THE INNER EAR: CAPTURING AND PHYSICALIZING HOME VIBRATIONS

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ABSTRACT

We present the Inner Ear: a porcelain device that both captures and represents data. In particular, we focus on sensing vibrations—for their hidden yet omnipresent qualities in domestic environments. We designed the Inner Ear in response and in contrast to a growing collection of 'always on and recording' smart home devices. With the Inner Ear, we purposefully let participants choose when to capture vibrations and which capture should be physicalized. In this pictorial, we describe the design and fabrication process of the capturing device as well as the data physicalization workflow. We contribute insights on (1) the design rationale and development of a double function artifact (to both capture and represent), as well as (2) design decisions involved in balancing legibility with leaving room for meaning making during the transcription of home vibration data.

AUTHOR KEYWORDS

Physicalization, vibration, 3d printed ceramics, ceramics, porcelain, data, IoT, research through design, interpretation, home, design process.

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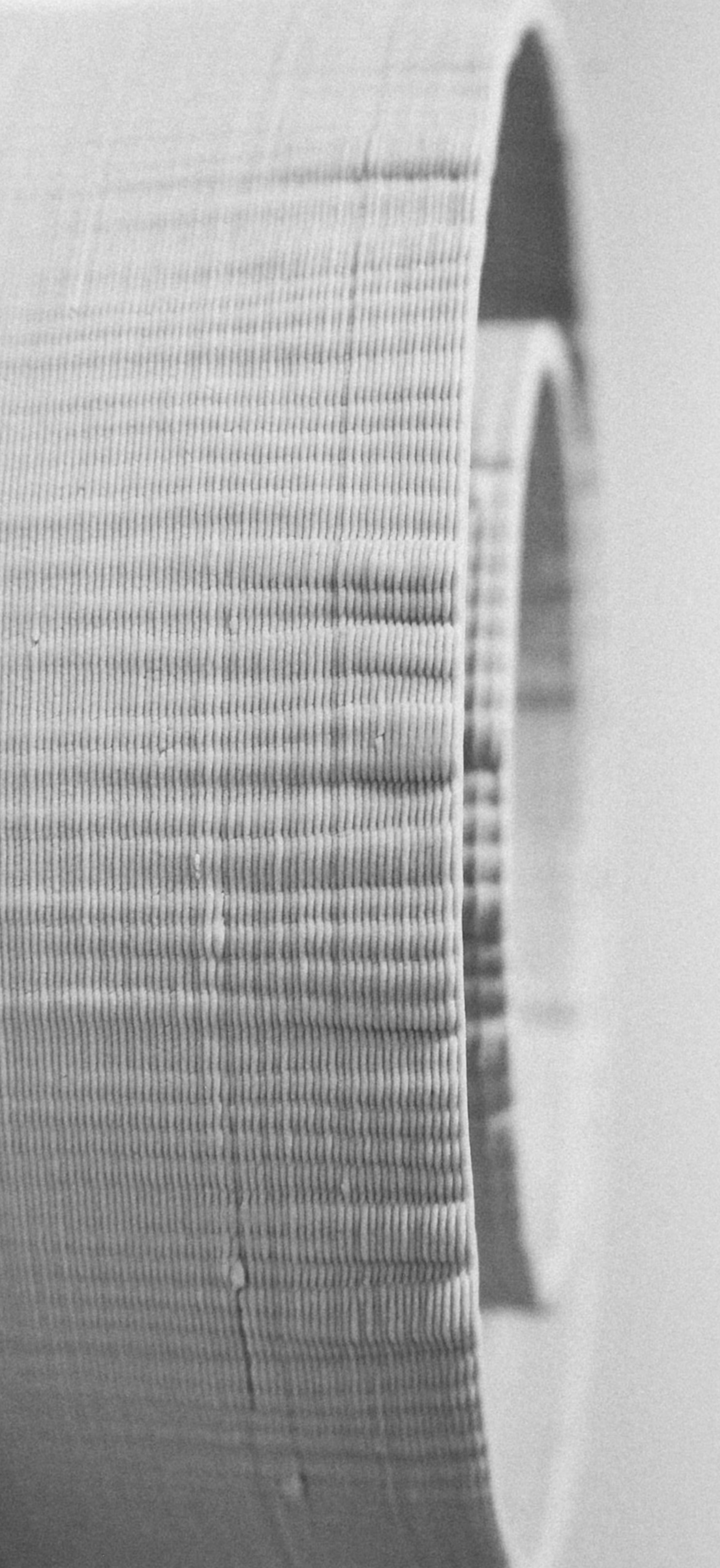


REFRAMING DATA RELATIONSHIPS

Convenience at the cost of surveillance. Giving up private data in exchange for a service. Such are some of the common tradeoffs (and debates) [4,11,15,37] regarding living with smart devices in private and intimate spaces like home. Alongside these debates, an underlying issue remains: who owns and controls smart devices' data, and for what goals. In a context of surveillance capitalism and data economy [40], home dwellers often find it challenging to reclaim and be in control of what data are produced in and from their homes [11,39]. Precisely, D'Ignazio and Klein state in *Data Feminism*: "This extractive system creates a profound asymmetry between who is collecting, storing, and analyzing data, and whose data are collected, stored, and analyzed" [9]. In response, we designed the Inner Ear, a device that prioritizes agency in regard to how data is collected and interpreted.

In this pictorial, we present the Inner Ear: a ceramic object that is both the device for capturing and the very artifact which comes to represent data. More specifically, we chose to capture and materialize **vibration data** within homes—both a deeply physical phenomenon and an abstract view for conceptualizing home—as a focal point to explore new data relationships. We make two conceptual pivots that reframe smart sensors and data in home contexts. First, we placed the control of sensing in the hands of the home dwellers. Instead of a device that lets sensors constantly sense and capture data covertly in the background, we purposefully made the act of capturing a central, durational, and intentional act. Second, we carefully linked the process of capturing data with the physical representation of that data within the same object. In fact, the ceramic Inner Ear transforms itself with the presence of data. In the following pages, we offer insights and annotations of our design and making process of the Inner Ear.

CERAMICS AND DATA

This project was led by design researcher Audrey and artist and ceramicist Timea, with the collaboration of undergraduate and graduate students in art, design, and engineering. We had worked together in a previous project (the ListeningCups [7]) where we explored how to transform sound data into tactile representations on 3D printed porcelain cups. Here, we expand on our learnings from this project to rethink not only the physical representation of data, but also the material form of sensors and sensing devices in a home environment.

We chose to work with clay for its long-standing object history within the domestic sphere, as well as for its haptic quality. Through the sense of touch, the body is instantly informed about textures and forms, as well as the temperature, weight, and balance of the object. Interactions with ceramic objects also require us to balance our sense of familiarity with a precariousness due to the material's fragility. Not only in the way the data is represented, but also in its scale and material considerations, the Inner Ear further extends previous work at the intersection of ceramics, data, fabrication, and design. For instance, designers and artists have examined the relation between working with clay and digital fabrication [16,18,29,30,33], teasing out challenges and opportunities. An interesting example for using low frequency sound for the manipulation of clay is Solid Vibrations [14], a collaboration between sound designer Ricky van Broekhoven and designer/artist Olivier van Herpt, which uses a specially constructed speaker rig mounted below the 3D printing platform that produces very low sound. The resulting vibrations are embodied by the pronounced moire effect in the clay. Our work continues to expand reflections around the nature of working with ceramics processes. While others have explored ceramic's fragility [27], glazes [8,31] and the entanglement of electronics and ceramics [21,38], our work specifically focuses on how a ceramic artifact may transform over time and how ceramic shapes may embody data in different ways.

WHAT IS THE INNER EAR?

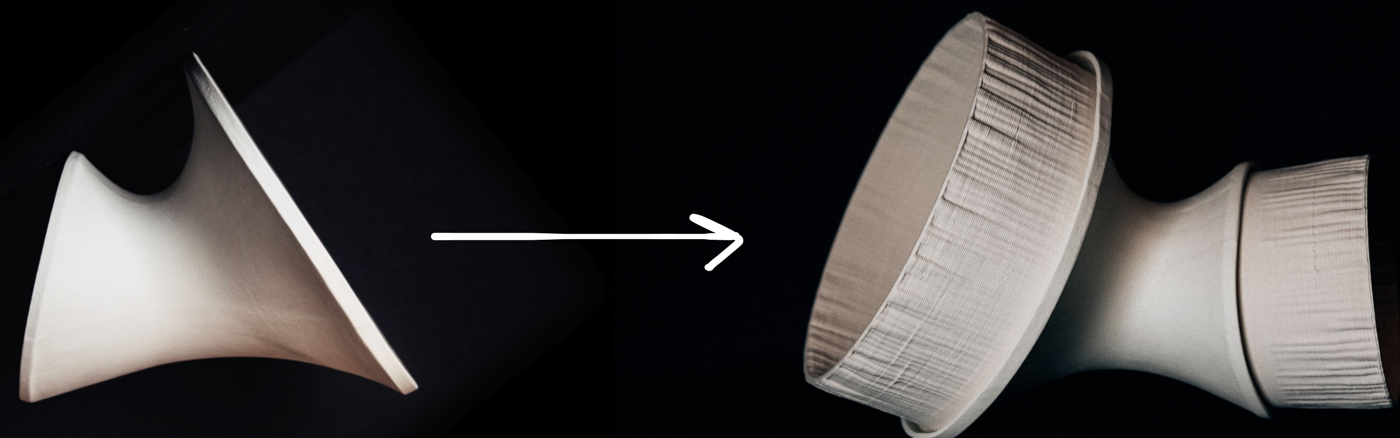
The Inner Ear is a portable device that participants can use to capture and represent vibrations. First, participants can collect a series of vibration captures (15 minutes each) over about a week. Second, they select one vibration capture to be materialized. Then, our team generates and 3D prints in porcelain the data. We glue the newly printed data rings to the central module and give it back to participants.

WHY IS IT NAMED THE *INNER EAR*?

We named this project the *Inner Ear* for the poetic quality of the term as well as the human biology reference. The Inner Ear refers to an ability to listen, to gain (or lose) balance, to be attuned to a space and to the presence of other bodies (animate and inanimate) in that space. Listening, as it relates to audible subsets of sound to the human ear, may be expanded to encompass a broader set of sonic vibrations, which typically go unregistered by the human ear.

WHY TWO STATES?

In an effort to offer an alternative to other data sensing devices in domestic environments, we purposefully created an artifact that explicitly showcased what state or mode it was in: sensing or representing. First, in the data capturing state it is a smart listening device that records environmental vibrations. Second, in the data representation state, it becomes a sculptural object, an archive of the data event recorded.



Data capturing state

Data representation state

WHAT ARE EXAMPLES OF VIBRATIONS?

It is possible to capture a range of vibrations with the Inner Ear. Over the course of the project, we saw vibrations such as the rain on the skylight, kids getting ready in the morning, late night conversations with friends, putting dishes away, the soundscape of making a floral arrangement, a pet cat's constant movement.

WHOSE VIBRATION DATA WAS USED?

We worked with seven people across six households in the Seattle area (USA) to create six distinct Inner Ears. We recruited people who were interested in vibrations, in data collecting devices and/or in knowing their homes differently. While in this pictorial we don't report on the deployment and the participants' experiences, we plan to do so in a future publication.

WHY ARE THERE TWO RINGS?

The smaller ring represents an overview of the vibration capture selected by a household, while the larger ring zooms in on an event (a few seconds) within that capture. The event was selected by the participant(s) with the purpose of exploring more deeply the vibrational portrait of a certain moment. There is a granularity to the recorded data which made us wonder about the texture effect at various magnifications of the data. We hoped to provoke reflection about the interpretative process of choosing, preparing, and materializing data.

KNOWING THROUGH VIBRATION

Many current Internet of Things (IoT) devices allow for a multitude of ways of sensing the home: via temperature, movement, air quality, sound, video, etc. Within design and HCI, researchers have proposed alternative ways of sensing and representing domestic environments, may it be via a ludic approach to indoor climate [13], a speculative take on home health [12], with fiction stories [5], by casting data as always hungry for more [20] or by challenging the objective nature of data [6]. These alternative ways of connecting data with domestic environments emphasize more intimate, personal, and interpretative ways of making meaning. We argue that vibrations might open a surprising space for noticing and paying attention to home settings.

When we started the project, we wondered about how vibrations might layer on top of each other, offering a range in how they might be perceived (from the mundane rumbles of a kid or pet running around, to the terrestrial movement of the grounds beneath us (as for example in [25]). Merriman, a geography scholar, proposes a shift in understanding the world by focusing ongoing events: "tracing the unfolding of events, processes of becoming, and the incessant movement, flux, buzz and vibrations of a world comprised of folds upon folds" [24]. He further reminds us of the deeply embodied experience of feeling the world through vibrations: "the rhythmic intensities, visceral sensations, dynamic movements and emergent visualities of the world" [24]. This proposition to center ongoing, but invisible, fluctuations offers us a starting point to reimagine how we might know our homes and how we might remember our home experiences.

SOUND AND VIBRATION

Sound is a form of vibration, but we intentionally wanted to focus the project on ranges of amplitudes which include but go beyond to the human ear capabilities. The human body can detect substantial vibrations through mechanoreceptors located in the skin (Pacinian corpuscles), but our conscious awareness of vibrations is limited— and often oriented towards sound. Strong or sustained vibrations to the body can lead to adverse health effects and it may be helpful to gain a stronger understanding of the vibration landscape of a home. In contrast, vibrations can also be applied for their beneficial application, for example to promote healing of connective tissues and muscles [28] or to decreasing heart rate [19]— even though the Inner Ear does not produce vibrations, building a practice of noticing vibrations in a home may be a starting point to either moving away from them, or embracing their presence.

In essence, with this project, we argue for building a practice that supports paying attention to vibrations. In other words, we aim at defamiliarizing home data by making its capture a 'strange' interaction [3] and by making the data physical, tactile and part of an object for the home [23].

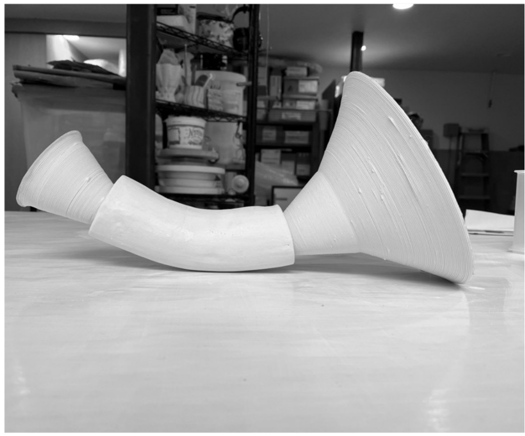
PHYSICALIZING DATA

Data physicalization is "the practice of mapping data to physical form" [2]. Design researchers have often argued that data physicalizations are "multisensory experiences [that] are richer and better understood than those that tend to privilege only the visual dimension" [23]. Data physicalizations strive for a balance between data readability [1], opportunities for self reflection [32], and aesthetic and sensory qualities [7,22,34,36]- all elements that we unpack in our design process. While data physicalization as a field has experimented with a number of materials and processes for materializing data [17], experimentation with where the data comes from and how it is captured are rarer (but see these exceptions [10]). Further, in recent years, scholars [23,35] have argued for embedding data physicalization within everyday life. Willett et al. argue that this would "bring physicalizations closer to their data referents, or in other words to where data was or is collected" [35].

At a more holistic level, in [23], Lupton discusses 3D materializations as a way to make digital data more perceptible and interpretable by "invit[ing] users to *feel your data*." To Lupton 'feeling your data' has two meanings: the sensation of touching the object and visceral/emotional responses generated from the sensory encounter itself. The Inner Ear probes the intersection of physical vibrations, embodied home data, and users visceral/emotional responses to it. Hence, we are interested in thinking about both how home dwellers feel vibrations (for instance pets running around, the hum of a refrigerator, planes flying by, etc.) at the moment of data capture, but also how they might feel them again when they touch the data physicalizations.

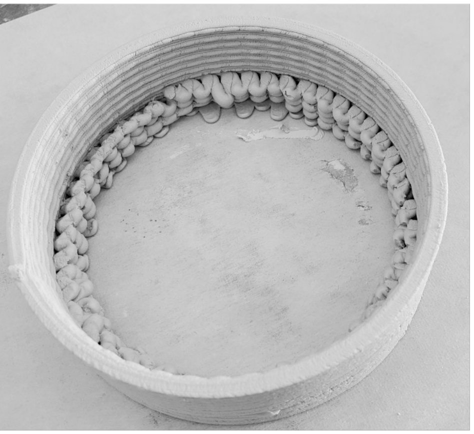
SHAPE DEVELOPMENT: ROLE SHIFTING

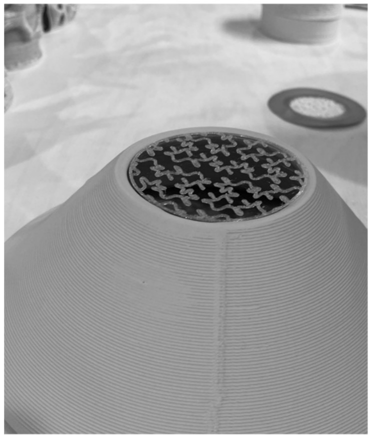
In developing the Inner Ear, our goal was to create a ceramic shape that could transform mid-way through the project: from an object capturing vibrations to an object representing vibrations. Our development process balanced considerations around working with clay and electronics, as well as the logistics of fabricating and deploying these pieces with six households.

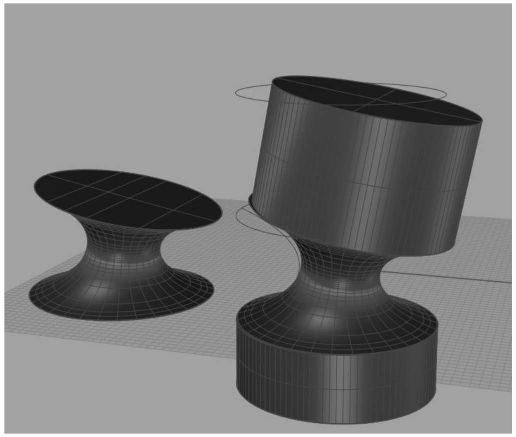


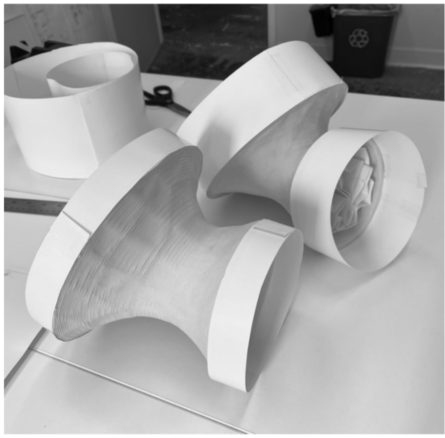
Initial ideas quickly focused on conic shapes inspired by historic hearing aids and listening devices. We tested our working hypothesis to see if shape or sensor placement within the form also supported amplification of vibrations.

We worked simultaneously on the shape and the electronics hardware. In that collaborative process, we started to think about a 'central module' which would host the electronics and become the central part to which data materializations would be attached (or displayed).







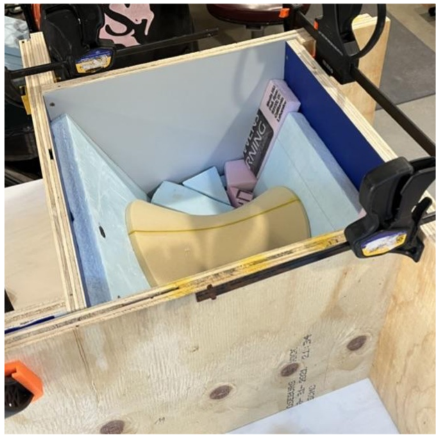


We explored a variety of ideas for how vibration data could be represented. These included a series of ceramic disks or rings, which would manifest data not on their exteriors but on their interiors. Our intention was to only have data revealed when the user chooses so intentionally, for example by turning on a light inside the object. Staying with the idea of interior lighting, we also prototyped flat disks on a PLA 3D printer which transcribed the data through a random walk algorithm. We even envisioned a library of data disks that each user can build from various instances of repeat recordings. We had various design challenges with ideas that involved light, such as power supply and light leaking, and abandoned these ideas in favor of a more tactile and visible final form.

Finally, we arrived at a form consisting of multiple congruent units: a saddle shaped central module and two data rings. The central module has the capacity to host electronics. Its openings can be both covered up or left exposed, terminating in flanges that are the receptacles for each of the two rings of data. Both the sensing center module and the combined finished data object can be displayed in versatile ways (horizontal, vertical, imaginative).

A MODULAR MULTI-STEP PROCESS WITH CLAY

There are a multitude of traditional and technological ceramic processes used in the making of the Inner Ear. Our multi-step deployment project (first data capture, second data physicalization, and then assembling) implied a slow and staggered process with fabrication. This process also had implications on aesthetic decisions we made regarding not glazing the pieces (to simplify the process and reduce more chances of distortion and irregular shrinkage), as well as building a 10 mm collar on the central module to 'hold' the data rings.

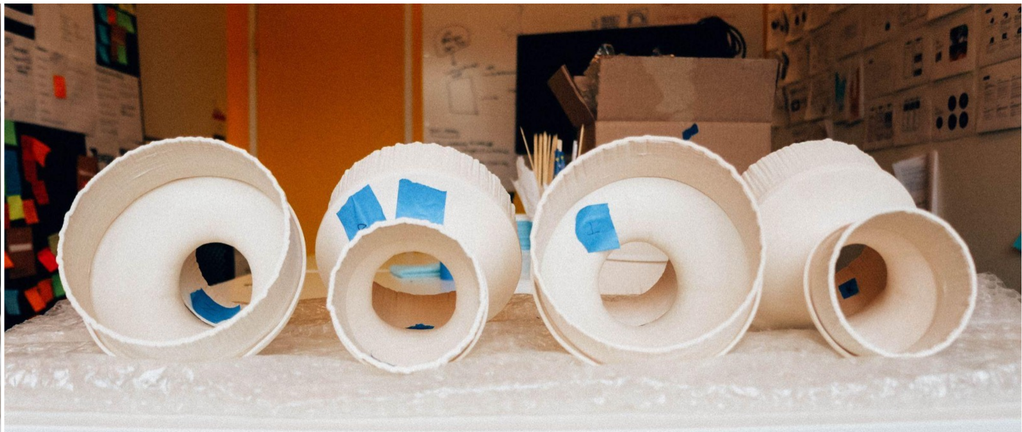


The central module's curvature made it difficult to seamlessly produce by 3D printing. After some preliminary testing and we opted to CNC a foam prototype. Around this, a six-part plaster mold was made to ensure easy demolding. Slipcasting produces a hollow form, a perfect shell for the electronics. The wall thickness of the central module was matched with the thickness of the extruded 3D printed ring.

The 3D printed rings are printed with a 2mm nozzle on a PotterBot clay printer. The ideal nozzle diameter was chosen to be small enough to accurately reflect the intricacies of the data, but wide enough to produce a stable wall.

All the central modules were produced in advance: 12 in total, two for capturing data, and several extras for the six which were to become the final object. After the casting process concluded, the studio was turned over to 3D printing. Each opening on the main form has a 10mm collar, which takes a printed data ring.

Once the aesthetic aspects of the desired result were clarified, fit testing proved to be the biggest challenge of the project. Porcelain shrinks an average of 15-20% and tends to warp throughout the drying and firing process. Even small amounts of warping could (and did) create incongruencies of the forms in a way that they no longer fit together.



The deployment was planned as a series of three consecutive weeks, where the two interactive Inner Ears could be sent to the first two participants, then recharged, and sent to the next two, and final two. Working with participants comes with timing complexities: some participants got sick, were out of town, or moved, stretching our schedule. Hence, data from the participants was trickling in slowly, further challenging the making process as a certain amount of consistency was needed with the materials, techniques, and minute nuts and bolts of the workflow.

HOW THE INNER EAR WORKS

The interaction model for the Inner Ear is driven by a desire to create an artifact that doesn't always 'record', and to instead give control to people in terms of when they choose to capture data about their space. As such, a household can keep the Inner Ear for 5-7 days and do as many vibration captures as they want. A single capture duration is 15 minutes.

The data physicalization aims at emphasizing a singular memorialized data capture as the Inner Ear transforms from a capturing device to a representing artifact.

DATA CAPTURE

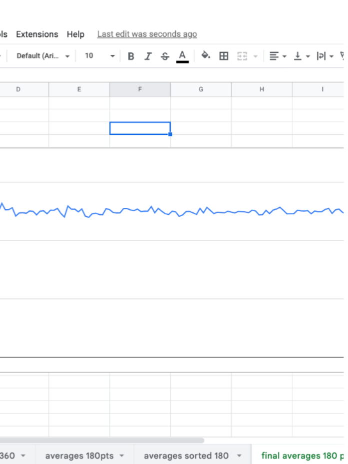
1. A household chooses a location for vibration capture

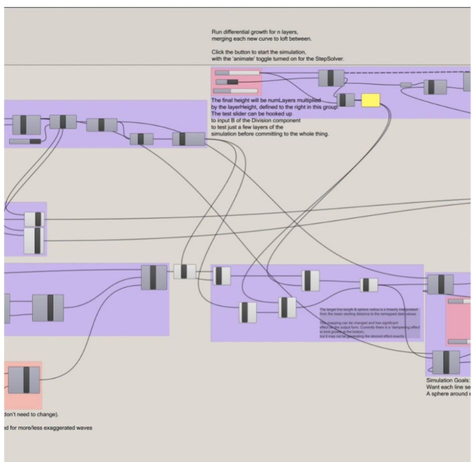
2. Press the surface to start capturing the moment. The light turns on.

3. Wait 15 minutes for the capture to be completed.

4. When the capture is done, the light turns off.

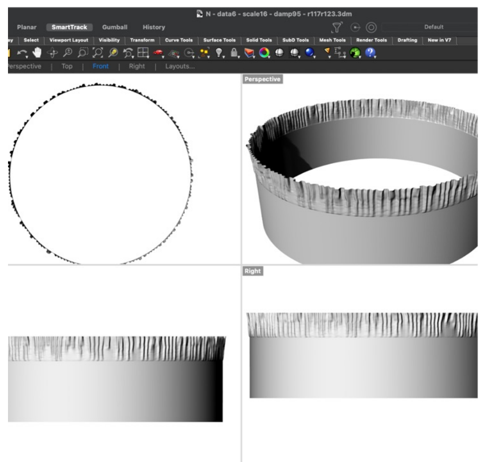
DATA PHYSICALIZATION



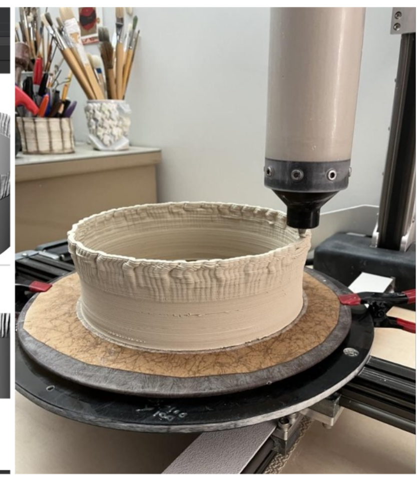


5. Once the captures are completed, the household chooses one capture they want represented in the rings.

The research team downloads and processes the data using a Grasshopper definition to create a 3D shape.



6. The research team adjusts the scale of the piece for printing (to make sure it fits the central module).



7. 3D models are 3D printed in porcelain on a PotterBot clay printer.

8. After being fired, 3D printed data rings are attached to the Inner Ear central module.

9. Final piece is delivered and offered as a gift to the household who collected the vibration data.

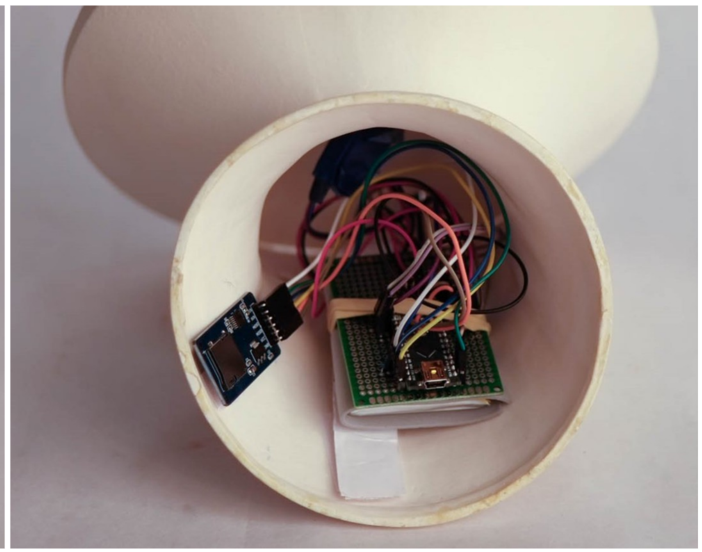
DATA PRIVACY, CONTROL AND DEPLOYMENT LOGISTICS

When designing the electronic components, code, and data management system for the Inner Ear, we prioritized control, trust, and privacy. We intentionally chose to make the capture button central and obvious and to store data offline, on an SD card that only our research team would access. This contrasts the widespread existing models of passive and ongoing data collection in IoT devices.

This local treatment of data storage meant that our team needed to access the SD card after each deployment (we had two interactive central modules that were rotating between the six participating households). We designed an easily accessible back side to the central module for access to data and power recharge.

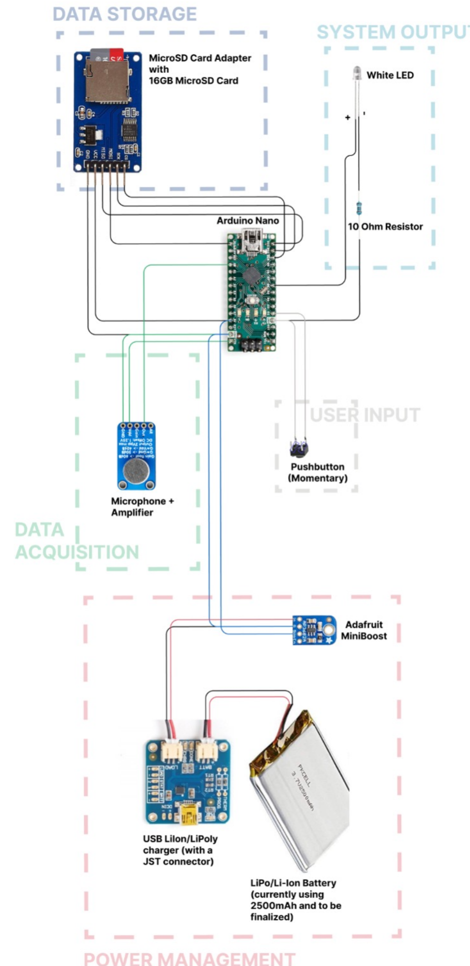
The Inner Ear's front faceplate conceals a 3D printed threaded cap and screw system ensuring that the push button sits at the correct distance from the face. This cap rests on a 3D printed plate fitted to the Inner Ear's nearly-circular central opening. The plate also houses the LED and microphone (our sensor for capturing vibrations). This simple design introduces the necessary rigidity to trigger the push button easily against the non-uniformity of the porcelain body in which the electronics rest.

Our use of the push button maintains the user's ability to control the moment of data capture.



Removal of the rear faceplate allows team members to access the SD card for data retrieval, the batteries for charging, and the microcontroller for troubleshooting.

In this, the Inner Ear enables two interactions models, one for the participants and one for the team members. Because the hardware is concealed behind vinyl sheets, participants are unaware (and are not told) that the device they initially interact with is different from the final, assembled Inner Ear that they receive.



The interactive functions of the Inner Ear are built around an Arduino Nano. Users trigger 15 minutes of vibration data capture by pressing the push button centered behind the vinyl faceplate. Aggregated amplitudes of vibrations in the 20-20KHz range are captured by an electret microphone and recorded into a text file every 0.1 second. Data is intentionally collected and stored offline on an SD card (not online). By limiting vibration data collection to numeric text, rather than collecting audio files, audio information about what may have been said or done during the capture period is inaccessible, maintaining privacy.

Software is available online at https://github.com/Studio-Tilt/innerear.

ON NEW WAYS OF 'READING' DATA

We purposefully asked participants to choose only one data capture for us to physicalize. Our intention was to move away from large—almost infinite—IoT data archives. Instead, we wanted to celebrate *one* capture and to build a physical object that would invite curiosity and contemplation. We resisted the desire for direct legibility of data in favor of building a broader, perhaps more holistic experience, of the data. By blurring the line between the data and how it is represented, we asked: how far this association can be pushed while being authentic to the event and meaningful to the user.

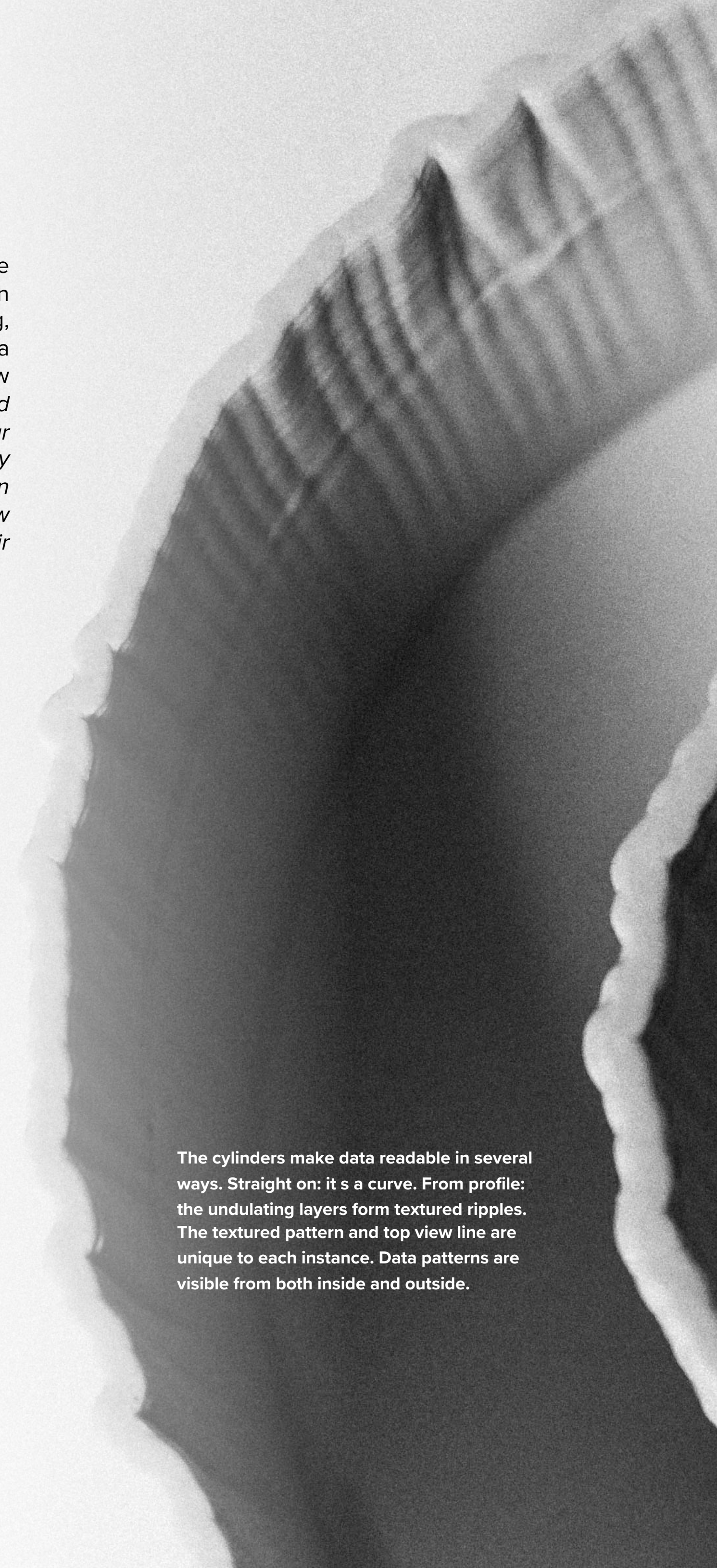
By contrasting two views of the same dataset on the same object (two rings), we hope to provoke reflection about the interpretative process of choosing, preparing, and materializing data. Our conceptual approach to data physicalization opens a series of questions around how participants will make meaning around their data. *Would participants accept (re-learn) indirect and non-linear representations of data and how do they consciously interpret it for themselves? What potential is stored within this tactile representation of time, space and event? How will participants relate to the physical memory of their data?*

Aesthetic priorities, alongside the constraints of translating vibrations into ceramics, played an important role in determining the circular shape, ripple patterns and emergent form of the Inner Ear's Data Rings. The circle is reminiscent of historic hearing devices, which inspired the central module's shape, and its connecting rings. Further, the circle responds well to our goal to represent more holistic data portraits (instead of linear point to point reading of data), which also has an impact on who or what could read and access the data.

Through trial and error, we optimized how the rings would both look and feel, as well as how they would be produced on the Potterbot ceramic 3D printer. The machine is optimized for vessel-like shapes that are described by a single perimeter. As a result, the rings' walls are built in a spiraling fashion.

The small ring represents the full 15 minutes of vibration data capture.

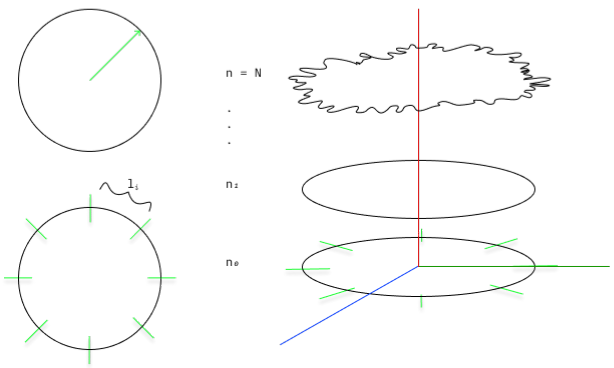
The large ring is a 'zoomed in' view (36 seconds) of a chosen segment within these 15 minutes. The segment is chosen by the household.



The cylinders make data readable in several ways. Straight on: it s a curve. From profile: the undulating layers form textured ripples. The textured pattern and top view line are unique to each instance. Data patterns are visible from both inside and outside.

AMPLIFYING THROUGH ALGORITHMIC GROWTH

We sought to represent data as both a whole portrait of the vibrations (small ring), as well as a focused 'zoomed in' perspective (large ring). The ripples on these rings are generated using a differential growth algorithm directed by the vibration data. We aimed at playing with scale in terms of how data might be presented (across the two data rings). We kept the constraints and scaling of the algorithmic mapping consistent for both rings, which came to display similar patterns through ripples, even though one represents a mere 36 seconds and the other the full 15 minutes of vibration. We decided to use the 180points on the smaller and 360 points on the larger because of both aesthetic and legibility reasons. After testing we came to see that this scale of the ripples fits the overall aesthetic intentions of the object best. We liked how poetic, subtle and fabric-like it was. The second reason was due to the limitations of the printer: The nozzle we used created an extrusion with 2-3mm thickness (diameter) coil. The implication of this is that each datapoint on the surface would have to be at least 2-3mm from its neighbors to be visible/legible.



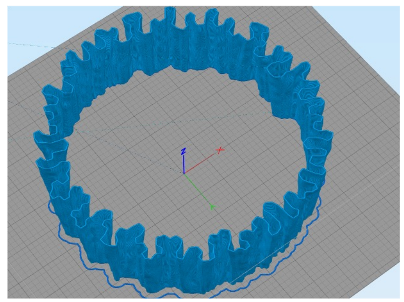
$l_{segment} = (l_{target} - l_i) * n/N + l_i$

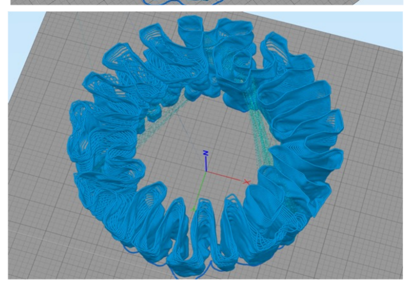
l_{target} = Vibration Capture Amplitude [-1,1]
l_i = initial length
n = current layer
N = total number of layers

The last (top) layer of the rings most accurately represents the vibration data captured. The 'dampening' of data points from the first (bottom) layer and up connects the rings to the central module (both visually and practically to fit the ceramic flanges).

The vibration amplitude maximum and minimum are mapped to a range of -1 to 1, normalizing silent vibrations at zero in the range. The Grasshopper definition maps the -1 to 1 range to the desired scale for the rings. The use of the differential growth equation produces the dampening effect generating the ripple patterns.

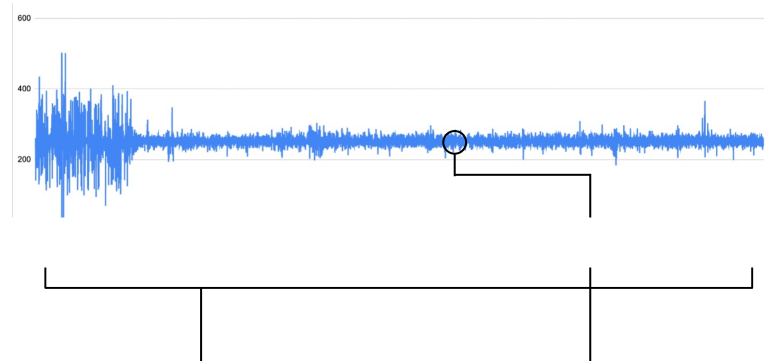
A circle is divided into equal segments (l_i). Each segment has a target length to reach (l_{target}) equal to the amplitude of the vibration data point. The initial length of each segment is expanded or contracted based on the vibration data by layer (n) until it reaches the final layer (N) and corresponding target length. Each segment may not reach its target length, thus the ripple effect emerges as segments collide when each 2D layer is lofted and 3D printed.





In brief, delicate vibrations lead to smaller ripples (left) and stronger vibrations lead to bigger ripples (right). These 3D models show how large growth algorithms can become. For printing purposes, we constrained the growth of our rings to a maximum variation of 6mm.

Full dataset: 15 minutes, 8920 points



The small data ring contains 180 points, averaging the full dataset into 180 segments.

The large data ring contains 360 consecutive points selected from the full dataset by the participant. This ring represents 36 seconds of vibrations.

FROM CAPTURING TO REPRESENTING

From the beginning, we envisioned an object that would be completed by the data representation. This transformation over time implied complex conceptual decisions: how do we create an object that holds only part of its purpose at each given moment? How do we prevent limiting user's ideas of purpose (ideas for 'capturing' or 'sensing') by inadvertently suggesting the missing data representation that is yet to come? A shape shifting artifact has intersecting and overlapping functional and aesthetic demands from both states. For instance, we needed to balance the ease of capture for the user, access to data and trouble shooting for the research team, and the fabrication and assembly of ceramics. To create an aesthetically 'satisfying' object in both states was challenging, especially one that would fit a variety of homes and personal lives. This was resolved through prototyping with a myriad iterations of combining paper, plaster, found object, clay and sketches.

The closer we got to conceptualizing the form, the more its meaning became layered. For example, moving from capture to representation within the same object allows participants to know that the artifact is clearly no longer collecting data. Unlike other data collecting devices (like smart watches or security cameras), the hollow shape of the ceramic object offers an assurance that there is no more electronic sensing capacity in the object once it returned to the household with its data ring extensions.

Adding or removing the sensing module allowed for different types of defamiliarization of the ceramic object, moving away from the familiar ceramic vessels often found in domestic settings. Instead, it became a device, and then further an art object that carries the personal significance of the data. The finished object is delicate but not ephemeral, it is aesthetic but not merely ornamental.

COLLIDING TIMESCALES

While in this pictorial we did not report on the deployment of the Inner Ear, part of our decision making process revolved around how we would deploy the Inner Ear (in its collecting form) first, collect the data, print the data rings, and assemble the final piece.

Porcelain is a rather tempestuous material. Like all clays, it has memory. By the nature of its materiality, it shrinks and warps throughout the process of fabrication, regardless of the process (slipcasting or printing) used. It further changes during the firing, often unpredictably so. Our project involved the collision between two timescales: clay time and participant time. While at times we were waiting on the fabrication process (material preparation, printing, drying, firing), at others, we were delayed by participant recruitment, data capture in the wild and its transcription, or the research team members' availability. There is a complexity to working with clay in multiple stages, and with a variety of stakeholders on whom the fabrication process depends.

LEGIBILITY AND INTERPRETATION

This project aimed at turning home data on its head and reimagining ways we might engage with data in our everyday lives. Throughout our process, we balanced our own aesthetic vision for the artifact, with how we imagined users being able to make meaning out of their data. While we didn't have a vision for an 'ideal final outcome', we knew we wanted to find alternatives to existing modes of seeing data represented: data as inherently clear with a 'one to one' correspondence between signal and effect. Data is often neutrally presented or shown with directly readable singular meaning. In contrast, our research vision for data is 'holistic.' It includes the whole process of capture by the users but also the development of the device itself. It gives authorship to the user participants, while also makes the process of transcription and interpretation present for them.

Our work foregrounds the many design decisions we made as a design and fabrication team, embedding the final data physicalizations with our own imaginaries for how others would interpret them. The possibility for the participants to get to know us through the various drop offs and pick ups also challenges their understanding of what—or rather who—transforms their data.

Throughout the design and development process we are keenly aware of the choices we made and how each choice influenced the final product. We realized that making choices was inevitable; sometimes they were serving artistic ends, other times design and interaction ends.

ON TRUST AND DATA

The Inner Ear was designed to offer an alternative to constantly surveilling smart devices and the massive archives of data they generate. Our design decisions prioritized control (the button to start a capture), boundaries (temporally bound captures, 15 min), visibility (light as feedback), and agency (participants could choose which data to physicalize).

As we continue the deployment of the Inner Ear (to be reported on in future work), we realize that we cannot write about how this project addresses privacy, surveillance, and trust with data collection and representation without also writing about how we have organized the deployment with the six participating households. We met with participants at least four times to exchange the Inner Ear in its multiple forms. Over these visits, we have started to know them, and them us. As we built a relationship, we also gave a human face to who (or what) was collecting their data, and for what reasons. They were able to ask questions and to enter in dialog, something that is very rare with other smart devices (and their associated entities and corporations). We hope that our care for the craft of building the Inner Ear is matched by our care for mediating the relation between the participating households, their Inner Ear and vibration data and our research team.

IN CLOSING: DATA POTENTIALITIES

This pictorial covers over a year of conceptualization, trial and error, prototyping, fabrication and the first phases of a deployment. The goal of creating real artifacts that could live into participants' homes (similar to research products [26]) required an important commitment from a large and revolving team of research students and collaborators. While this pictorial points to clear contributions for design and the DIS community so far (the complexities of working with clay and ceramics, the dual life of a capturing and representing object, as well as the questions around data interpretation), we are animated by the potential emergent discoveries that are coming with exchanging ideas with the participating households. For instance, so far, we have been surprised by the various orientations the Inner Ear has taken in our participants' hands (as demonstrated by the range in our photographic documentation in the pictorial). While we had conceptualized it as a horizontal piece, with data rings extruding from each side, we have since then been curious about how this unfamiliar shape gains meaning in participants' homes. As we start writing about the deployment, we will continue to examine the relation between form (as context or instrument of data capture), interaction (as it shapes the capture, both in choosing when to record, but also what it records), and again form (as materialized data, and as transformed object). This dual focus on form over time opens new potential for data physicalization as a field: both for designers, artists and researchers creating them, but also for users capturing and reading their own everyday intimate data.

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