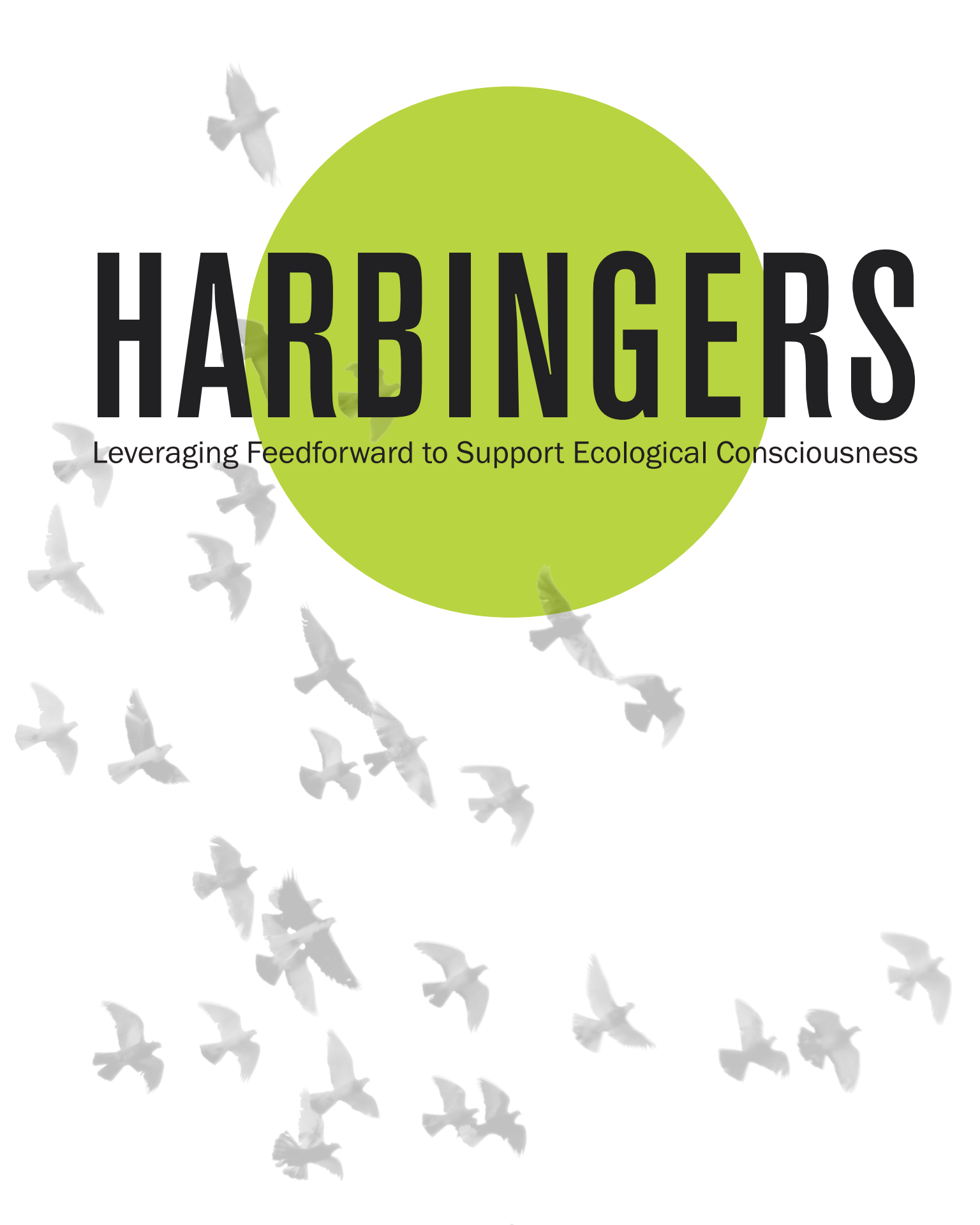

HARBINGERS

Leveraging Feedforward to Support Ecological Consciousness

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A thesis submitted to the School of Design, Carnegie Mellon University, for the degree of Master of Design in Design for Interactions.

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ABSTRACT

Given the dire nature of recent climate projections, fundamental shifts in our patterns of thought and habitation are not only desirable, but necessary for our long-term sustainment on Earth. To this end, a multitude of approaches to "eco-feedback" have emerged in recent years, with interventions ranging from in-home energy meters to urban-scale art installations. However, most of these approaches aim only to expose existing patterns of behavior, failing to address the lack of ecological consciousness that underpins the "unsustainable" cycles of consumption and waste.

The ultimate goal of this study is not to claim a solution to the monumental task at hand, but to challenge the existing paradigm for delivering environmental data, propose alternate strategies for encouraging more "sustainable" modes of living, and elicit further questions about the ways in which technology might support us in living for the future.

IMPORTANT TERMS

Critical design
According to designers Anthony Dunne & Fiona Raby, critical design "offers an alternative to how things are" (Dunne & Raby, 35) by exposing the gap between what is and what could be for the purpose of facilitating discussion.

Dark design
As described by Dunne & Raby, dark design leverages negativity with the goal of reaching positive outcomes. In the context of this investigation, dark design is considered a sub-genre within critical design practice and as such, shares its larger objectives.

Eco-feedback
The term eco-feedback refers to information regarding individual or group behaviors provided with the goal of reducing environmental impact.

Ecological consciousness
As outlined by author Christopher Uhl, ecological consciousness is achieved with an awareness of one's place within the greater ecology or an understanding of "our embeddedness in something far grander than our minuscule selves." (Uhl, 23)

Environmental signal
In the context of this thesis, environmental signal is an umbrella term used to describe an exchange of information, encompassing both feedback and feedforward.

Experiential futures
Futurist Stuart Candy defines the practice of experiential futures as "the design of situations and stuff from the future to catalyse insight and change." (Candy, 2015)

Feedforward
Coined by Tom Djajadiningrat and colleagues, the term feedforward is a conceptual counterpoint to feedback, providing antecedent information as to the result of an action. (Djajadiningrat, 285)

Food waste
The USDA's Economic Research Service (ERS) defines food waste (otherwise known as food loss) as "the edible amount of food, postharvest, that is available for human consumption but is not consumed for any reason." (USDA.gov)

Harbinger
Merriam-Webster defines a harbinger as "something that foreshadows a future event" or "something that gives an anticipatory sign of what is to come". (Merriam-Webster.com)

Hyperobject
A term coined by philosophical scholar Timothy Morton, hyperobject is a word used to describe an object or phenomenon so "massively distributed in time and space relative to humans" (Morton, 1) that it alludes our understanding (e.g. climate change).

Speculative design
As defined by Dunne & Raby, authors of Speculative Everything, speculative design practice uses design "to open up all sorts of possibilities that can be discussed, debated, and used to collectively define a preferable future." (Dunne & Raby, 6)

Sustainable
Used broadly across a myriad of disciplines, the word sustainable most often describes modes of thought and habitation which serve to decrease environmental damage. However, I acknowledge and support Tony Fry's assertion that to simply "sustain" ourselves and our planet is grossly insufficient. As such, through the course of this investigation, "sustainability" connotes not only a shift in behavior, but one in outlook towards environmental stewardship.

Unsustainable
A term which describes the antithesis of sustainable practice as defined above, unsustainable herein refers to modes of thought and habitation which serve to increase or maintain current levels of environmental harm.

INTRODUCTION

As the long-forecasted effects of climate change take shape before our eyes, issues of sustainability have come to the fore in political discourse and corporate strategy alike. However, while inadequate policy and deficient infrastructure each play a major role in climate change, many of society's most unsustainable habits take place at the level of the individual consumer and as such, a ground-up recalibration of our day-to-day lives is a prerequisite for meaningful progress.

In an article published in the May 2011 issue of American Psychologist, researcher and psychologist, Robert Gifford, asserted that "for almost everyone who is not severely restricted by structural barriers, adopting more pro-environmental choices and behaviors is possible, but this adoption is not occurring to the extent necessary to stem the increasing flow of greenhouse gases and other environmental damage." (Gifford, 290) This succinct observation highlights the grim reality of a world barrelling—despite the conscious efforts of an impassioned minority— towards a dark and volatile future. It also raises a critical and timely question: how might we, as designers, encourage and support individuals in making more sustainable choices?

In an attempt to meet this need for bottom-up change, eco-feedback has emerged in many forms over the last several decades. From individual artists to international corporations, many have taken on the challenge of surfacing environmental data with the goal of creating a more sustainable future, but few have succeeded in addressing the root causes of unsustainability. Through this thesis, I aimed to explore these root causes as part of a larger effort to assess and challenge existing environmental signals with the ultimate goal of proposing a new paradigm.

APPROACH

The overarching goal of this study was admittedly (and perhaps ambitiously) broad and an undertaking of this size demanded that large amounts of metaphorical ground be covered in short order. Knowing, however, that a thorough investigation would require a bottom-up understanding of not only the manifestations of unsustainability, but also the underlying psychology that supports this thinking, I set out to grapple with the root causes of unsustainable behavior. Armed with the results of this probe, I conducted a broad survey of existing and proposed environmental signals to identify areas of opportunity. From there, I worked to establish a set of principles that aim to support designers who are interested in creating new modes of environmental signalling. Lastly, I conducted a series of experiments as a first step in exploring possible manifestations of these principles.

To support the arc of this investigation, I have endeavored to combine the theoretical grounding of human-centered design research with the provocative potential of a critical output, and in doing so, I aim to elicit conversation about the ways in which technology might challenge our patterns of behavior and ultimately, our relationship with the wider world.

01

UNDERSTANDING UNSUSTAINABILITY

My goal for the initial phase of study was to establish a holistic view of unsustainability by probing not only the physical manifestations, but the psychological underpinnings of environmentally damaging behaviors and in doing so, I aimed to build a rhetorical foundation on which to develop new modes of environmental signaling.

Driving Questions
What are the obstacles that need to be overcome in living more sustainably?
What are the psychological roots of our unsustainable behaviors?

“On every right side mirror of every American car is engraved an ontological slogan that is highly appropriate for our time: OBJECTS IN MIRROR ARE CLOSER THAN THEY APPEAR.”

- Timothy Morton, *Hyperobjects*

INFLUENTIAL TEXTS

The following texts were instrumental in shaping the work undertaken in this phase.

Hyperobjects, Timothy Morton
Hyperobjects is a philosophical exploration of ecological theory. Here, Timothy Morton introduces the concept of the hyperobject—a phenomenon so "massively distributed in time and space relative to humans" (Morton, 1) that it alludes our understanding. Morton outlines a series of properties that characterize all hyperobjects, and for the purposes of this investigation, one of these traits—nonlocality—is particularly poignant. Nonlocality, in the environmental sense, is a concept derived from Quantum Theory that Morton uses to illustrate the challenges inherent in the process of understanding planetary health. While we experience the local effects of global warming on a daily basis, its sheer temporal and physical scale make the totality incomprehensible.

This text provides a vocabulary as well as a conceptual lens through which I was able to better understand unsustainability. By delving into the philosophical implications of today's prevailing worldview—that an individual's day-to-day experience is removed from the collective reality—Morton identifies some of the psychological obstacles to be overcome in fostering sustainable behaviors. This analysis, in turn, hints at a potential approach for encouraging more sustainable modes of living: by strategically reframing an otherwise "invisible" issue as a systemic problem in which each individual has their own role to play, we might encourage habit change and therefore lessen environmental harm.

Developing Ecological Consciousness, Christopher Uhl
Through Developing Ecological Consciousness, author Christopher Uhl describes the profound separation humanity has engendered between itself and the larger "Earth community." (Uhl, 3) He asserts that this isolationism is damaging not only to the living systems of which humans are an influential part, but to our very conception of what it means to be alive. He goes on to implore readers to "develop the capacity to see our lives in the context of a wondrous, unfolding universe" (Uhl, 23) as a way of "healing" (Uhl, 106) the rift between nature within and nature without through reflection and observation (e.g. stargazing

or walking in the woods.) “In short,” he says “the call is to wake up to our embeddedness in something far grander than our minuscule selves and in this way to experience a genuine homecoming.” (Uhl, 23)

This text positions a lack of “ecological consciousness” as the ontological source of our current environmental crisis and as such, offers a potential target — so to speak — in altering behavior. Specifically, Uhl posits that by “healing” this ecological divide, humanity might come to terms with its impact on the biosphere and equip itself to stem the tides of environmental damage. The book’s closing section presents a path for reaching this healed state; Uhl suggests that to write a “new story” (Uhl, 8) we must develop entirely new ways of seeing ourselves as human beings and the role we play in Earth’s systems.

SURFACING MENTAL MODELS

In order to surface the prevailing mental models associated with environmental systems, I conducted a drawing activity with 10 participants. Almost like a Rorschach test in reverse, this activity was designed to elicit immediate and instinctual responses as a way of revealing psychological impressions (rather than "accurate" representations.) After a brief introduction, I provided each participant with a blank sheet of cardstock along with a set of colored pencils, and asked them simply to draw whatever came to mind upon hearing "the environment". After completing their drawing, participants were asked to explain their illustrations and overall thought process to the best of their ability.

Several overarching patterns emerged across the collected responses.

First, participants who were actively engaged in the field of sustainability (either through coursework or academic research) tended to illustrate evidence of "human" activity in their renderings of "the environment", whereas those less embedded in environmental study often omitted any trace of humanity. Of the participants who included signs of people, nearly all of them spoke about the products of "natural" and "human" processes as distinct concepts and often struggled to reconcile the two. One respondent even chose to draw the "natural" and "human" environments side by side, penning a vertical line between them. Others chose to transpose "human" and "natural" systems onto one another, but in each case the two entities were visually distinct. One respondent, thinking aloud, even remarked "Oh! I guess there are people too." after realizing mid-way through the task that he'd omitted any "human" elements. Interestingly, the use of color further underscored this separation as "natural" elements invoked familiar earthy tones — shades of green, brown, and blue — while evidence of "human" activity was rendered almost exclusively in black.

The tension surfaced through this activity validates the lack of "ecological consciousness" referenced in Uhl's work and illustrates our natural human tendency to view ourselves as separate from the greater ecology.

Figure 01. *"The environment" is rendered as a small woodland vignette*

Figure 02. *"Human" elements, including the Space Needle, Great Pyramids, and Eiffel Tower, are transposed onto the Earth's surface*

Figure 03. *A vertical line divides "natural" and "human" environments*

THE ENVIRONMENT

“In the end, it all comes down to how we see ourselves. If we believe that we are fundamentally separate from each other and Earth, we will live in ways that engender precisely this separation.”

- Christopher Uhl,
Developing Ecological Consciousness

CASE STUDY: FOOD WASTE

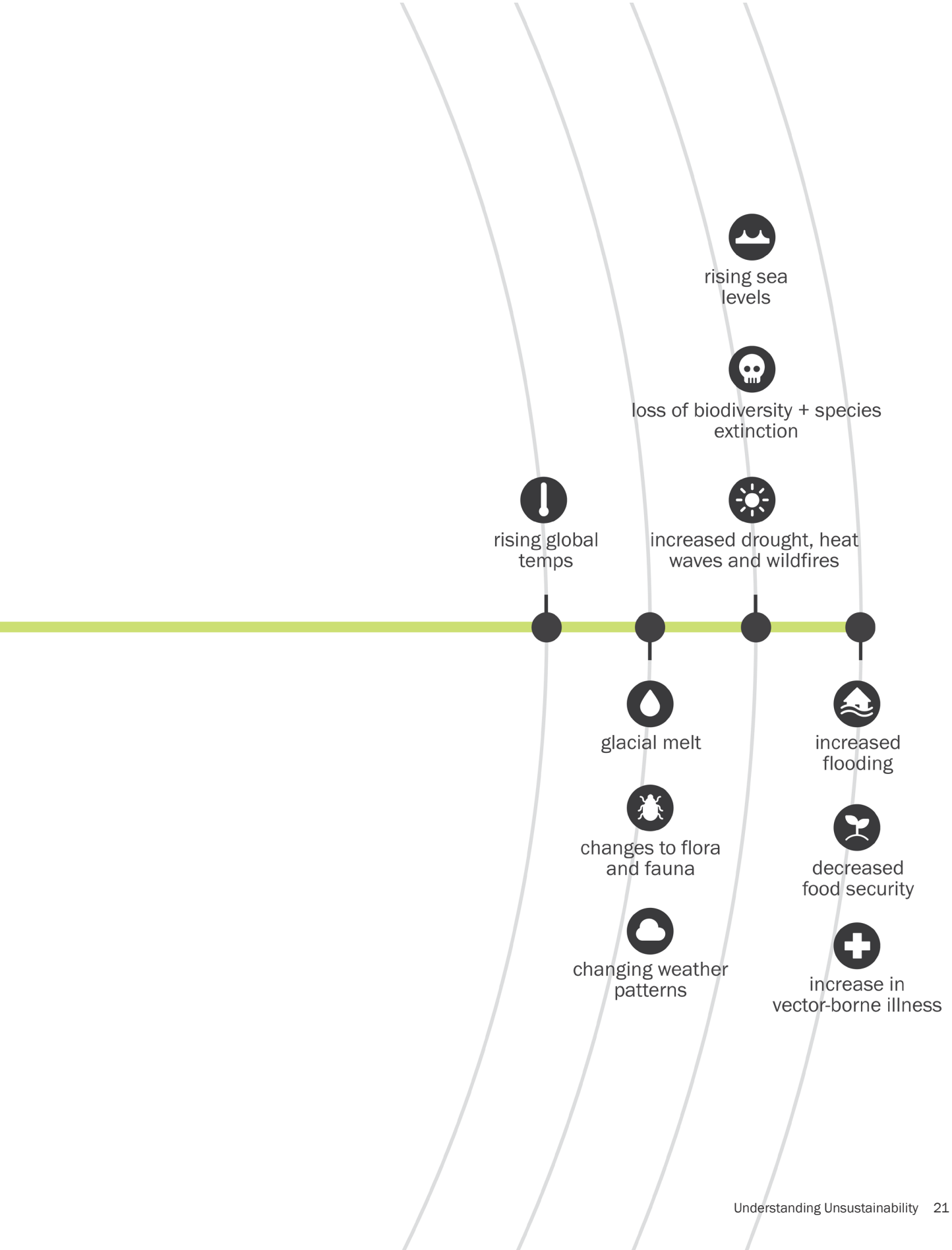
As an entry point into the forces at play in this lack of ecological consciousness, I selected a case study for focused investigation. The following diagram (not to scale) is the result of an exercise intended to surface the immediate as well as long-term consequences of residential food waste.

Food waste, while relatively underexplored in design (as compared, for example, to energy consumption), represents a staggering problem in the United States. An estimated 40% of all food produced in the US goes to waste, totaling roughly 400 pounds per capita each year. Not only does this wasted food represent a loss in terms of resources spent growing, harvesting, and transporting each item, but it contributes to an already-untenable collection of methane sources across the globe. Nearly half of this waste occurs on the residential, consumer level as uneaten bananas go soft, excess milk turns sour, and forgotten lo mein spawns carpets of mold. Fortunately, individual agency is high in the home environment, providing an opportunity for ground-up intervention.

So how did we get here? Waste management systems in the US are built not only for our physical health, but also for our psychological comfort. From the moment goods become refuse, they are all but invisible, traveling from home to curb to landfill cloaked (most often) in opaque plastic bags. However, invisibility doesn't end with collection and disposal; the ecological impacts of food waste are widely distributed and largely remote (for example, the methane produced by food deposited in landfills accelerates global temperature rise, but this increase is happening over time and on a planetary level.) This physical and intellectual distance makes it easy for the vast majority of Americans to dismiss the consequences of their everyday food choices.

So for many, the old adage rings true: out of sight, out of mind.

Figure 04. *Map of short- and long-term effects of food waste illustrating that impacts range from local to global.*


rising sea levels
loss of biodiversity + species extinction
rising global temps
increased drought, heat waves and wildfires
glacial melt
increased flooding
changes to flora and fauna
decreased food security
changing weather patterns
increase in vector-borne illness

SYNTHESIS & IMPLICATIONS

Through this phase of work, a series of promising threads worthy of further investigation emerged that point to the psychological forces underpinning our patterns of consumption and waste.

Scale
Climate change, in the truest sense, is a hyperobject; its sheer scale in both time and space make comprehension extremely difficult, and its distribution dilutes our understanding. The rising average temperatures and erratic weather patterns we encounter year after year are merely local signals of a global reality, providing us with an incomplete picture of the threats we face.

Temporality
Compounding this crisis of scale are a host of innately human qualities, including a natural tendency to discount the future in favor of the present. As human beings, we're wired to prioritize short-term thinking as the cognitive biases inherited from our ancestors still weigh heavily in our decision-making process, driving us instinctively towards instant gratification and crippling our long-term vision. This temporal myopia, combined with the fact that the ecological effects of our most unsustainable habits (like wasting food) are predominantly remote, makes it difficult, if not impossible, for most people to engage with the consequences of their everyday decisions. This chronic lack of long-term vision ultimately begets a damaging intellectual isolation and paves the way for what's known as "the tragedy of the commons"—a concept employed in the social sciences to explain the overexploitation of shared resources as a result of weakened feedback signals between individual and collective.

Ontology
What's more, centuries of human development have drawn modern society further and further from the environmental synchrony on which our ancestors once depended, giving rise to a pervasive mental disconnect between humankind and the "natural" world. By viewing "nature" with a certain alienation, we remove ourselves from the larger ecology and this psychological isolation, in turn, absolves us of our most pressing responsibility: to protect the system of which we're a part.

A Way Forward

Together, these findings suggest that to address unsustainable practice at its root, it's critical to first close existing mental divides; between present and future, here and there, us and them. However, many of today's "eco-friendly" products and services are designed solely to lessen the impact of ingrained behaviors rather than endeavoring to alter the underlying mindsets that beget them. By making it easier for us to "do the right thing" with minimal effort and limited self-reflection, these interventions fail to disrupt our unsustainable patterns of thought and in doing so, enable their perpetuation. This thesis aims to challenge this prevailing strategy, proposing that to affect meaningful change in the lives of its users, a design intervention must work on a psychological level to reconnect individual and collective.

"...to tear down a factory or to revolt against a government or to avoid repair of a motorcycle because it is a system is to attack effects rather than causes; and as long as the attack is upon effects only, no change is possible. The true system, the real system, is our present construction of systematic thought itself, rationality itself, and if a factory is torn down but the rationality which produced it is left standing, then that rationality will simply produce another factory."

- Robert M Pirsig,
Zen and the Art of Motorcycle Maintenance

02

IDENTIFYING OPPORTUNITIES

Through the second phase of study, I focused on exploring existing mechanisms of environmental signalling. The goal in surveying current methodologies was to identify opportunities to shift the current paradigm to target the psychological underpinnings of unsustainability surfaced in the previous phase.

Driving Questions
What are the misalignments between the root causes of unsustainable practice and current approaches to environmental signaling?
What are the initial opportunities to shift the paradigm and create better alignment?

“...redirection is a process of establishing new signposting systems that first indicate the error of following those existing pathways of thought and action as they serve to defuture all that is vital for viable futures.”

- Tony Fry
Design Futuring

INFLUENTIAL TEXTS

The following texts were instrumental in shaping the work undertaken in this phase.

Thinking in Systems, Donella Meadows
One particularly relevant section of Thinking in Systems focuses on the aforementioned Tragedy of the Commons, a concept employed in the social sciences to explain the overexploitation of shared resources. Meadows asserts that "the tragedy of the commons arises from missing (or too long delayed) feedback from the resource to the growth of the users of that resource." (Meadows, 117) This means that while individuals benefit immediately from behaviors that erode the common resources (e.g. the continued use of fossil fuels), they share the burden of long-term effects, causing a dilution of consequence and weakening feedback signals. According to Meadows, "tragedy can lurk not only in the use of common resources, but also in the use of common sinks" (Meadows, 118)

This analysis was pivotal in the overall trajectory of this study, and its value was twofold: first, it provided a sociological foundation for the ecological divide identified in the preceding section, and second, it neatly encapsulated a first step – so to speak – in overcoming that divide to promote more sustainable behaviors. Meadows' rhetoric suggests that by strengthening the naturally weak feedback loops between individual and collective, designers might be able to lessen the erosion of common resources and reduce environmental harm.

Design Futuring, Tony Fry
Throughout Design Futuring, Tony Fry argues that a fundamental shift in our modes of living and dwelling are critical for our survival as a species and as a planetary community. He argues that to strive for anything less than holistic change—redirection in not only behavior but also thought—would be dangerously insufficient; "to simply deal with problems as they arrive would be myopic in the extreme." (Fry, 173) To this end, we must rethink and reshape our relationship with technology, prioritizing its ability to aid us in doing what is right, rather than doing what comes easily. He writes, "The challenge before us now is how we can induce and maintain sufficient 'alienation' to

negotiate new relations with technology that are more sustainable. This does not simply mean more environmental technologies, but rather, the arrival of a level of technological literacy within a regime of 'design intelligence' based on responsibility rather than mastery." (Fry, 187)

The rhetoric presented in Design Futuring underscores the importance of "redirective" design practice—an approach Fry describes as "more radical than reform but less disruptive than revolution"—as a societal step towards establishing more sustainable futures. To this end, Fry advocates for the elucidation of consequence as a first step towards the development of "sustainable" practice, acknowledging "human action will always be destructive; there is, however, an enormous divide between not knowing and knowing this fact and thereafter making critical decisions in the light of this knowledge." (Fry, 201) Echoing Uhl's hypothesis, Fry asserts that a bit of "pain" might be necessary for these transformations to occur: "we do not feel our unsustainability beyond occasional touches of guilt as we fill-up our car's fuel tank, look at the contents of our supermarket trolley or check-in at the airport for a flight we really can't justify. Certainly, few of us feel the tyranny of our human centeredness. But we have to—being unsustainable has to hurt." (Fry, 247)

MAPPING THE LANDSCAPE

To gain a sense of the existing eco-feedback landscape, I conducted an artifact review across a variety of subject areas, including concepts centered around food waste as well as adjacent topics like energy use.

In order to evaluate trends among existing environmental signals, I distilled and mapped each design intervention based on the following parameters:

Input (individual vs collective)
The framing of environmental signals ranges from small-scale and individual to large-scale and collective. For example, while energy bills detail the consumption patterns of a single household, installations like Nuage Vert reveal the combined habits of an entire city.

Output (feedback vs feedforward)
Environmental signals often take the form of information regarding past events (feedback) while forecasting and prediction models are employed across a variety of fields to provide information about what's to come (feedforward).

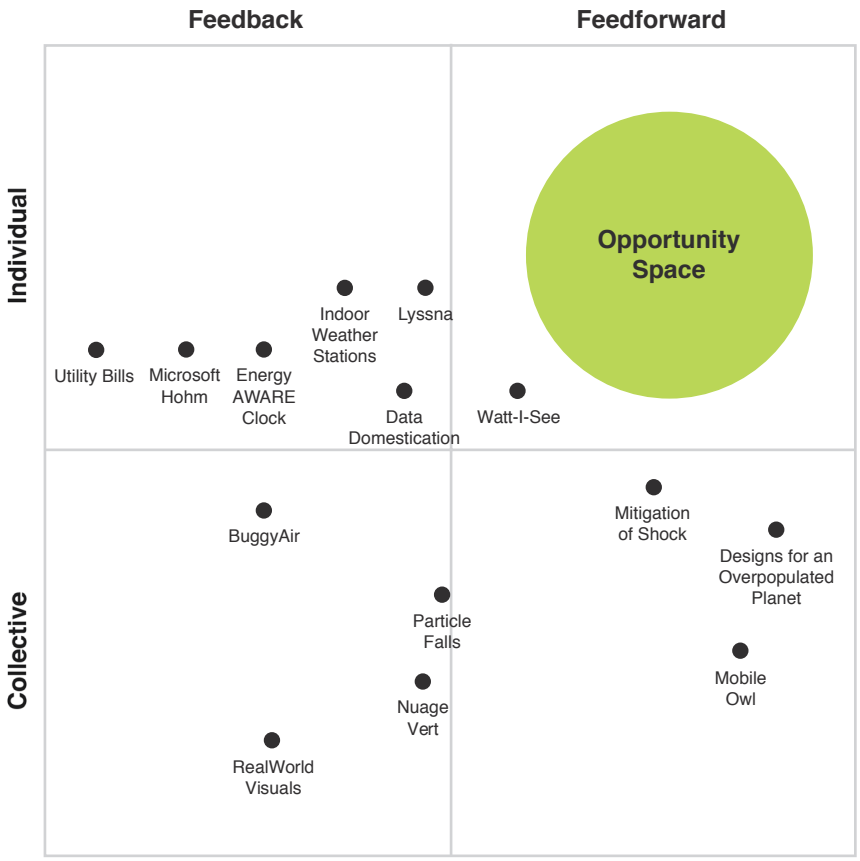


Figure 05. *The collection of projects reviewed here, which includes existing and former commercial products as well as more speculative designs, is by no means exhaustive, but represents the distribution of solutions uncovered throughout the research process.*

Mapping each project on this matrix revealed that interventions fall primarily into two camps: individual feedback (common examples include utility bills) and collective feedforward (which includes things like awareness campaigns and experiential futures.) Mechanisms focused purely on individual feedback tend to emphasize consumption, leaving users with little information about the implications of their behavior. In contrast, visions of a collective future often leave viewers wondering where they fit in, revealing an opportunity to bridge individual action with anticipated impact.

The following projects served as valuable references for the work ahead.

Lyssna by Doenja Oogjes

Lyssna is a speculative project created by designer Doenja Oogjes as a way of reframing our relationship with the food in our homes. Lyssna is described as a sort of "hearing aid" for your refrigerator, allowing you to relate to the food inside auditorily. Each food item has its own unique sound, communicating (albeit in a way that's not entirely clear from the documentation) to the listener its flavor profile and relative freshness. In general terms, a fridge full of food waiting to be eaten would relay a symphony of sound, encouraging and hopefully inspiring the user to make use of it.

This project is of particular interest to my own work as it exists at the intersection of speculative design and food waste mitigation, and is deployed within the home (much of the discourse surrounding food waste occupies a more conceptual plane rather than being grounded in-situ.) It also takes a decidedly positive tact, positioning the feedback gathered from the food as a whimsical gain, rather than exposing potential loss.

Figure 06. *Lyssna produces data in the form of music with the goal of inspiring users to cook.*

Indoor Weather Stations by Bill Gaver et al

As a set, the objects were intended to pique curiosity and encourage discovery within the home environment by leveraging elements of ludic design. The set distributed to test users included a “temperature tape” designed to reveal temperature gradients across a span using thermochromic ink, a “light collector” which measured and displayed the light collected in a location over the course of 2 hours, and a “wind tunnel” which represented the air currents detected in the home utilizing a fan and tiny forest of film trees.

According to the designers, “a ludic approach to domestic technology undermines assumptions about ‘smart’ appliances for the efficient and productive home and presents instead curious systems for exploration and reflection about domestic space.” (Gaver et al., 1) One of the most intriguing aspects of these devices was the concerted effort to create transparency in the dynamic between user and sensor as a means of mitigating “the suspicion and feelings of intrusion which such systems have given rise to in the past.” (Gaver et al., 4) The researchers also found that engagement with the devices quickly faded for many participants, as they found the sensors simply didn’t provide enough novel feedback; as one respondent pointed out, the stations recorded phenomena that were already available to a home’s occupant, they simply presented the data more concretely.

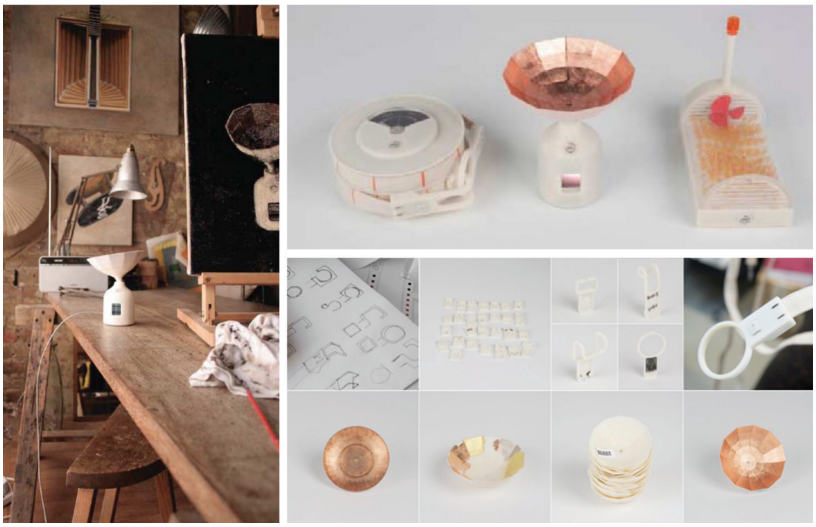


Figure 07. *The temperature tape, light collector, and wind tunnel were designed as tools for exploration, creating an environmental “laboratory” in the home.*

Data Domestication by Iohanna Nicenboim

Iohanna Nicenboim's Data Domestication aims to explore one potential strategy for fostering more "human" interactions in a world where environmental sensors are commonplace in the residential setting. She asserts that "humans are not good at remembering numbers, but rather very good at interpreting vital signs," and it's this observation that drove her to develop a series of pet-like devices that could report environmental information to their users in "meaningful" ways. Unlike environmental sensors on the market today, Nicenboim's "Air-Quality Birdcage" is imbued with a sort of artificial life-force, and as such, thrives under favorable conditions and "dies" when conditions exceed a particular limit.

This project served as an inspiring precedent for works of design fiction that challenge the existing user-device paradigm of IoT and smart objects, particularly within the space of eco-feedback. As seen in Gaver's study of the Indoor Weather Stations, each of Nicenboim's conceptual devices possesses a certain autonomy, which ultimately creates a dynamic of care and cohabitation between user and object. Nicenboim's hope was that this relationship would transcend the typical exchange of information occurring in today's "smart" environments, fostering greater emotional attachment and deeper user engagement.

Figure 08. *Nicenboim's Air-Quality Birdcage has a full coat of feathers when conditions are favorable, and gradually sheds them as air quality worsens.*

BuggyAir by Superflux

BuggyAir was developed as a network of mobile air-quality sensors to be deployed on strollers so that as parents went out for walks with their children, they could monitor the quality of the air they were exposed to. As the studio noted in their write-up for the project, “we believe that true power of IoT technology lies in the hands of people and communities who decide to use this technology to gain empirical understanding about issues that matter most.” (Superflux.in)

This project, as noted in several other precedents reviewed, aimed to challenge the contemporary culture surrounding IoT objects — in this case by democratizing the process of gathering and analyzing environmental data — and as such, served as a successful example of an IoT “tool”. Instead of acting as passive objects intended for the dissemination of centrally controlled information, each BuggyAir kit empowered its user to actively sense and record otherwise unseen data.

Figure 09. *Each BuggyAir kit was designed to empower users and connect them with a larger data-gathering network.*

Mitigation of Shock by Superflux

In 2017, design studio Superflux created Mitigation of Shock, an exhibition designed to situate viewers in a London flat in the year 2050 in order to relate the impacts of climate change directly to the individual. The reconstructed home was populated with omens of a food-insecure scenario, from cookbooks instructing readers on food prep in times of scarcity ("Pets as Protein") to micro-laboratory setups for in-home agriculture, driving home the profound shift that could (and likely would) occur in our everyday lives should global warming continue at its current rate. By prompting visitors to confront a harsh impending reality in the present day, Superflux hoped that the installation might "mitigate the shock" of this bleak eventuality and spark meaningful conversation about preventative action.

This project, along with several other Superflux creations, served as an extremely valuable case study into the potential of futuring in supporting environmental discourse. Elements of this strategy, which make an extrapolated future condition clear and relatable, have proven highly effective in eliciting emotional responses from viewers and as such, may be employed to spark engagement with otherwise unpleasant or invisible topics. However, like many interventions of this nature, the scene depicted here reads more as a grim (and slightly absurdist) postcard from an impending reality than it does a mutable condition, and therefore falls short in empowering its viewers to mobilize against it.

Figure 10. *The London flat staged for Mitigation of Shock provides viewers with an eerie glimpse into a possible future.*

Energy AWARE Clock by The Interactive Institute
The study of eco-feedback is saturated with designs meant to curb energy consumption, but the Energy AWARE Clock is one of the best examples of an abstract, yet intuitive representation. The design draws on a familiar interface—the clock face—as a display that most homeowners are already accustomed to referencing for information. Mimicking each of a clock's hands, three overlapping starbursts depict energy usage by the hour, minute, and second, with the largest spikes occurring when energy usage is at its highest. Its house-shaped enclosure reinforces the underlying notion that the device is depicting energy used within the home (rather than some larger, more abstract universal concept like time.)

The techniques employed in this design, including the strategy of leveraging a familiar clock interface, provided inspiration and reference for my own explorations. By tapping into established behavioral patterns, the designers have lessened their users' cognitive load, requiring less explicit attention and increasing the likelihood that this new display will integrate seamlessly with their day-to-day lives.

Figure 11. *The Energy AWARE Clock plays on familiar household objects to foster trust and spark curiosity.*

Energy Babble by Andy Boucher et al.
In association with the Interaction Research Studio, members of a multidisciplinary team developed Energy Babble, a series of computational devices team member Bill Gaver described as "automated talk radios obsessed with energy." (Boucher et al., 7) The Babble — designed to explore new ways of engaging with environmental discourse and encourage communication regarding conservation efforts — draws content from a variety of sources including social media, policy announcements, and direct inputs from other Babble users, and then disseminates it throughout the network of users. The resulting experience was intentionally controversial; users expressed frustration at being confronted with the often-messy conglomeration of outputs — described by Gaver as a "tangle" of environmental issues — but the Babble's creators maintain that this experience accurately reflects the reality of environmental rhetoric and may, in fact, "paradoxically represent the more effective way forward." (Boucher et al., 148)

The goals of Energy Babble are, in many ways, closely aligned with those of this study in that each Babble serves as a conduit, bringing feedback from the community into the home, therefore connecting the individual to the collective. The Babble's formal references to familiar household objects proved critical in encouraging users to adopt the device as part of their day-to-day lives, but for many participants the object's physical presence was ultimately overshadowed by the disruptive nature of its content.

Figure 12. *The Energy Babble connects individual users with a like-minded community using familiar material tropes.*

"Certainly, a nerve is touched when we summon the courage to open our eyes and look straight-on at the suffering, separation, and violence now being inflicted, not just on humans but on the whole family of life. Facing the pain of our times— allowing ourselves to feel — is a necessary prelude to waking up."

- Christopher Uhl,
Developing Ecological Consciousness

SYNTHESIS & IMPLICATIONS

Through this phase of work, I discovered several points of misalignment between the psychological factors at play in unsustainable behavior and existing approaches to environmental signalling.

Communication Breakdown
Having identified a breakdown in the communication between individual and collective states as a driving force in our unsustainable behaviors, I hypothesized that in order to encourage more sustainable habitation, there was an opportunity for designers to reconnect the individual with the wider ecology by repairing and/or strengthening these signals. However, few interventions employ this strategy, instead favoring more anthropocentric models that emphasize consumption. It's critical, though, to recognize that there is a limit to human understanding. Over time, our species has developed robust psychological mechanisms to process complex information, and it's these heuristics that enable us to make decisions without becoming overwhelmed. In designing for greater awareness of a system, caution must be taken so as not to overlook this bounded rationality.

Leveraging Feedforward
As designers, how might we support users in widening their view of their own role within the greater ecology without drowning them in information? Building on Fry's definition of "redirection," (Fry, 11) an environmental signalling mechanism might serve to "indicate the error of existing pathways" (Fry, 11) by elucidating the consequences of common behaviors. As such, a feedforward approach applied on the individual level — that is, bridging a user's everyday actions with the anticipated ecological impact — could strengthen the feedback loops between individual and collective without forcing a user to grapple with systems-level concepts and support agency where traditional (i.e. group) feedforward applications fall short.

03

DEVELOPING DESIGN PRINCIPLES

In the third phase of study, I focused on developing principles for designing environmental feedforward mechanisms; first, by exploring the heuristics used in analyzing analogous examples of forecasted information; and second, by deploying a participatory activity to draw out preferred user-device dynamics.

Driving Questions:
What delivery method might effectively support engagement on a daily basis?
How might designers ensure trust between user and device when delivering forecasted information?

“...human action will always be destructive; there is, however, an enormous divide between not knowing and knowing this fact and thereafter making critical decisions in the light of this knowledge.”

- Tony Fry
Design Futuring

INFLUENTIAL TEXTS

The following texts were instrumental in shaping the work undertaken in this phase.

Towards Designing Persuasive Ambient Visualization, Andrew Vande Moere
Recent trends in data representation— including ambient, ubiquitous, and persuasive visualization—have opened new avenues for surfacing otherwise unseen information and influencing user action. Ambient visualizations that employ metaphor have the power to inspire deeper engagement, revealing further layers of information as the user invests greater time and attention. Ubiquitous ambient displays in particular further enable users to receive information at critical moments, allowing them to make informed decisions with less mental overhead. Thus, while traditional data visualization is often used solely as a means of transmitting information, ambient displays can be leveraged to convey larger, more subjective messages and by focusing on the higher-level concepts underlying the data, these displays have the power to encourage shifts in attitude and behavior. Vande Moere states that persuasive visualizations "utilize data to justify the relevance and significance of the representation by focusing on the meaning of the data, instead of detecting any patterns hidden inside it." (Vande Moere, 52)

This text provided insight as to potential strategies for conveying data with the purpose of encouraging behavior change, enumerating a series of related approaches. Vande Moere, however, also surfaces an important consideration in the process of evaluating these strategies. He points out that the metrics currently available for measuring the long-term effects of persuasive visualizations are insufficient, as techniques that rely on self-reporting and reflection are notoriously unreliable as a result of low participant compliance and objectivity.

Ambient influence: can twinkly lights lure and abstract representations trigger behavior change?, Yvonne Rogers et al.
In an effort to demonstrate the potential impact of ambient information on decision-making, the authors of this study designed and tested three visualizations; two were highly abstract representations (twinkling lights guiding people to use the stairs and a constellation of spheres that depicted stair

usage vs elevator usage), and the third employed more “traditional” modes of visualizing data (pie charts on a public screen.) After installing these three interventions in an office building, they found that the abstract representations were far more successful in capturing attention and piquing curiosity than the “traditional” display, however these visualizations also caused greater levels of confusion and led to more misinterpretation than the more familiar forms of a pie chart.

This study was particularly relevant for its evaluative data. It provided self-reported information surrounding perceived behavior as compared to actual behavior and revealed a gap between the two, implying that the abstract displays successfully affected behavior, but did so on an unconscious level. This would suggest that abstract representations might be well-suited to influencing behavior over time regardless of user’s explicit awareness of the transformation.

DYNAMIC (MAKETOOL STUDY)

Having selected a feedforward model, I conducted a make tool activity to explore what type of user-device dynamic would be well suited to encourage long-term engagement with forecasted environmental information. In this activity, I asked five participants to create a hypothetical device based on a design prompt of their choosing. To build this design prompt, respondents filled in a series of blanks on a printed worksheet, choosing from a bank of responses according to their personal values. I then asked each participant to create a 3D representation of a device that might support them in achieving the goals laid out in their prompt.

Devices created during this activity fell into one of two general categories:

Assistant
These devices effectively "did the right thing" for their users, telling them which food items were in danger of spoiling or finding someone to take on unwanted food. This type of device, while potentially effective in reducing waste, circumvents the attitudinal shift that this study hopes to achieve by relieving the user of responsibility and therefore negating any need for introspection.

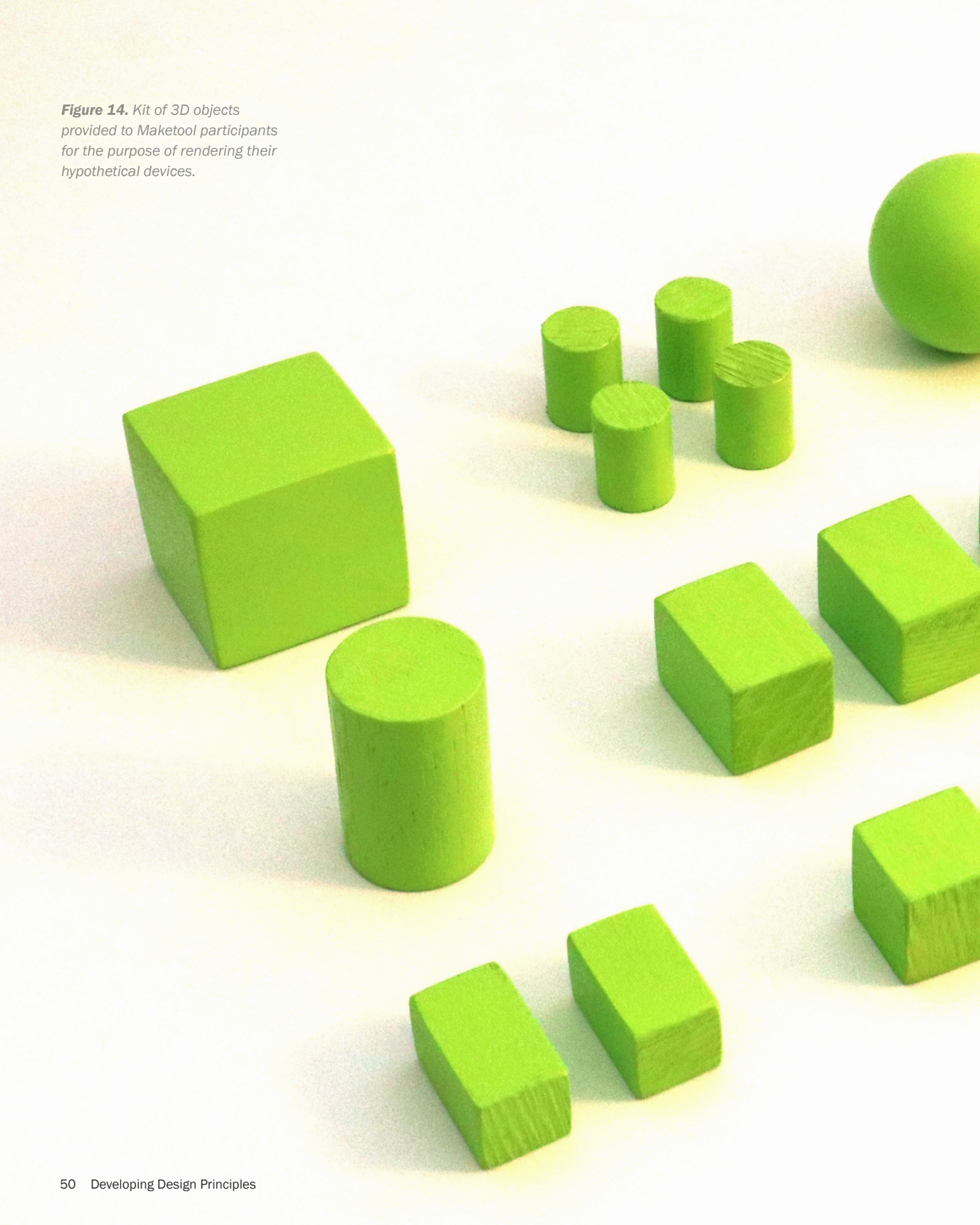
Tool
These devices functioned as tools, equipping users to surface unseen information on their own time. This type of device positioned the user in an active and reflective role, and as a result, was well aligned with the goals of the study (to encourage users to contemplate their place in the greater ecology.)

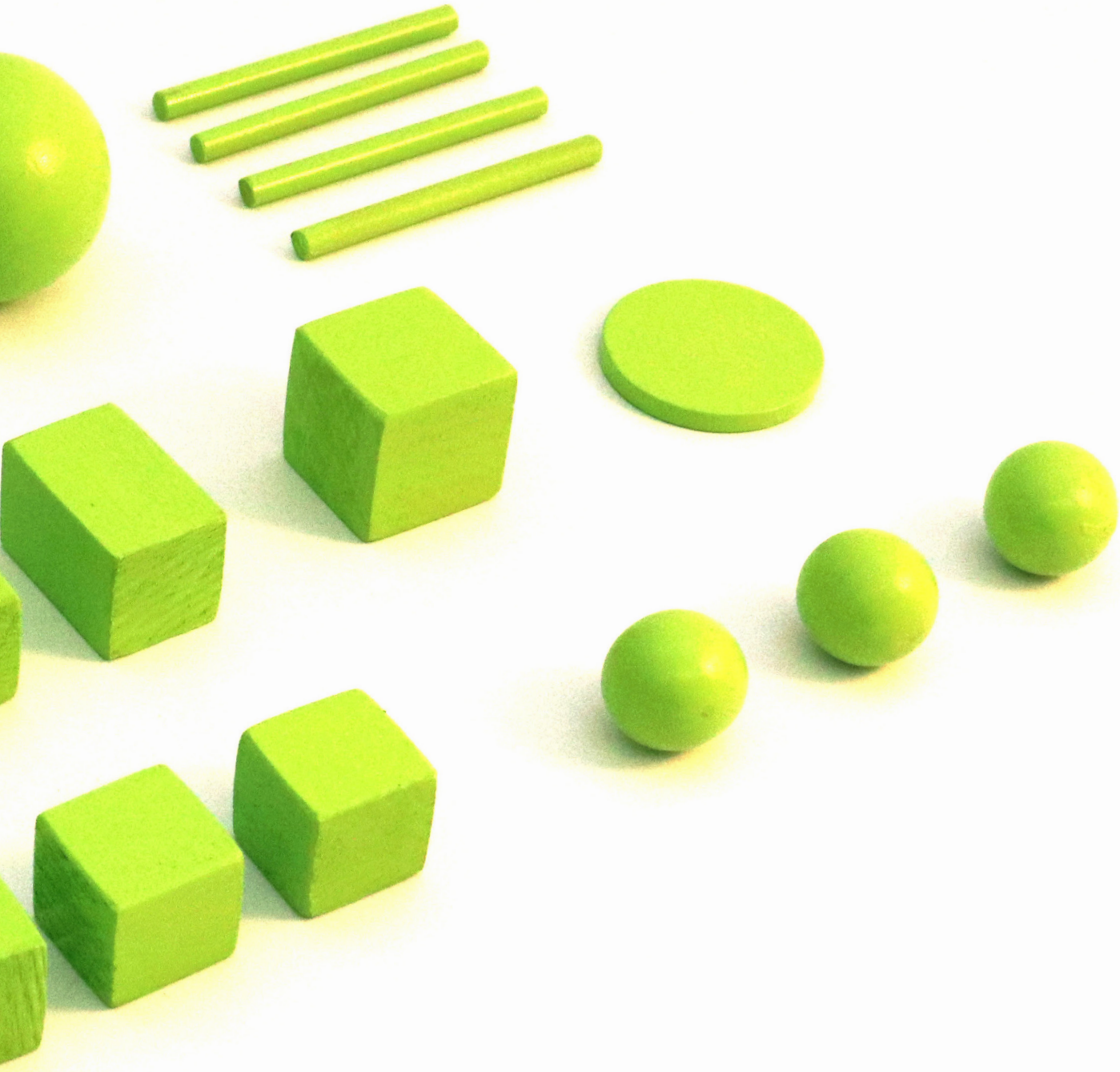
Interestingly, creators of both assistants and tools agreed on one key characteristic: they wanted to "pull" information from their creations rather than receive "pushed" notifications (perhaps because our lives are already oversaturated with digital alerts.) Even those who created "assistants" wanted to engage with the object on their own terms; one participant likened their ideal user-device dynamic to that of an answering machine, imagining their digital assistant would essentially "leave a message" for them to check. Participants who assembled tools also expressed a desire for information regarding long-term patterns as a way of altering their behavior over time, rather than relying on "in-the-moment" nudges.

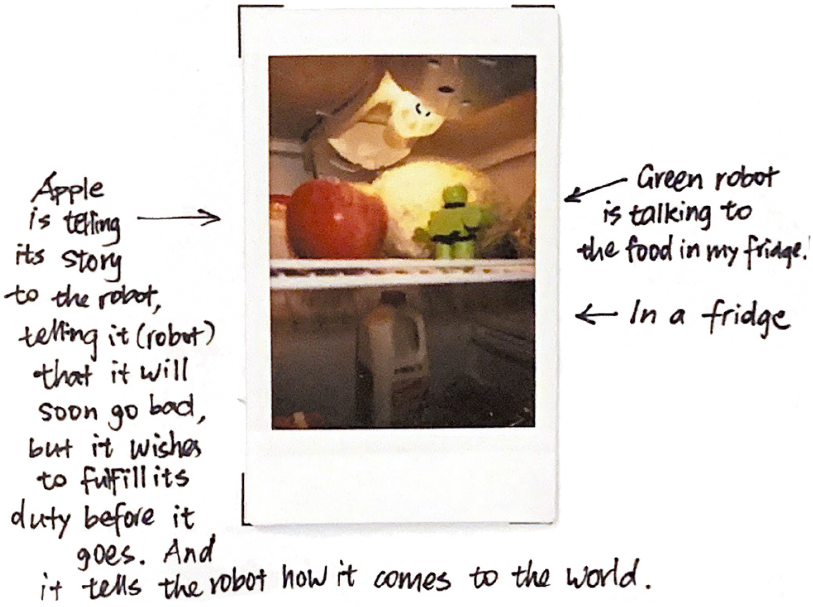
Figure 13. *Each participant in the Maketool activity was given a worksheet to guide them in creating a speculative design prompt.*

's specific function by selecting a card
(matching the color of card 2.)
formation about 3
3
4
MICRO
Once you've finished defining your design prompt, please build a representation of this device using the pieces provided.
Snap a photo of your completed tool in context using the instant-film camera and affix it here.
Please label each component.
3
Land Use + Resource Depletion
[custom]
3
Finance + Economy
3
Range + Migration Patterns

Figure 14. *Kit of 3D objects provided to Maketool participants for the purpose of rendering their hypothetical devices.*







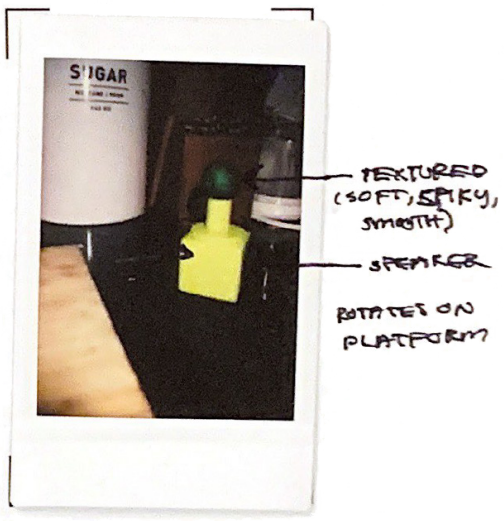


Figure 15. *A sample "assistant" device (top) and a sample "tool" device (bottom) created by participants in this activity. Annotations were done by each device's creator.*

TRUST (CARD SORT)

To probe the role of trust and the ways in which it might be supported, I conducted a card sort. In this activity, I provided participants with a set of cards, each labelled with a type of forecasted information, and asked them to place the cards in order according to the degree to which they trusted each kind of prediction. After completing their sequence, I asked each respondent to explain the rationale for their ordering.

A series of key heuristics emerged from the discussions with each participant. When recounting their process for evaluating forecasted information, participants spoke of the following qualities:

Proximity (temporal and, to a lesser extent, spatial)
Data that was perceived as temporally or spatially distant tended to be less trustworthy than data that was proximate. For example, respondents considered the weather forecast for the next day to be much more reliable than the next week.

Concreteness
Respondents were less likely to trust data they considered abstract (rather than concrete). For example, the concept of a personal "credit score", while familiar, is relatively abstract, casting doubt on a participant's ability to evaluate its accuracy.

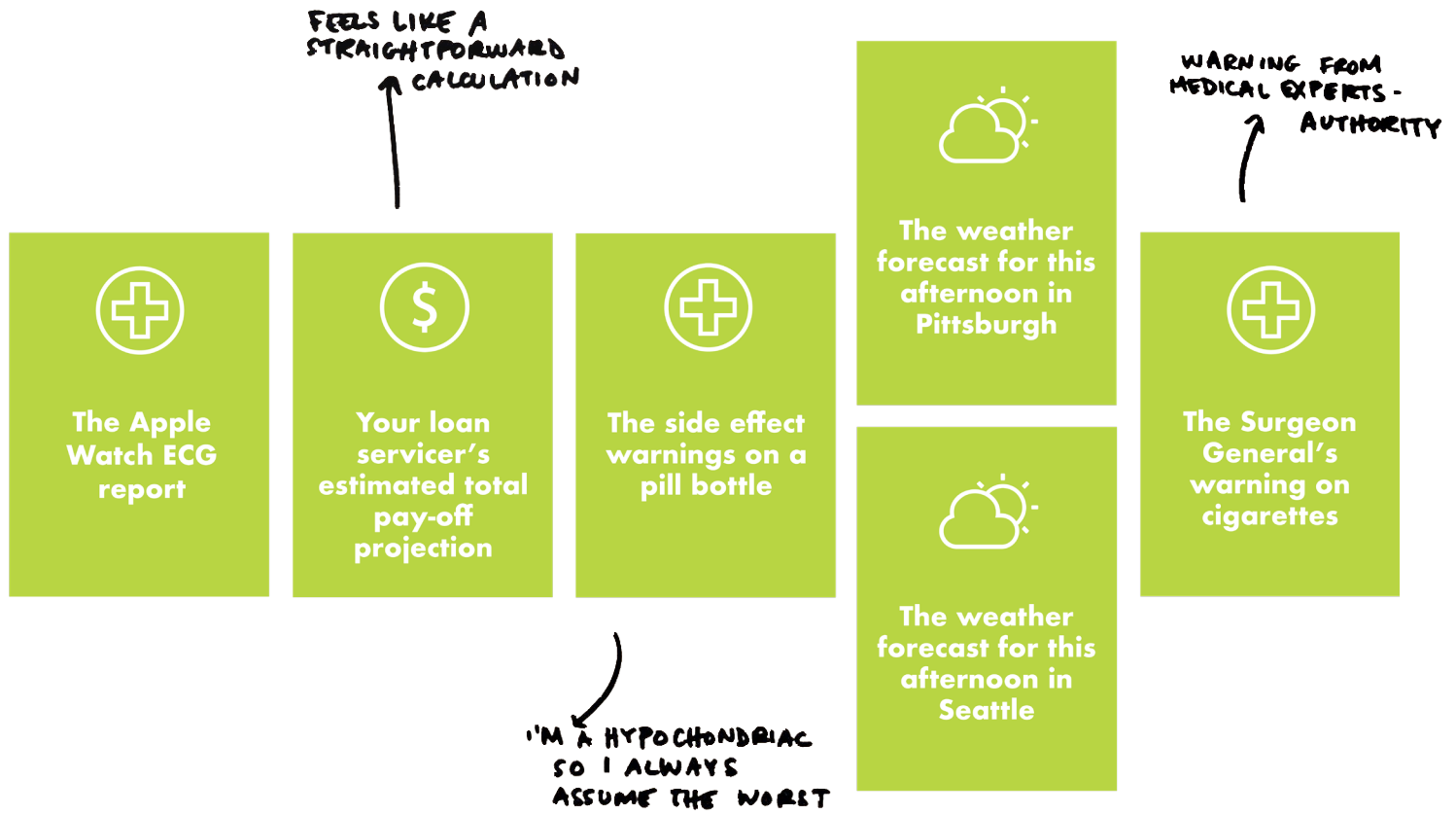
Transparency
Participants were more likely to trust predicted information if the inputs were clear and easily understood. For example, online "calculators" were considered trustworthy when users were able to manipulate inputs directly.

Conversations with participants revealed that trust plays heavily into an individual's willingness to act on forecasted information, and while the three heuristics enumerated above were common across all participants, the order in which an individual employed them was much less consistent. For example, some participants ranked the tip calculations on a receipt low in terms of trustworthiness because of the perceived interest a restaurant may have in inflating the numbers (lack of transparency), whereas several others placed

this card on the high end of the trust spectrum based on its nature as a straightforward calculation (concreteness). This discovery suggests that while the heuristics to be considered when providing information about future events are relatively similar amongst users, prioritization of the perceived qualities is more variable.

Figure 16. *Samples of predicted data on the topics of weather, health, and finance were chosen with the hope that they would be familiar for the maximum number of people within the participant pool (consisting primarily of current or recent students.)*

Figure 17. *Example of participant card sequence (annotated based on conversation record).*


FEELS LIKE A STRAIGHTFORWARD CALCULATION
WARNING FROM MEDICAL EXPERTS - AUTHORITY
The Apple Watch ECG report
Your loan servicer's estimated total pay-off projection
The side effect warnings on a pill bottle
The weather forecast for this afternoon in Pittsburgh
The weather forecast for this afternoon in Seattle
The Surgeon General's warning on cigarettes
I'M A HYPOCHONDRIAC SO I ALWAYS ASSUME THE WORST
More Trustworthy

"A new worldview won't take hold because of clever arguments or impassioned pleas; it will only emerge after many, many people come to understand that the present worldview (story) is causing irrevocable damage and must be abandoned. To paraphrase Einstein, a new story begins to gain traction when people come to understand that the problems they face can no longer be solved from the same level of consciousness that created those problems in the first place."

- Christopher Uhl,
Developing Ecological Consciousness

SYNTHESIS & IMPLICATIONS

Each of the exercises conducted in the preceding research provided valuable insight as to the delivery of environmental feedforward. The following principles were gleaned from the research process in its entirety and are intended to serve as guidelines for designers who aim to produce new mechanisms for providing environmental signals.

Target Mental Models
If designers hope to address the root causes of unsustainable behaviors, we might design environmental signalling mechanisms to combat the underlying ecological disconnect rather than simply treat the "symptoms" by targeting habits themselves.

Strengthen Signals
Unsustainable practices are enabled by a breakdown in communication between individual and collective. By strengthening the weak or missing signal loops, we might widen an individual's view of their place within the greater ecology and encourage new, more sustainable mindsets.

Support Exploration
In a technological climate saturated with digital alerts, notification fatigue inhibits our ability to absorb new signals and as a result, users are drawn to tools with which they can choose to surface otherwise invisible information. This thesis hypothesizes that by equipping users with the tools to explore the implications of their habits rather than imposing punitive systems, we might satisfy the desire for both control and non-intrusive presence while encouraging an active role in the learning process.

Foster Trust
Trust plays heavily into an individual's willingness to act on forecasted information, and while issues of concreteness, proximity, and transparency all factor into a user's trust in feedforward, the hierarchy among them varies from person to person. This finding suggests that in order to engage users with differing values, an environmental feedforward mechanism might allow for output flexibility and customization.

04

EXPERIMENTING WITH EMBODIMENT

Through the fourth phase of study, I explored a series of speculative methods for embodying the insights gained in the preceding sections.

Driving Questions
How might designers embody environmental signals in our day-to-day lives in such a way that empowers us to explore the connection between individual action and collective impact?

“...we need to move design upstream, beyond product, beyond technology, to the concept or research stage, and to develop speculative designs, or “useful fictions,” for facilitating debate.”

- Anthony Dunne & Fiona Raby,
Speculative Everything

INFLUENTIAL TEXTS

The following texts were instrumental in shaping the work undertaken in this phase.

Speculative Everything, Dunne & Raby
In addition to providing a collection of speculative design projects for reference and inspiration, Dunne and Raby illustrate the role of critical design in challenging the status quo. To address some of the most common criticisms levelled against speculative design practice, they assert that the goal of design fiction is not to "solve problems" in the traditional sense, but to raise questions that might otherwise go unasked. The true value of these speculative "probes" is in their ability to provoke thought, facilitate conversation, and support reflection rather than to simply fill a need. Holding fast to the idea that this type of design aims to influence consciousness, the authors also emphasize the importance of free will in speculative design and maintain that more subversive methods of encouraging behavior change ("nudging") unfairly limit individual agency. As such, these design fictions can be leveraged to present completely new realities, therefore catalyzing and motivating change rather than imposing it.

This text outlines the potential advantages and pitfalls of speculative practice, and was highly influential in my decision to situate the output of this study within a speculative space. Dunne & Raby demonstrate that this approach not only allows for experimentation on deeply complex topics, but also acknowledges that perhaps the only way to overcome society's most wicked problems is not by "fixing" them as designers often feel compelled to do, but "by changing our values, beliefs, attitudes, and behavior." (Dunne & Raby, 2) The collection of projects presented (as well as the accompanying narrative) underscore the potential inherent in the creation of design fiction to alter perceptions and disrupt prevailing modes of thought.

Emotionally Durable Design, Jonathan Chapman
Echoing the sentiments expressed by Morton in Hyperobjects, Chapman identifies a disconnect between humankind and the natural world as one of the driving forces in our modern culture of excessive waste. He posits that "in seeing ourselves as beyond this 'ecological consciousness', we have broken

partnership with the biosphere, developing alien practices, processes, materials and lifestyles that far exceed the Earth's regenerative capacities." (Chapman, 5) He goes on to assert that while the prevailing patterns of interaction prioritize speed, efficiency, and convenience—a trend which effectively alleviates the need for users to engage in the decision-making process—this needn't be the case. He argues that it's "the subtle and more ephemeral user experiences that penetrate the psyche through the slow and steady passing of time" (Chapman, 87) and therefore possess the potential for fostering the deep emotional connections he believes are crucial for reshaping our consumptive behaviors. These "fuzzy" (Chapman, 83) interfaces present users with the challenge of understanding and mastering their use over time, a process which builds a bond between human and object in which both evolve simultaneously.

Chapman's discussion of "fuzzy" interfaces and their role in the formation of emotionally durable user-object bonds was extremely valuable in this phase of study. As he describes them, the effects of this approach to interface design (encouraging reflection, promoting sustained engagement, and fostering emotional connection) closely aligned with the goals of this investigation, and as such, suggested a path forward.

FEEDBACK STUDY

To better understand the plurality of ways in which we gather feedback regarding our impact on the world around us, I completed the following exercise. First, I examined and recorded the channels through which information is gathered during an everyday task, and second, I compared it with the channels leveraged by common household devices. The results are illustrated on the following spread.

Scenario
You stand at the kitchen counter, preparing breakfast. As you place the first slab of bacon into the pan, the volume and pitch of the subsequent sizzle indicate that the pan is too hot. You probe the scrambled eggs with a spatula, but they're not quite firm enough. You extract a piece of sourdough from the toaster and you can tell by its color that it's just how you like it. The smell of cooked bacon draws you back to the stove.

Insights
This seemingly mundane scenario illustrates the breadth of sensory information humans receive on a daily basis. These are the "fuzzy" interactions through which we naturally engage our environment and develop an intuitive understanding of our situation within it. However, the devices that fill our homes today rely chiefly on visual and auditory cues to convey meaning. Screens, dials, gauges and meters dominate the digital landscape, and while the rise of voice interfaces has brought us one step closer to "natural" exchange between users and objects, the emotive potential of sensory communication remains largely untapped. As summarized by designer Bruce Mau, "We have allowed two of our sensory domains - sight and sound - to dominate our design imagination. In fact, when it comes to the culture of architecture and design, we create and produce almost exclusively for one sense - the visual....We need to explore, experiment, and invent new formats and combinations of sensory experience, new ways of telling stories." (Mau, 20)

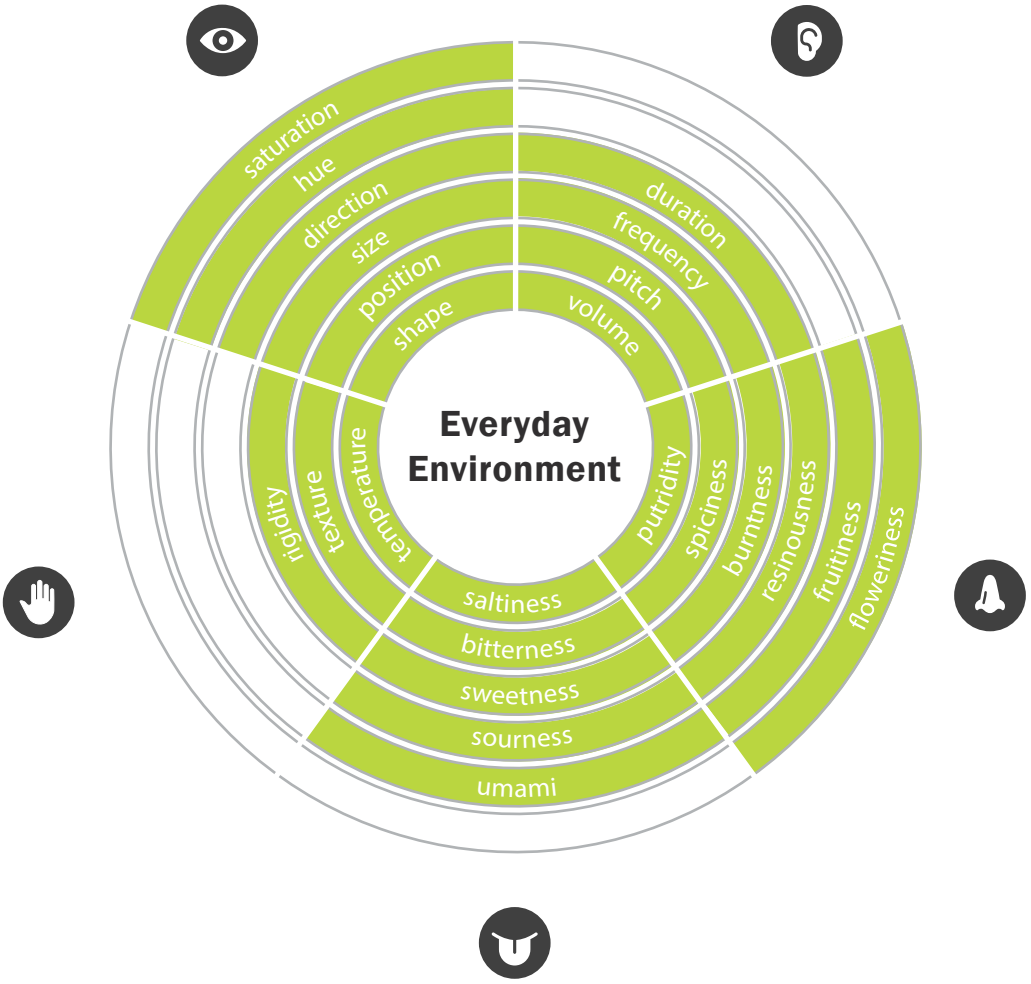


Figure 18. *This mapping illustrates the plurality of multisensory cues leveraged by human beings in the everyday environment. The qualities shown were compiled from a variety of sources, including Nathan Yau's text Data Points: Visualizations that Mean Something as well as Ellen Lupton & Andrea Lipps's text The Senses: Design Beyond Vision. It's worth noting that mapping the qualities of taste and smell were considerably more difficult than those of the other senses as a result of deficient vocabulary.*

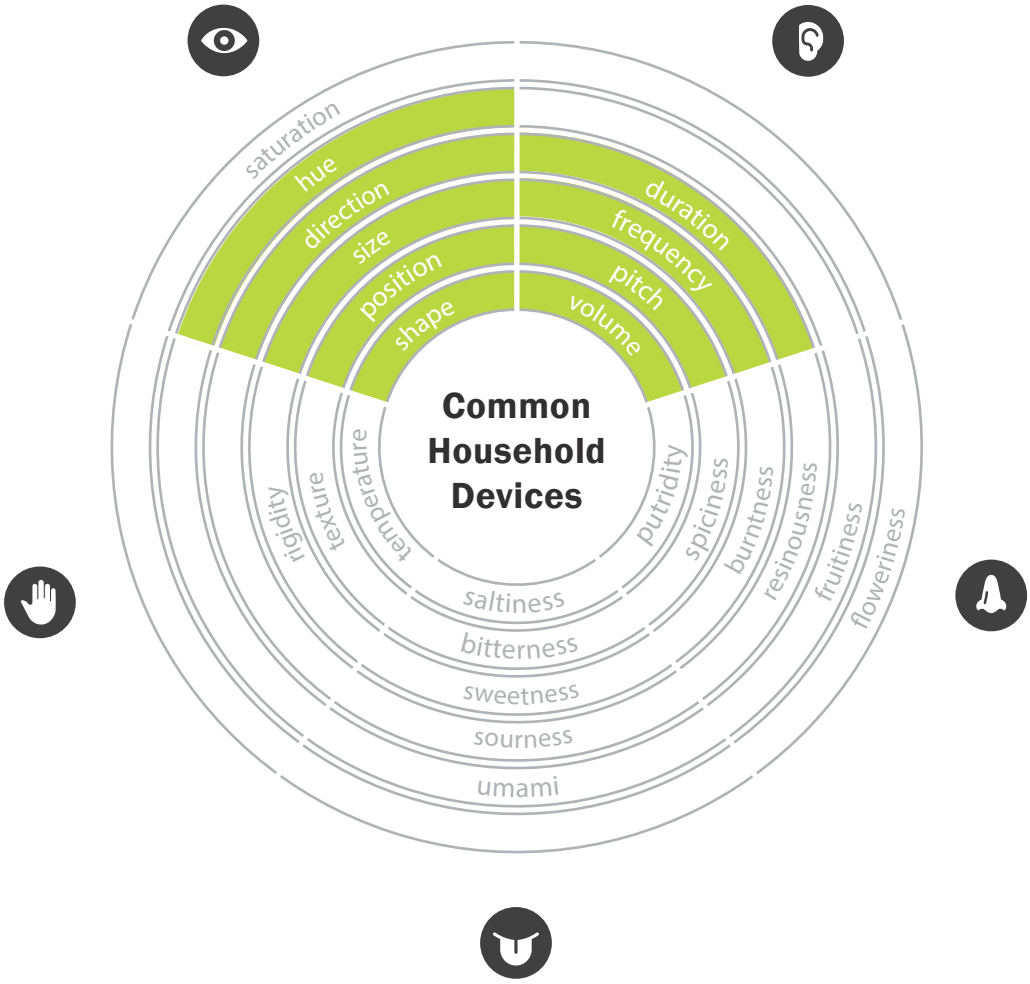


Figure 19. *In contrast to the rich, multisensory experiences encountered in everyday life, devices commonly found in homes today are comparatively limited in the qualities used to convey meaning.*

"Darkness as an antidote to naive techno-utopianism can jolt people into action. In design, darkness creates a frisson that excites and challenges. It is more about the positive use of negativity, not negativity for its own sake but to draw attention to a scary possibility in the form of a cautionary tale."

- Anthony Dunne & Fiona Raby,
Speculative Everything

CRITICAL CONTEXT

For this phase of study, I chose to situate the following explorations within what I'll call, with tongue in cheek, an alternate reality. Temporally, this world might sit adjacent to ours, or it may be situated somewhere in the near future. In either case, the plausibility of technologies utilized and urgency of needs met are both highly contemporary. Devices in this world leverage the full "bandwidth of reality" (Mau, 21) to deliver multisensory information and in doing so, engage users on an emotional level.

An argument could be made that the concepts explored through this phase fall within the critical sub-genre of dark design (not to be confused with so-called dark UX, dark pattern design, or any of its manipulative variants), meaning that they leverage negativity with the hope of reaching a positive end. Anthony Dunne and Fiona Raby, originators of the critical design moniker, offer the following explanation:

"Dark design is not pessimistic, cynical, or misanthropic; it is a counterpoint to a form of design that through denial does more harm than good. Dark design is driven by idealism and optimism, by a belief that it is possible to think our way out of a mess and that design can play an active role. Negativity, cautionary tales, and satire can jolt the viewer out of a cozy complacency that all is well. It aims to trigger shifts in perspective and understanding that open spaces for as-of-yet, unthought-of possibilities." (Dunne & Raby, 43)

This approach, which has emerged organically from the preceding research, was leveraged in this study to elicit discussion surrounding the catalytic potential of what Uhl, Fry, and others refer to as "pain" and it was in this space that my own conception of an ecological harbinger began to take shape. This vision was explored and materialized through the remainder of this phase.

HARBINGERS: SPECULATIVE SPRINTS

The following section illustrates a series of speculative sprints undertaken as a first step on one of many potential paths illuminated through the preceding phases.

As the smart home paradigm continues to evolve, the environments in which we live are becoming increasingly data-rich. For designers hoping to encourage sustainable modes of habitation, the value of this data saturation is twofold: first, it allows for the collection of information regarding existing behavioral patterns and second, it affords the delivery of persuasive signals in the moment of decision. The overarching goal for these sprints is to imagine novel interfaces through which users might engage with these signals.

Carrying forward the design principles previously established, each of the following speculative devices is designed to serve as a tool for users to explore the link between daily behavior and projected environmental transformations.

Radio Nowhere

A 2019 statement released by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) lays bare the grim reality of climate change's impact on Earth's ecosystems: "The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide...1 million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history." (IPBES.net) This, as the statement asserts, paints a truly "ominous picture" WWof life as we know it today. According to the "rivet-popper hypothesis" (Ehrlich & Ehrlich) developed by biologists Paul and Anne Ehrlich in the 1980s, Earth's ecosystems – like the wing of an airplane – are built with a certain amount of redundancy. The loss of a single rivet (or species) may not be enough to cause a crash, but it's impossible for us to know which rivet will send the entire system into freefall.

Drawing from the familiar and whimsical form of a cuckoo clock, Radio Nowhere utilizes sound to convey meaning. Positive behavior trends are communicated through a vibrant, and diverse soundscape – including a variety of bird, insect, and amphibian calls – to evoke the biodiversity of a healthy ecosystem, while negative trends elicit a diminishing array of sounds as voices disappear.

This is radio nowhere, is there anybody alive out there?
This is radio nowhere, is there anybody alive out there?

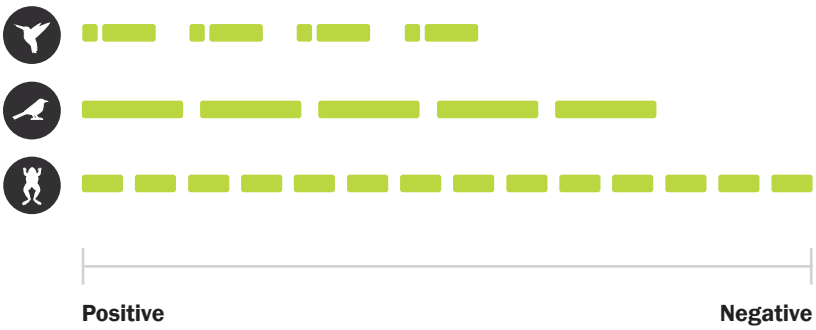


Figure 20. *Positive trends in behavior are conveyed using a mixture of sounds, but voices fade as patterns trend towards the negative.*

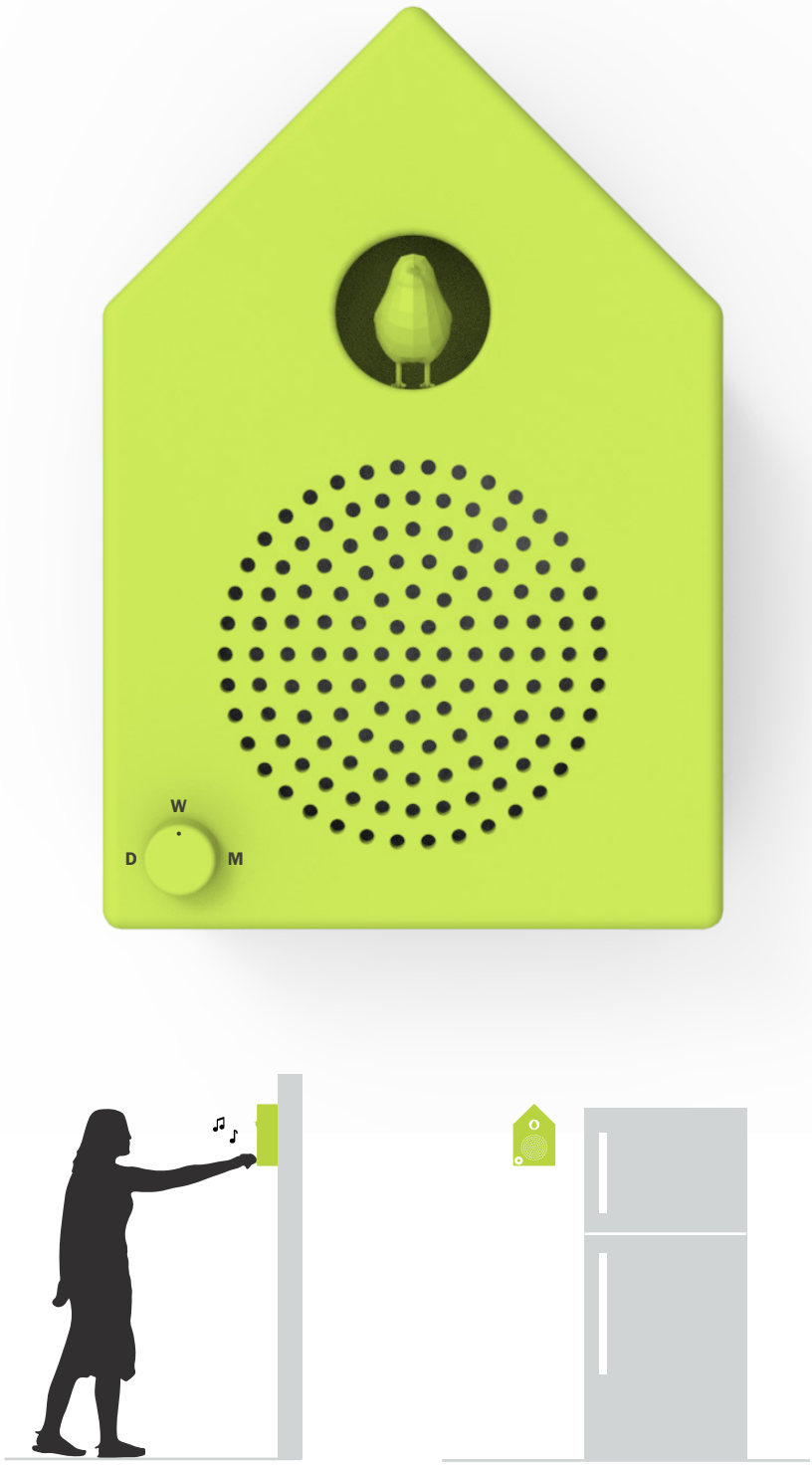


Figure 21. *A small dial on the device's face allows a user to adjust their desired output, enabling them to explore their daily, weekly, or monthly behavior.*

Sweet Surrender

The list of plant and animal species threatened by climate change grows with each year of inaction, and among them are some of the exotic foods we take for granted. Recent studies suggest that in a future transformed by climate change, chocolate – at least as we know it – may no longer be on the menu. Cacao trees flourish only in the warm, humid climates surrounding the equator and as global temperatures rise, average moisture levels in many of these areas is expected to drop. Accelerated evapotranspiration in regions including West Africa, where two thirds of the world's cacao is produced, could prove disastrous for global supply. (Scott) Carob, a drought-hardy legume, is often touted as a sustainable alternative to water-hungry cacao and while the future of chocolate remains uncertain, climate scientists and consumers alike can agree on one inconvenient truth: the difference in taste is stark. According to author Sandra Boynton:

"Some consider carob an adequate substitute for chocolate...because it can, when combined with vegetable fat and sugar, be made to approximate the color and consistency of chocolate. Of course, the same arguments can as persuasively be made in favor of dirt." (Sandra Boynton via climate.gov)

In 2016, Dutch design studio Michiel Cornelissen Ontwerp produced a 3D chocolate printer small enough to sit on a kitchen counter. (Tucker) The concept for Sweet Surrender expands upon this technology to produce edible data as a way of communicating trends in food waste. As waste increases, the candies produced contain progressively less cacao, replaced instead with carob. The hope is that over time, a user will become sensitized to variations in the relative levels of cacao, and learn to associate everyday action with the loss of natural resources.

Figure 22. *The amounts of cacao and carob in each candy are inversely proportional, creating a gradient in flavor.*

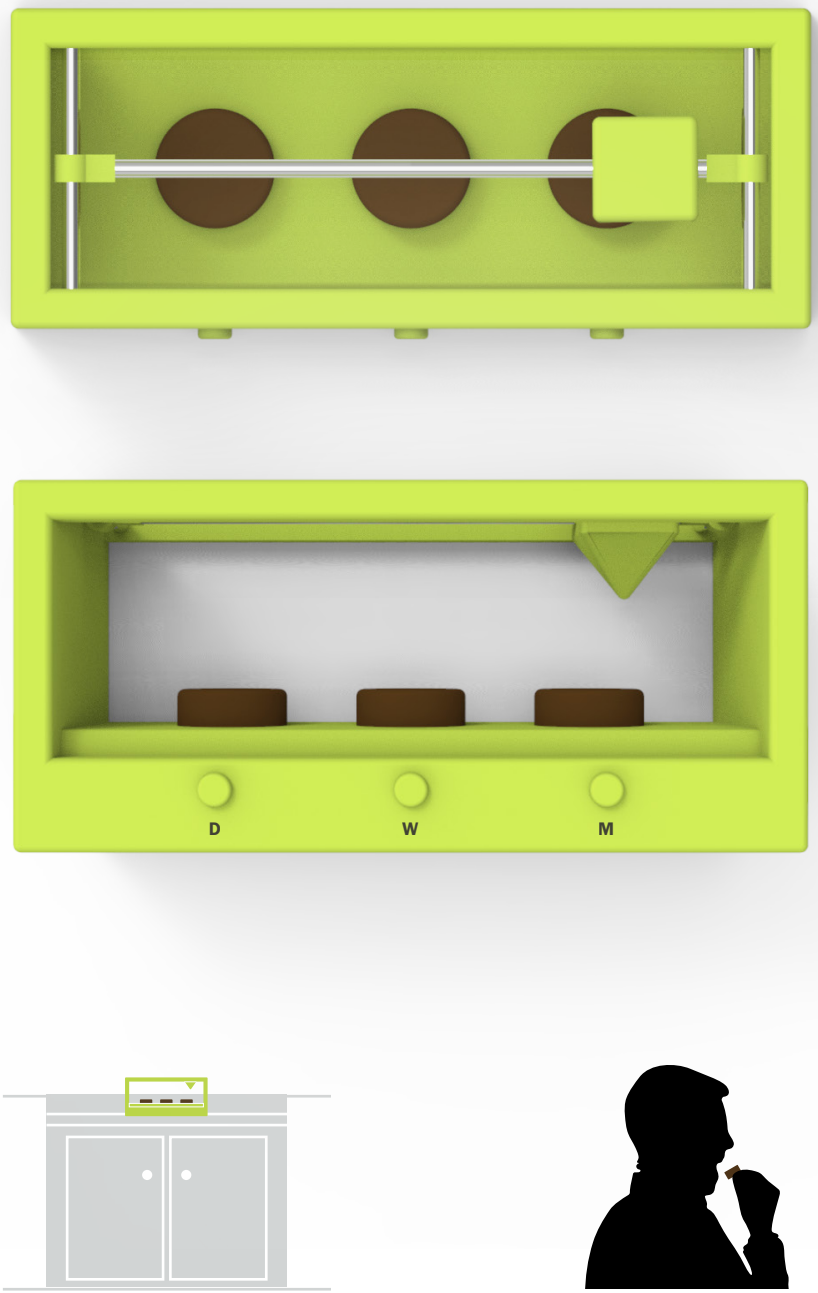


Figure 23. *The printer is equipped to produce a chocolate based on daily, weekly, and monthly data, allowing a user to make comparisons among them.*

Pushing Up Daisies

A recent study conducted at the Hebrew University of Jerusalem revealed a correlation between rising global temperatures and diminished scent production in flowering plants, an observation researchers attribute to “arrested expression and activity” (Hebrew University of Jerusalem) in the proteins that facilitate biosynthesis of scent compounds. This shift, while potentially inconvenient for horticulturists and florists, could place further strain on a fragile network of pollinators and set in motion an ecological cascade.

The concept for Pushing Up Daisies utilizes the deep emotive power of scent to reveal patterns in a user’s behavior. Rather than relying on a gradient of intensity (a distinction which would be difficult to make over time without the aid of direct comparison) Pushing Up Daisies leverages a gradual shift in the relative proportions of two scents: one floral and one sour.

Dimethyl trisulfide is the organic compound responsible for the unpleasant odor produced by the notoriously pungent corpse flower and, more familiarly, overcooked cruciferous vegetables. In the process of cooking broccoli and cabbage, the scent of dimethyl trisulfide is said to be “unmasked” as more pleasant compounds are lost. (Maruyama) In Pushing Up Daisies, this aroma, which is often associated with organic decay, is similarly revealed when the dominant floral notes fade away.

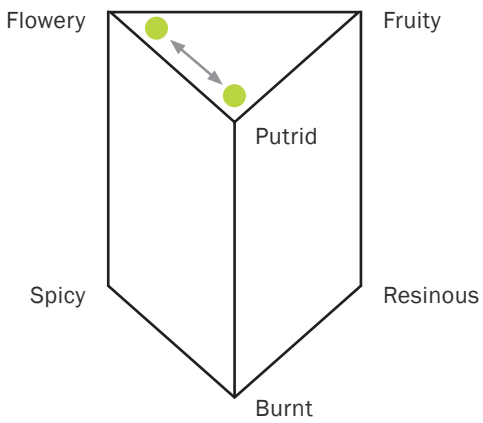


Figure 24. *While inadequate as a framework for distilling all perceivable scents, Hans Henning’s Odor Prism provides a useful lens for viewing this transformation.*

Figure 25. *Each flower provides information regarding a different time period: daily performance (shortest stem), weekly performance (medium stem), and monthly performance (longest stem).*

05

KEY FINDINGS & REFLECTION

In the final phase of this study, I summarised key findings gathered throughout preceding sections, reflected upon the process as a whole, and identified opportunities for future work.

Driving Questions:
What have I learned through this investigation?
What are the opportunities for future designers to build upon the work presented?

"Ecology is not a luxury science. It is not about pleasant appearances. It is about survival. About whether we are all going to make it."

- Ben Horne,
Twin Peaks

KEY FINDINGS

Today more than ever before, models, statistics, and intergovernmental reports issue urgent warnings of the profound and intractable environmental challenges we face in the absence of widespread change, but for many, climate change remains a distant concern. Its sheer magnitude in both time and space naturally dilutes our understanding and hinders our ability to engage with the consequences of our present trajectory. But beneath these physical and temporal constraints is something far more damaging: an ontological dilemma of global proportions cultivated throughout human history. In the name of "development" we've alienated ourselves from the living systems of which we're an influential part, and in doing so, shirked our responsibilities as members of a planetary community. It's this lack of ecological consciousness that enables us to deny our agency within Earth's systems and ultimately, supports our continued unsustainability.

In an effort to stem the tide of ecological harm, a range of approaches to environmental signaling has arisen in recent years. A broad survey of realized as well as proposed interventions revealed two dominant categories: individual feedback and collective feedforward. Mechanisms that provide individual feedback tend to focus on revealing patterns of consumption, while neglecting to indicate the implications of an individual's behavior, and therefore do little to disrupt our habitual navel gazing. Mechanisms that deliver collective feedforward reveal the larger effects of society's rampant unsustainability, but often fail to connect these future scenarios to present action and as a result, fall short in supporting individual agency.

This study proposes that in this misalignment lies an opportunity for designers to shift the paradigm for residential environmental signals by connecting individual action with collective impact, and that in doing so, we might begin to tell what Uhl refers to as a "new story" about our role in the greater ecology. However, with a feedforward approach such as this comes a unique set of challenges. Concreteness, proximity, and transparency all contribute to an individual's willingness to trust forecasted information and must therefore be weighed against the emotive power of metaphor.

Ultimately, it's my belief that the transformative potential of a population aware

of, and engaged with, its own impact on Earth's living systems far outweighs the challenges faced in achieving such a condition. To quote a character from David Lynch's series Twin Peaks:

"Ecology is not a luxury science. It is not about pleasant appearances. It is about survival. About whether we are all going to make it." (Ben Horne, Twin Peaks)

REFLECTION ON PROCESS

In addition to the findings enumerated above, this study surfaced a series of insights regarding the challenges and potential advantages of pursuing a human-centered design research process to produce a critical or speculative output.

Challenges

As a student at Carnegie Mellon University, I've been exposed to a wide range of design research methods and engrained with a healthy respect for a human-centered approach. However, this methodology tends to produce, in my experience, solution-oriented outcomes and as a result, I found myself in limbo upon completing the research phase of this study. I struggled to craft for myself a speculative design prompt which incorporated all that I had discovered through research, and early experiments suffered as a result of my hesitation. In an effort to distance my work from solution-oriented critique, I clung to abstract representations of hypothetical interactions and in retrospect, I believe this choice effectively drained these initial concepts of their emotional valence. It was only when I committed fully to the formal liberties afforded by a speculative approach and stepped away from stripped-down manifestations that each concept took on life.

Advantages

Despite the challenges encountered in unifying human-centered research and critical design, I'm confident that their intersection could prove extremely fruitful for willing designers. Specifically, the theoretical grounding provided by a thorough human-centered research process might alleviate some concerns as to the often "unfounded" nature of speculative projects by anchoring concepts in demonstrable human need. Similarly, a critical output might lessen the pragmatic burden of a strictly solution-oriented approach, allowing greater freedom for designers to provoke debate and challenge the status quo.

FUTURE WORK

Further evaluation is required to confirm the long-term efficacy of the principles proposed and to do so would require a robust process for measuring ecological consciousness as well as sustained behavior change. However, as previously identified by Vande Moere, these metrics are not yet well established. It's my belief that qualitative approaches — while not rooted in a statistical paradigm – might prove effective in this application as demonstrated by the preceding mental modeling exercise.

The opportunities for other designers to build on the ideas put forth in this investigation are innumerable as the waters of environmental feedforward are, as of yet, almost wholly uncharted. Through this study, I've devoted my attention to the process of establishing novel channels to bring new information into our everyday lives. My hope is that the speculative nature of the devices shown allows them to be considered as embodied ideas rather than fully fledged products and creates space for each device to manifest in entirely new ways. An existing voice assistant, for example, might take on the task of delivering auditory feedforward, negating the need for a dedicated device.

However, it's important to acknowledge that the speculative concepts rendered are, by nature, reductive. Climate change, after all, is a complex phenomenon which cannot be truly understood through any one of the explored manifestations alone. Christopher Uhl writes:

"Certainly a nerve is touched when we summon the courage to open our eyes and look straight-on at the suffering, separation, and violence now being inflicted, not just on humans, but on the whole family of life. Facing the pain of our times – allowing ourselves to feel – is a necessary prelude to waking up." (Uhl, 174)

This confrontation, though, poses a daunting psychological challenge; to expose an individual to the full "pain" of a planet in crisis would likely prove counterproductive if not outright impossible. As such, the task at hand is much larger than what could be addressed in the scope of this investigation. While it's my belief that contemplation on one's agency within Earth's living systems is the first step in a long journey towards sustainable living, the succeeding steps

towards continued action are great in both number and scale. As designers and as citizens of Earth, I believe we must work towards a world where the boundaries between “human” and “natural” systems begin to soften if we hope to rectify the ecological discord we currently abide.

My ultimate intention is for this investigation to serve as a point of conversation, and perhaps even a source of inspiration, for designers looking to support new modes of environmental signalling, and if I’ve succeeded, it raises far more questions than it answers.

Future Inquiries

To what extent could (and should) devices of the future challenge our prevailing patterns of thought and behavior?
How might these devices support us in living for the future?
How might we forge emotional bonds with environmental information?
And how might our relationship with that information shape our relationship with the outside world?

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Image Attributions

Figure 6: Oogjes, Doenja, et al. “Lyssna: a design fiction to reframe food waste.” Everyday Design Studio online. Accessed January 9 2019. http://eds.siat.sfu.ca/?eds_project=practice-informed-speculation-on-interaction-designs-role-in-domestic-food-practices-with-less-room-for-food-waste.

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Figure 9: “BuggyAir.” Superflux.in. Accessed March 27 2019. http://superflux.in/index.php/work/buggyair/#temp.

Figure 10: “Mitigation of Shock.” Superflux.in. Accessed February 13 2019. http://superflux.in/index.php/work/mitigation-of-shock/#.

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