Gut-Tracking as Cultivation

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ABSTRACT
Contemporary self-tracking devices take forms that reflect particular cultures of self-tracking that emphasize clinical perspectives and numerical precision. In this pictorial, we explore alternative forms to speculate on other possible self-tracking cultures. We present how we involved experts on the relationship between the gut and the brain to inspire a design brief for an alternative gut tracking device. This led to the design of Loupe and Lightbox, which together operate to externalize gut biota for closer examination, aesthetic appreciation, and reflection on the self. The device represents an example of self-tracking as cultivation—building a longer-term relationship with the self as something to be nurtured, tended to, and cared about.

Authors Keywords
Self-Tracking Devices; Gut-Health; Gut-Brain Axis; Probes; Research through Design.

DIS '20, July 6–10, 2020, Eindhoven, Netherlands

ACM ISBN 978-1-4503-6974-9/20/07…$15.00
https://doi.org/10.1145/3357236.3395588

CSS Concepts
• Human-centered computing~Interaction design process and methods

INTRODUCTION
Emerging science about the body facilitates new cultures, both for self-tracking practices, and alongside it how we understand the "self" in self-tracking [29]. Insights from emerging medical science, advancements in data science and analysis, and the availability and accessibility of product development infrastructure, have led to an increasing number of commercially available self-tracking devices.

The material forms that self-tracking devices currently take reflect a particular culture around self-tracking [19,23]. In their design, self-tracking technologies bring clinical procedures into non-clinical space. One of the underlying assumptions of these existing approaches to self-tracking is that the medical phenomenon under study can be measured and reflected upon, and that this reflection can lead to knowledge, action, and therefore self-improvement [6].

Rather than aiming to design effective and accurate devices, we explore alternative forms and materialities in order to expand the design space of self-tracking devices, and to articulate other possible cultures of self-tracking. One of the ways that interaction design research operates is to contribute to the shaping of and development of emerging technological possibility. It has a strong tradition in proposing design directions that deliberately offer alternative perspectives [10]. These perspectives can facilitate wider conversations about medical science and its uses, encourage a broader understanding of the possibilities for designing technology, and ultimately inform and inspire novel trajectories for development.

In this pictorial, we address the developments in medical science that study the biochemical signals sent between the gastrointestinal tract and the central nervous system, popularly referred to as the *gut-brain axis*. Medical research has studied how the composition and diversity of the gut microbiome links to moods and emotions and vice versa, influencing mental diseases or disorders [9,20]. It proposes that our mental states are affected by the microbiome, and in turn, that mental states can influence the microbiome. This relationship is still contested, however, especially as studies have so far mainly been done with rodents [27], and only one large scale study with humans exists [35]. These medical developments are being closely followed and slowly taken up by developers of self-tracking technologies. For example, applications that act as diaries to help uncover relationships between the food a person consumes, characteristics of feces, digestion related pains, and notably mood and stress [3,5,33]. Some applications include a stool sample test that can be sent back to the lab

for analysis, returning a report that links the microbiota to ailments such as anxiety and depression [1,36]. Others come with a breathalyzer to track fermentation levels—akin to the breath test performed in clinical settings to diagnose common gastroenterological conditions such as small intestinal bacterial overgrowth (SIBO) and irritable bowel syndrome (IBS) [31]—and combine this with sleep quality and stress levels [14]. In this emerging science and technology domain, alternative perspectives are especially necessary, as later applications will be rooted in early commitments and choices [38].

As an alternative avenue for self-tracking that considers the gut microbiome and mental well-being at the same time, we present Loupe and its Lightbox. The format of the pictorial allows us to elaborate on their development process, in order to better represent the complexities of the design and its related considerations [8,28]. Rather than providing behavioral patterns and offering medical diagnosis, Loupe and Lightbox embrace cultivation as a means to relate to oneself. That is, the devices allow a user to externalize and cultivate their gut microbiome in order to conceptualize gut-health differently for individuals as well as their social environment. We discuss how the notion of cultivation in self-tracking, exemplified by Loupe and Lightbox, fundamentally allows us to frame self-tracking technology as slow technology [18], opening up avenues for future design research.

ENGAGING EXPERTS WITH PROBES

To understand the medical science at play has led us to use design research approaches that are commensurately open-ended and exploratory while being rooted in both rich personal experience and relevant domain expertise. This led us to design a self-tracking probe [13,16,15], deployed for two weeks with domain experts: five members of a research group from a medical museum who designed and curated an exhibition on the gut-brain axis. They were knowledgeable about the research that has been taking place in this domain, and skilled in how science about the body is communicated. We hoped that they would use the probe to collect reflections that

THE SELF-TRACKING PROBE

A cardboard cube containing an ethanol gas sensor, a small display, and a reset button. In use, the gas sensor in our probe is cast as a breathalyzer, assessing the composition of gut bacteria [31], which in turn promises to be related to mental states such as depression or stress. In fact, the device is solely reacting to ethanol on the breath.

Given both the immaturity and complexity of the current state of the medical science, the design of the self-tracking probe aimed to evoke reflections by deliberately reducing this complexity to an extreme. The design of our probe follows the critical design technique *reductio ad absurdum*, which uses the logical device to demonstrate the ridiculousness of an argument by taking it to the extreme and reveal its absurdity [11]. The extreme reduction of complexity translated into a simple number between 0 and 250 to display the state of the entire gut microbiome, based on the input from the gas sensor. The dissonance that this presentation creates was intended to open a space for reflection, letting the experts articulate issues they come across regarding self-tracking the gut-brain connection in their everyday life.

combined their knowledge with personal reflections of experiencing the topic in a different way than they would normally, and inspire speculation on what kinds of devices could come in their place. Rather than adapting one device to fit the diverse ways in which the probe was experienced, we aimed to articulate a plurality of alternative design directions from the individual experience outwards. In this pictorial, we elaborate on one of the reported experiences, in particular those from a researcher with a background in psychology and wellbeing, who studies personal experiences and perceptions of the human gut.

Towards a Design Brief

Upon conclusion of the two-week probe deployment, the expert expressed some concerns about the probe: *I felt a bit nervous about measuring my microbiome, what if it turns out to be unbalanced or unhealthy?* She forgot to use the device at times, and described feeling embarrassed: *This might have created a feedback loop where, if my mind affects my microbiome—does that mean that the number of today measures embarrassment in some weird way?* The device had created a situation that changed how she experienced herself, even if she forgot to do the self-tracking each day: *I think I have been more aware of how my stomach and my mind have been doing during these days*. From her experiences we drew out that the very idea of measuring the gut microbiome might instigate new health concerns, instill a negative feedback loop, and create a hyper-awareness.

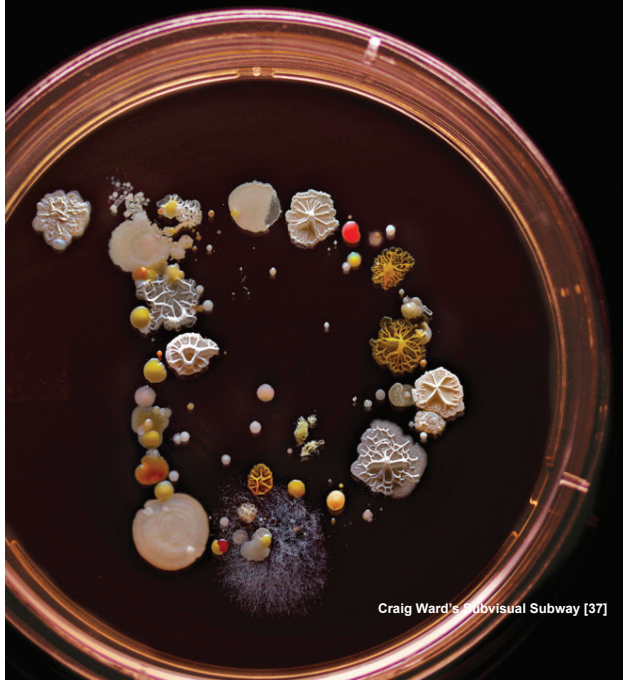
After the deployment had taken place, we asked her to speculate on what the self-tracking probe she had lived with might become. The purpose of a device attending to the gut microbiome was contested: ***why am I relating to a box, why am I not meditating instead? Could I have engaged in other kinds of practices to consider this thing?*** Her experiences inspired alternative ways of connecting to oneself, finally articulated in terms of externalization and cultivation of the gut microbiome. For her, an externalization was seen to be less confrontational than a real-time measurement, while the **cultivation of a microcosm of inner workings would reflect the complex notion that the microbiome has commensal, mutualistic and parasitic relationship with the human body** [32].

She connected her experiences to her research on the wellbeing of patients who suffer from Irritable Bowel Syndrome (IBS), which includes symptoms such as bloating, regurgitation, heartburn, vomiting, abdominal pain, or diarrhea. There is a growing number of people who do not enjoy good gut health—as indicated by the high prevalence of functional and gastrointestinal diseases in the Western world [2]. **She expressed that people with poor gut health tend to conceptualize their gut microbiome as "other."** That is, it has its own behavior and desires that expresses itself in flare-ups and periods of remission [see also 17]. This results in impairment in health-related quality of life, such as physical health problems, bodily pain, and general negative health perceptions, stress and anxiety [34].

The bold themes above inspired the design brief for this project—to design a way to externalize, experience, and reflect on the self through the cultivation of the gut microbiome. The notions of externalization and cultivation as a form of self-tracking could support psychological and social well-being for people with poor gut health. Psychologically in the sense of reflecting on the self and recognizing the gut microbiome as being both "self" and "other." By operating in relation to a social environment, the design brief is meant to consider overcoming stigmatization of ill and unstable bodies, particularly issues of gut health that are often considered cultural taboos [21].

Design Brief:

Design a way to externalize, experience, and reflect on the self through cultivation of the gut microbiome.



Craig Ward's Subvisual Subway [37]

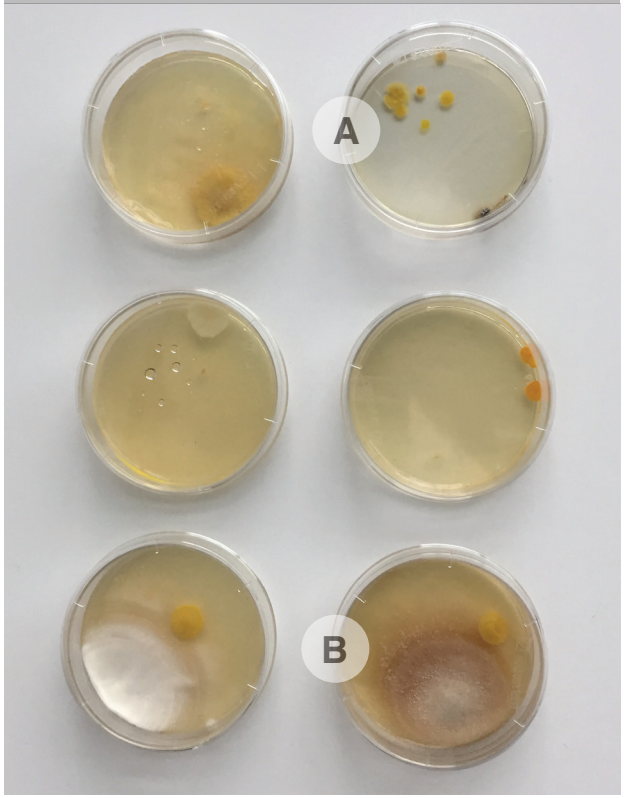
EXPLORING AGAR AND CULTURING

Our first step was to explore a way to externalize gut bacteria by culturing them in agar in petri dishes. Besides the breath test that is performed in clinical settings to diagnose common gastroenterological conditions [31], there also may be important interactions between the saliva microbioma and microbiomes in the gastrointestinal tract [22,26]. For our exploration, we took the interpretative leap that breathing on an agar plate or streaking a saliva swab over an agar plate both can culture gut microbiomes.

Neutral Nutrient Agar

Exploration of plain nutrient agar. The treated agar plates resulted in the growth of bacteria colonies (A) and fungus (B). As opposed to diagnosing, the structures and visual complexity of the microorganisms let us ponder what was happening.

Note Most bacteria will not be harmful. However, once multiplied into millions of colonies they can become more of a hazard. Proper disposal is essential for safety and sanitation.



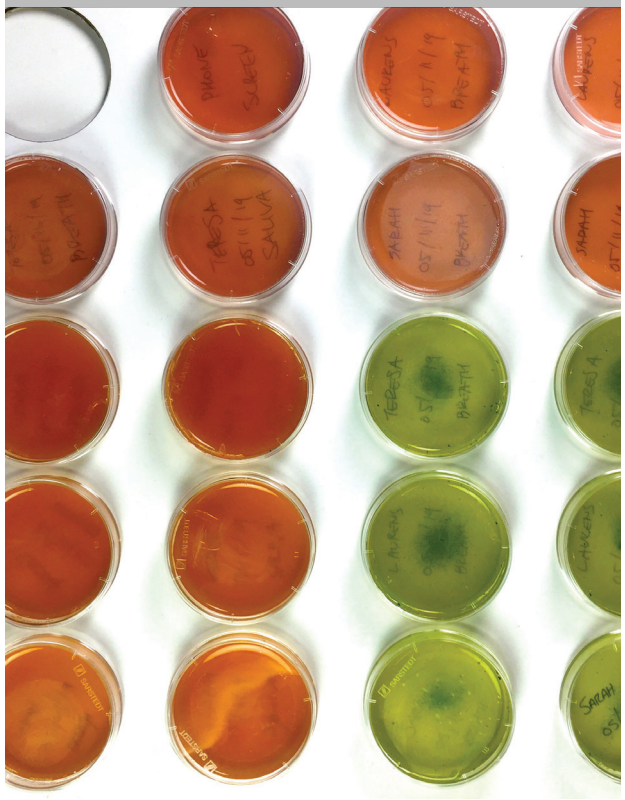
Naturally died Nutrient Agar

Other types than nutrient agar can be used for growing different strains of bacteria. However, in line with ideas of cultivation, we explored DIY dying of agar using natural coloring from carrots, blackberries, and spinach.

Procedure Blend fruit or vegetables until smooth. Filter, mix with agar and hot water. Cook for three minutes to gel, and pour into the petri dishes. Let solidify.

Acts of Collecting Bacteria

Three members of the design research team prepared two agar plates using each coloring. The first was breathed on for ten seconds, while a second was inoculated by a cheek-swabbed cotton bud. Each was monitored for seven days.



Culturing

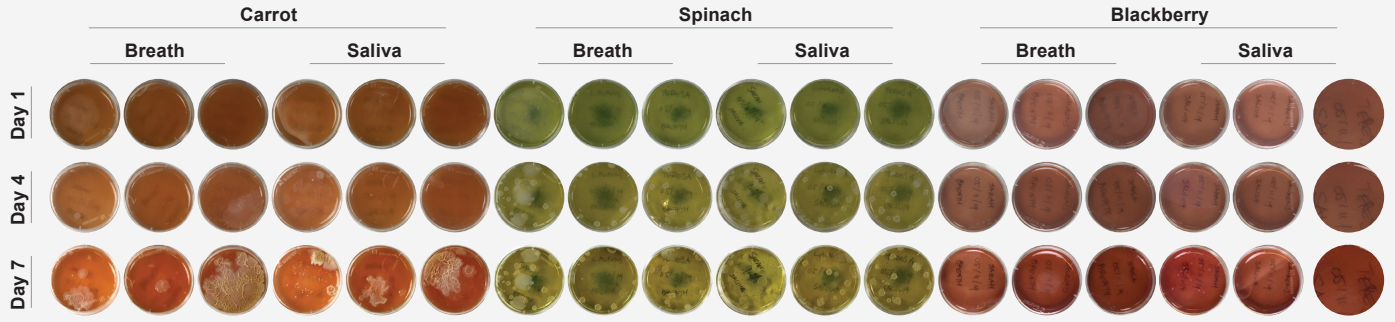
We found little difference between the breath- and saliva-treated agar plates. The results for the carrot and spinach dyed agar produced visually fascinating differences.

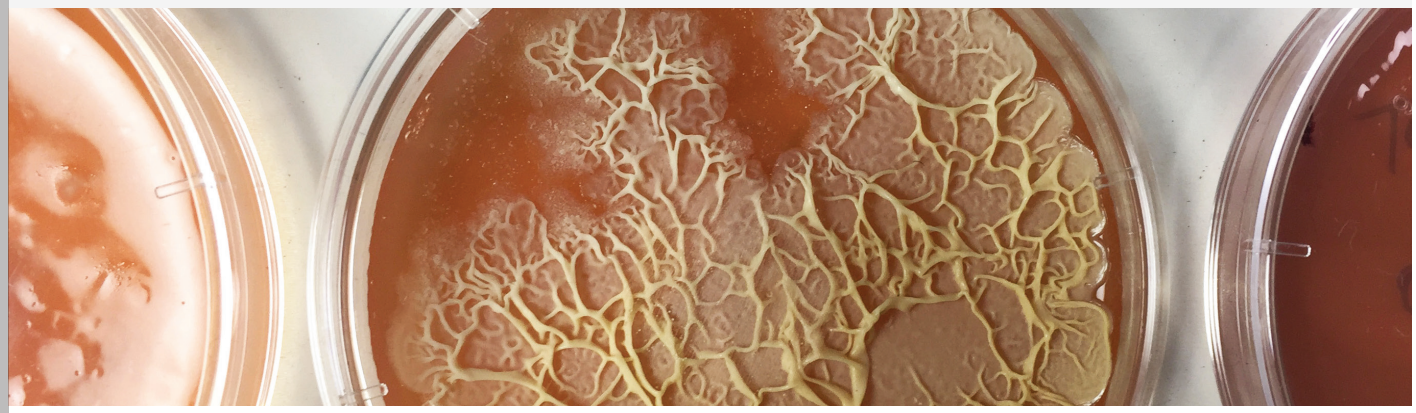
Culturing agar plates from swabs and breath samples prompted reflections on the experiential qualities of this culturing as a self-tracking practice. Taking a saliva swab and streaking it over an agar plate seemed more careful and intentional than simply breathing on an agar plate. The slow timeline of the culturing process led to experiences of daily curiosity about the evolution of the microorganisms and appreciation of the process. The emergence of complex bacterial structures was intriguing. We found that the presentation of the structural complexity of the biota could be strengthened by viewing the petri dishes against sunlight or backlight.

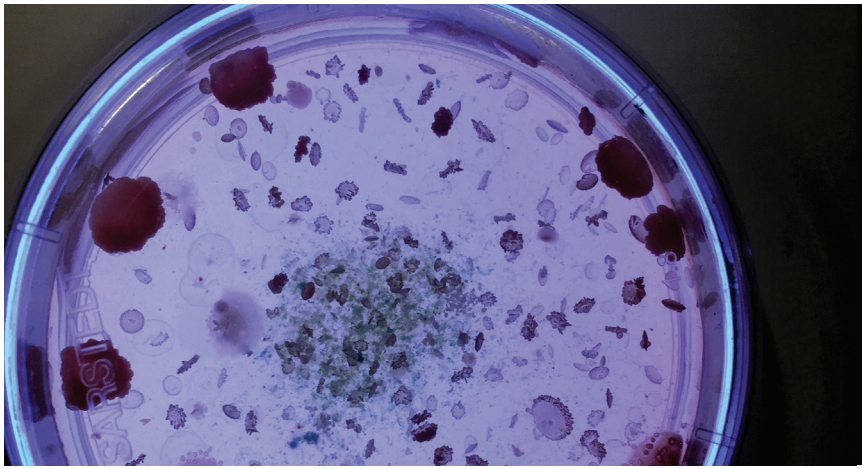
Culturing as Cultivation

These experiences led us to reconceptualize self-tracking as a kind of *cultivation*. By this, we mean that the relationship between the self and the microbiome can, by being externalized, become one of tending to and caring for the self in the other. These petri dishes offer a means to grow a different relationship to an underexamined part of yourself over time, raising questions about where "you" end.

The brief to design a way to externalize, experience, and reflect on the self was refined into the formulation of a design concept.







Design Concept:

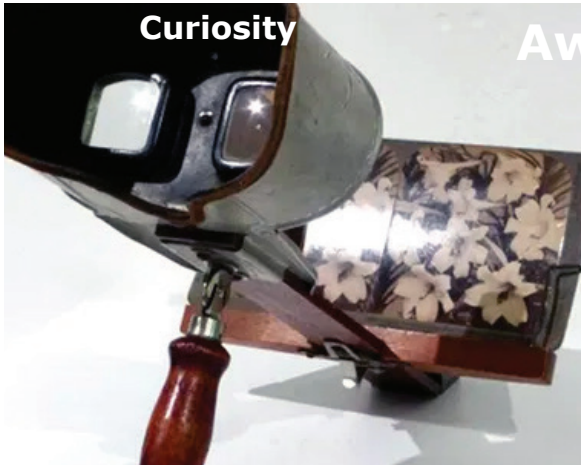
A viewer that stages the complex structures of cultured gut biota for close examination and aesthetic appreciation.

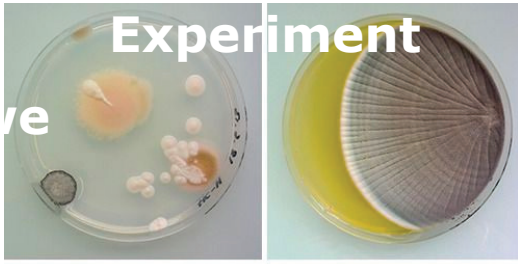
INSPIRATION

Exploring the design concept, we collected a patchwork of associations, inspirations, and ideas.

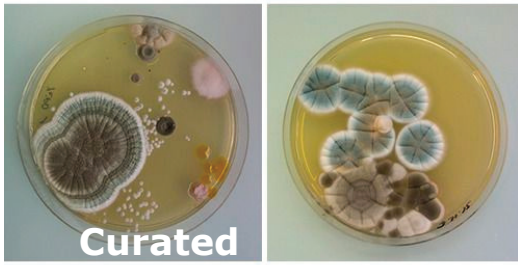
A stereoscope is a device for viewing a stereoscopic pair of separate images, depicting left-eye and right-eye views of the same scene, as a single three-dimensional image.

Culturing is an act or an instance of growing or maintaining a culture (especially of bacteria).





Portable photo viewers are used to view small photographs, typically of family or partners.



Microbial art, agar art,or germ art is artwork created by culturing microorganisms in certain patterns.

An agar plate is a Petri dish that contains agar as a solid growth medium plus nutrients, used to culture microorganisms. Sometimes selective compounds are added to influence growth.

FORM EVOLUTION OF THE GUT MICROBIOME VIEWER

A/ Decision for a tapered friction fit to pick up a petri dish. Delightful gentle feel. Reduces overall bulk and diameter of the bacteria viewer.

B/ Addition of loop for string or necklace so the bacteria viewer can be worn. Places the bacteria viewer over the gut area when worn.

C/ Angle of lens changed from 90deg to approx. 40deg viewing angle. Combined with a rotational ring for more detailed viewing and a more intimate, physical interaction with the device.

D/ Reduction in the diameter of the lens further reduced the size of the viewer. Small to large diameter posed a form factor challenge, but the result was an object with far more elegance with smooth surface transitions.

E/ Necklace ring replaced by two holes simplified the form and outer surface and improved the feel of the object in the hand.

F/ Addition of grooves for three brass colored thread wrappings added contrast to the white 3D print resin. Intention to improve the feel of preciousness.

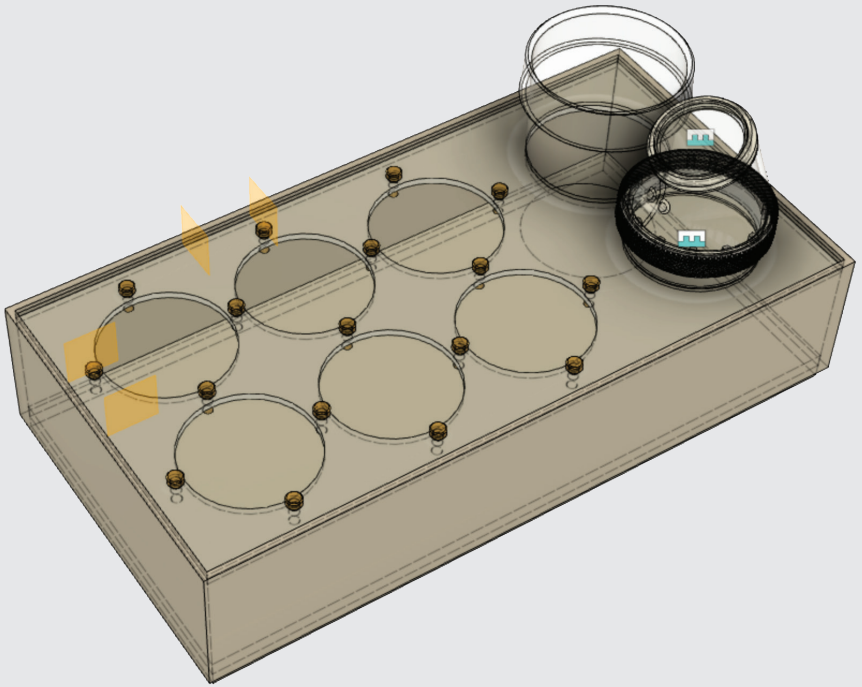
G/ An increase in knurling size and texture for additional grip meant better pick up of petri-dish. However the deeper knurling seemed too aggressive and the object lost its form balance.

H/ Three brass thread rings reduced to a single golden ring made from wrapping gossamer silk. More subtle and a cleaner look.

I/ Depth of rotation ring reduced slightly and knurling texture reduced to maintain clean, balanced and precious feel of the object.

‘LOUPE’

Loupe is a viewer that allows to closely examine and aesthetically appreciate the complex structures of cultured gut biota. The petri dish can be rotated to look closely from various angles at details of the structural complexities of the cultured forms. The transparency of the bottom of the device allows viewing the bacteria in backlight. It is designed to be worn around the neck and placed over the gut area when worn to challenge stigmatization of issues around the gut.



STAGING LOUPE

Loupe required staging in order to facilitate self-tracking as cultivation. The box offers a venue to appreciate growing structural complexity as well as creating a space to tend to petri dishes over time. Based on our initial exploration, we choose a light box as object to stage the culturing of the gut biota. It is where the agar petri dishes can be nurtured, providing dedicated room for the cotton buds for the saliva swab. Creating, monitoring, and disposing of the petri dishes creates an ongoing slow interaction [18], taking place over approximately one week’s time.

LIGHTBOX FOR LOUPE

A professional cabinet maker was commissioned to support the making of a home-base for Loupe, Lightbox. By paying attention to the details and craft of the box itself we wanted to elevate the importance of the cultured microbiome as something beautiful and precious as well as something to be respected and handled with care.

BACKLIGHTING AND DETAILING

Design Proposal:

Loupe, a viewer for close examination and aesthetic appreciation of the complex structures of cultured gut biota. Lightbox, a venue to culture, stage, and tend to growing structural complexity in petri dishes over time.

DISCUSSION

The Loupe and the Lightbox together offer a way for a user to reflect on and engage with their gut over time from a new point of view. By entering into a relationship of cultivation with their externalized microbiota, a user is afforded a vantage point to reflect on issues of food, mood, digestion, and other issues of gut wellness.

A vantage for reflection

Working with our design brief led us to ask the question "what happens when the state of one's gut becomes visible for others to see?" Loupe is worn as a necklace representing the gut's condition as well as the influence that it has on our mental lives to the people around us, making them visible and public. The design of contemporary self-tracking devices are shaped by societal and cultural norms [13] that encourage this tracking to be hidden and private. Conditions related to gut-health are at risk for stigmatization, in part because the nature of the symptoms are focused around the bowel and rectum [7]. In designing for a culture where gut health is not taboo, but instead celebrated, we hope to postulate and support alternative cultures of wellness.

Encountering a part of yourself

The ongoing relationship and interaction with the petri dishes externalizes the gut microbiome, creating a microcosm of our inner workings, a terrarium for our biota to live within. This reflects the concept that gut microbiome is both part of us, as well as other. In turn, this raises questions about who we really are: to what extent we can think of ourselves as a singular being. If the gut microbiome is composed of independent living organisms, with their own desires (e.g. for sugary foods), and our moods are influenced by these alien forms, then how much can we really say that we are singular beings? These questions reflect a more-than-human definition of the "self" being tracked [23].

Cultivating the self

As an interaction that takes care and engagement over time, we see the Loupe and Lightbox as an example of a slow technology. After Hallnäs and Redström [18], the Loupe creates a "moment of reflection" on a part of the self that could not otherwise be directly experienced. Using the Loupe is not designed to be as directly informative or as effective as contemporary self-tracking systems. By eschewing representational logics, such as a numerical interpretations, the design of this viewer and the platform invite a more complex and emergent understanding of the gut. Instead of presenting data about the material, we present the material itself.

Producing an ongoing relationship with a heretofore taken-for-granted part of the self might seem like a strange idea. Sampling, culturing, and keeping specimens over time is not a normal or natural thing to do. We argue that this relationship offers something that is missing from current self-tracking technologies in creating a familiarity with the materials that produce the sensation of wellness or illness directly, and over time can create a more intuitive, tangible assessment of health.

CONCLUSION

We began this process by probing experts in the relationship between the gut and the brain in order to consider how this emerging science could lead to new kinds of self-tracking devices. This led us to design a way to externalize the self through cultivating the gut microbiome. We built a viewer that stages the complex structures of cultured gut biota for aesthetic appreciation, reflection on the self, and closer examination.Together, the Loupe and the Lightbox are an example of self-tracking as a kind of *cultivation*—building a longer-term relationship with the body and its data as a material to be nurtured, tended to, and cared about. This cultivation articulates a different agenda for self tracking, and represents a different kind of self-tracking culture as a substrate for future work.

ACKNOWLEDGMENTS

We would like to thank the domain experts from Copenhagen's Medical Museion for engaging with the self-tracking probe and indulging our curiosity on the gut-brain axis.

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