour, and because I have not toiled and worried over them, they jump into my hands with all the pleasures of the unasked for and the unexpected. For a moment, my tired load of guilt is absolved, and, like a lottery winner, I am alight with the sweetness of life itself [40:142]." Such a delight is experienced when she receives a gift from nature—intimate, unanticipated, and probably also quite tasty. In many cases, humans seem to live the best while cohabitating with nature: treating dogs, cats, and other living organisms as our "significant others" [14]; planting trees and flowers to decorate the dull concrete blocks in the cities; and traveling into the forest and natural parks to enjoy a tranquil moment with other lifeforms on Earth. It seems to be human nature having the desire to get close to nature. Such a desire goes beyond meeting the basic needs in order to survive but to also find joy and fulfillment in life. However, this is only one side of the story. In constructing the material world, through design and engineering, we assert and enforce boundaries between nature and culture. In cities, skyscrapers roar into the skyline, competing with trees for the sunlight which they depend on for their lives; lands are taken by roads and buildings, expelling wildlife from nesting and foraging; and soils are covered with all sorts of construction, leaving no room for plants and animals to thrive.

In this paper, we wish to rediscover the excitement of designing with intimate connections with nature, a joy we lost while drawing boundaries separating nature and culture. In exploring ways of reconnecting with nature through design, we observe the natural process of decomposition and use it as the guiding principle in collecting, thinking, writing, and making designs. With the interest in co-creating with natureculture, we propose to loosen factors of precision and control in design practices. We consider design as an activity of scaffolding, which is more about cultivating a space to facilitate nature's participation than trying to exclude it from design. From a design perspective, we have showed that a proper scaffold balances the constraint and freedom it offers for natureculture co-creation. From a theory-building perspective, we have made more tangible the theoretical concept of natureculture by focusing on the natural process of decomposition and materializing it through physical forms. We have learned through our various design research activities that the visual language of natureculture often exhibits mixed material properties of the cultural (e.g., the scaffold) and the natural (e.g., the nonhuman actors and the environment), and the product of natureculture co-creation can't ever be fully predicted or replicated—such a result is not so much about the designers' incapability, but more about their willingness to listen, observe, and respond to what nature has to say, as well as learning to be vulnerable and amazed in the design process.

Much of this paper has been about materials, forms, crafting, design processes, and the material involved in our making experiments—ceramics, papers, and fabrics. These may seem to be unfamiliar to interaction design researchers. Even so, the lessons learned in our research activities might offer some thoughts in designing interactive systems. For example, we might consider the design tactic behind artificial intelligence as a digital version of scaffolding, in so far that computer engineers lay out the basic logic of processing, but the machine evolves and develops its own way of thinking. In addition, designers can also draw from the hybrid materiality created by the scaffold to sketch new forms of tangible bits—such as fabricating a sensing outfit that turns hard and functions as a shield when there is an external strike towards the wearer. In extending the present work, we see an urgency to address directly ways of incorporating the notion of decomposition in developing interactive technologies. Moving on, we will experiment with the tactics by embodying them in tangible bits—this work is part of a larger project of connecting nature and culture through technology and design.

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