

Additional document

APPENDIX

Project brief

introduction (continued): space for images



image / figure 1: Living light lamp: light is generated by electronic signals in the plant

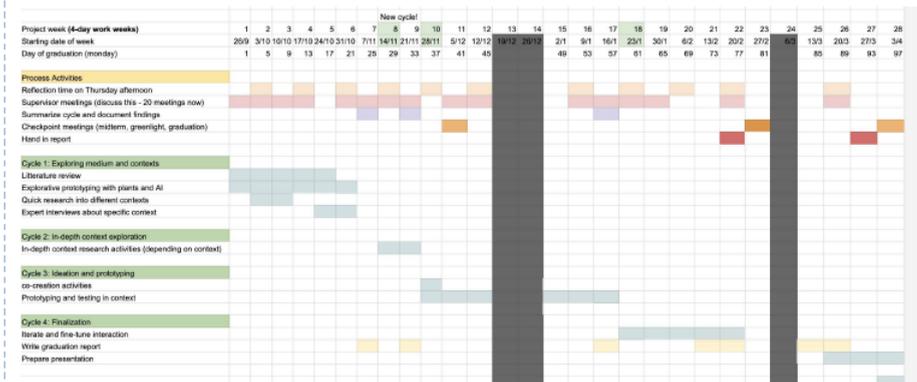


image / figure 2: PL'AI: embraces the notion of a play as an ontological condition of all living bodies, including plants.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 26 - 9 - 2022 end date 6 - 4 - 2023



The project will last 28 weeks, with 25 weeks dedicated to working on the graduation project four days a week and three weeks for vacations.

The plan consists of four main cycles: exploring medium and contexts, in-depth exploration of chosen context, iterative prototyping, and finalization. Each cycle has a corresponding set of materials I plan to hand in. Since this assignment has a relatively broad starting point, I expect the plan to evolve throughout the process. Although naturally present during the project, I've planned time to reflect and adjust the course every other Thursday.

The project starts with general research on plant expressions to form a basis for exploring contexts later. Then I will investigate and visit contexts where bio digital artifacts could be interesting to apply, such as botanical gardens, natural history museums, gardening, and houseplants. After this, I will choose a specific context direction and interview experts (biologists, artist, biodesigners) about plant expression possibilities related to the specific contexts.

Prototyping with plants, AI, and digital technologies from the first week will help me get familiar with the constraints and opportunities of working with the medium for ideation later on.

Cycle two will be an in-depth context exploration of the chosen context to form a better overview before cycle three, which will involve extensive prototyping in quick, iterative cycles. And the final cycle will focus on fine-tuning the interaction of the chosen concept direction.

Project brief



Personal Project Brief - IDE Master Graduation

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, Stick to no more than five ambitions.

I knew for a long time that I wanted to work with something involving interactions with emerging technologies for my graduation. After an elective in more-than-human design, I started thinking more about the future of human-centered design when we inevitably have to deal with the climate crisis and consider other living things as equal collaborators. After the more-than-human design course, I was left with one question: well, including other species in design processes sounds great, but how do I do it? This project is an opportunity to develop feasible manifestations using more-than-human design principles while exploring an emerging technology, and I am very excited about that.

I have three main ambitions for the project:

1. Experience in applying more-than-human design principles to iterative design work.
2. Get more familiar with AI and machine learning models and explore how they can be used in co-performances with plants.
3. I hope the project can inspire designers who want to implement more-than-human design techniques involving digital and biological things in the future. And that the result in itself can be something that provokes a reflection about our relationship with plants.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Project brief

Personal Project Brief - IDE Master Graduation



Bio-digital artifacts for provoking interspecies empathy

project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 26 - 09 - 2022 06 - 04 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Like all living things, humans are tightly interwoven and dependent on their surrounding natural ecosystems. Although this co-dependency exists, our current era (referred to as the Anthropocene) has been criticized for prioritizing human short-term needs over those of other living things and systems. Areas of more-than-human design critique the fundamentals of human-centered design and encourage us to sense, notice, and experience non-humans as equal partners rather than resources [1]. Similar research and experiments look at how we could move towards embracing the qualities of living artifacts in combination with digital or non-organic materials. Instead of building new things on top of nature, maybe there is an opportunity to reconnect and build with it.

Building with nature and things that are alive forces designers to revise how they design as it evolves from prototyping fixed things to also nourishing and training independent agents such as artificial intelligence or plants.

Co-performance presents another view on the future of design by viewing alive artifacts as autonomous and able to learn and develop next to people. This involves embracing the affordances and learning abilities of each actor in the network and "shifts the locus of design from matters of distributions of agency at design time, to matters of embodied learning in everyday practice for both human and artificial performers" [2]. In other words, co-performance is a helpful lens when designing with things that are alive. Maybe designing with nature as a collaborator rather than a resource can encourage us to take it more seriously.

If we shift towards collaborating with plants and living things, how do we foster collaborations where the needs of non-humans are understood, articulated and respected? Plants, for instance, have very different ways of expressing how they are doing that are far from how humans are used to expressing and relating to each other. Can technology play a part in facilitating interactions that foster empathy and understanding towards non-humans?

This graduation assignment is about bio-digital artifacts, which is a thing where a plant, a digital technology, and a human work together to do something. In a system like this, the AI can function autonomously through data pattern recognition, while plants, on the other hand, sense and adapt to their surrounding environment at a different pace. The three actors could learn and adjust to each other's affordances and thus co-perform and align towards a goal.

The next question for this graduation assignment becomes: what goal would it be meaningful and feasible for a bio-digital hybrid to co-perform in alignment with? And in what context? Previously developed frameworks for human-plant interaction point towards promoting interspecies empathy as a possible use-case category for designing with digital technologies and plants [3]. Implementing different technologies with plant interaction could bring new perspectives to the lives of plants, our connection to them, and our environment.

space available for images / figures on next page

Personal Project Brief - IDE Master Graduation



PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

This project will explore how bio-digital hybrids might be a tool to foster interspecies empathy and fascination toward plants in different contexts. By interspecies empathy, I mean empathy towards nature and natural processes.

This addresses the general issue that, in many industrialized societies, there is a tendency to neither notice nor value our entanglements with the ecosystems we live in, even though they are present and crucial for life and well-being. It also asks how we could collaborate and relate to plants in a future where we increasingly interact with autonomous and alive things.

The project starts by looking at a specific technology (bio-digital artifact), instead of a specific problem statement. A part of my assignment will be to explore contexts where bio-digital artifacts could be used to communicate plant expressions and foster interspecies empathy in meaningful ways. I will start the project by researching enhancements, principles, and human reactions to plant expressions. Subsequently, I will try to match the findings with opportunities in different contexts where people already sense and relate to plants.

I aim to end the project with one (or more) prototypes that provoke interspecies empathy and prompt people to reflect on their relationships with plants and non-humans.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

For the graduation project, I will design and build a bio-digital system that prompts people to feel interspecies empathy and that fosters a more-than-human approach of relating to plants.

References:

- [1] Forlano, L. (2017). Posthumanism and design. *She Ji: The Journal of Design, Economics, and Innovation*, 3(1), 16-29.
- [2] Kuijter, L., & Giaccardi, E. (2018, April). Co-performance: Conceptualizing the role of artificial agency in the design of everyday life. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (pp. 1-13).
- [3] Chang, M., Shen, C., Maheshwari, A., Danielescu, A., & Yao, L. (2022, June). Patterns and Opportunities for the Design of Human-Plant Interaction. In *Designing Interactive Systems Conference* (pp. 925-948).

Appendix B: Guerrilla test

Goal(s)	General procedure	Key insights
See if/how people empathise with basic plant expressions	Show basic plant expressions related to a plant and see how it influences peoples empathy towards the plant	The test setup can be improved. It was pretty obvious that the "ideal outcome" of the test was that they would feel empathy, so I think I should keep the next one more open or include different "positive" emotions. Should also have some questions to measure the effect of empathy without sensing the plant expressions.
Test different ways of assessing empathy		It was hard to connect what was going on on the screens to the actual plant in the room. The one with electrical signals made a connection but "The photosynthesis especially felt so abstract from the plant right there in front of me"
		2/4 participants expressed that the test made them think differently about their plants at home.
		3/4 participants tried to touch the plant to see if the electrical signals would change
		People need to understand what the expressions mean. Simply seeing the electrical signals didn't foster empathy because they didn't get what they were supposed to feel.

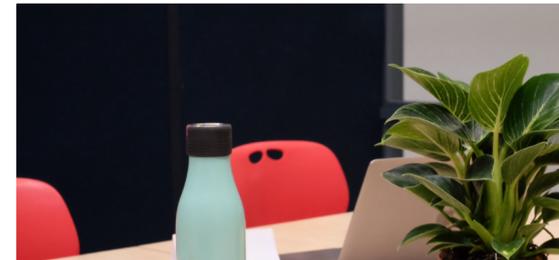
Measuring empathy - basic survey from Himanshus paper

State empathy	Revised question	Original question
Cognitive	I understood what was happening in the plant	I understood how the cyclist I was interacting with was feeling
Cognitive	I could relate to how the plant was reacting	The cyclist's feelings were transferred to me
Cognitive	I had feelings of concern for the plant	I had feelings of concern for the cyclist I was interacting with
Affective	I could sense how the plant I was interacting with felt	I knew what the cyclist I was interacting with felt emotionally
Affective	I felt the same way the plant was feeling	I felt the same way as the cyclist I was interacting with
Affective	I experienced a feeling of sympathy towards the plant	I experienced feelings of sympathy towards the cyclist
Compassionate	I could identify the expressions the plant was emitting	could identify the feelings the cyclist was having
Compassionate	I experienced the same feelings as the plant	I experienced the same emotions as the cyclist
Compassionate	I felt a sense of compassion with the plant	I felt a sense of compassion for the cyclist

Setup

I had three "stations" where people could experience different plant expressions.

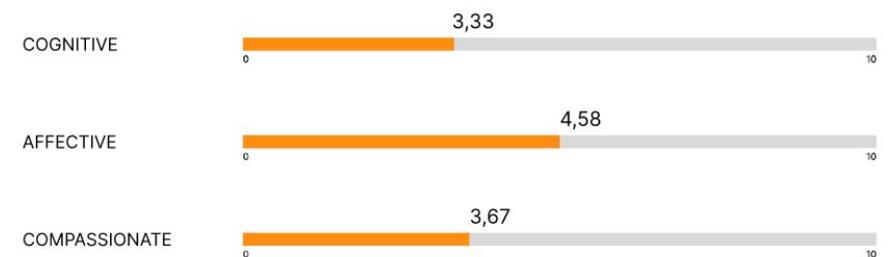
- Station 1: Electrical signals emitted from the plant to the iphone screen (mockup)
- Station 2: showed how plants have a "nervous system" that activates when they are touched.
- Station 3: showed a microscope image of a leaf photosynthesising



Results - individual participants

As Name	Reaction
Female, 23	<p>FORGOT RECORDING</p> <p>The first station (electrical signals) created a connection with the plant, but the two other ones didn't make her connect to the plant in the room.</p> <ul style="list-style-type: none"> - Hard to draw the connection between what is happening on the screen and what is happening in the plant. - The videos resonated more with her because they showed real scientific processes. The electrical signals she didn't get why it was doing it. - It would be interesting if you could experience how the plant reacts to the environment in real-time.
Boy, 23	<ul style="list-style-type: none"> - Respected that the plant didn't react to him. There were things happening. It was doing it's own thing and now trying to respond to me or anything. I respected that. - It's interesting I didn't get what was going on but felt like I didn't understand it. - Processes in the plants that happen fast were very interesting to me. We think of it in time-lapse scale where its growing very slow. - The electrical thing made me feel a different connection to this plant. The other ones didn't connect me to this plant. - I don't think we need this? I don't see a necessity or higher purpose.
Male, 26	<ul style="list-style-type: none"> - Was trying to understand what is going on. Was thinking "am I missing some part?". - Thought the electrical signals were noise. - I felt like there were some memories in high school biology class that I have to understand better to get what was going on. Was trying to connect it to that. - There's a difference between what's on the screen and on the table. The stuff didn't effect the plant standing there physically. Hard to connect the two. - If the plant signals don't react to anything what does it matter? - The context matters. In the studio here it's hard to really feel fascinated and stuff. Just wanted to analyse it.
Female, 24	<ul style="list-style-type: none"> - With the nervous system you see that it has a response when I touch it. Maybe I shouldn't rip things off the tree. You never see that normally but now I saw it. - I didn't relate this specifically to this plant. I should be more careful with my plants. - Liked the electrical signal. Tried to touch it. Didn't really understand what these signals were. - The photosynthesis felt more alien. Hard to take that image and think "ok so that is inside that". I didn't really look at the plant at all when I was doing this. - I'm more curious to know more about what happens in a plant. Remember from school but want to know more what exactly happens. Appreciate that plants are also living. Even though you know they are living you still step on them and stuff. - You've been told about photosynthesis, but you have to imagine it. - Connected it with seeing what happens inside a human body.

EMPATHY LEVELS RESULT



Appendix C: theme cards

Plant expression

Plants warn each other

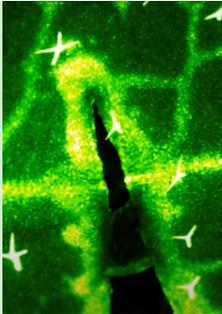
Plants emit volatile organic compounds (VOCs) as a means to warn other plants of impending danger. Nearby plants exposed to the induced VOCs prepare their own defense weapons in response. Tomato plants, for example, have also evolved to attract the animals that eat their attackers if they are attacked.



Plant expression

Plants can "feel" and respond

Plants know when they are being touched, can tell the difference between hot and cold, and know when their branches are swaying in the wind. They account for this when making choices. Vines, for example, start rapid growth immediately upon contact with an object like a fence they can wrap themselves around.



Plant expression

Plants "travel"

But they travel slowly compared to us. Plants travel by sending out seeds in different ways: through fruits that other animals eat, through wind, by shredding seeds to the ground, or by even by sticking to passing by animals.



Plant expression

Plants make new plants

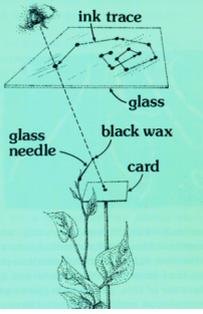
Plants make new plants by themselves or with the help of pollinators. They make new plants in different ways, for example by spreading seeds.



Plant expression

Plants move in different patterns

If you see time-lapse footage of a plant, you can notice that their movements are unique and different. Darwin recorded these movements by marking the top of a plant at different points on a glass.



Plant expression

Plants make choices

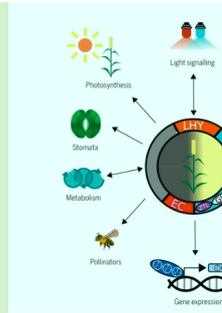
Plants constantly make choices about how to grow, when to shed their leaves, what chemicals to make, when to grow flowers or not.



Plant expression

Plants have circadian rhythms

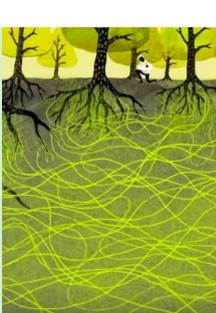
Plants have an internal timekeeper known as a circadian clock that anticipates environmental cues such as light, and temperature and regulates photo-periodic rhythmicity for the proper growth and fitness of the plants.



Plant expression

Plants communicate

Plant communication encompasses communication using volatile organic compounds, electrical signaling, and common mycorrhizal networks between plants and a host of other organisms such as soil microbes, other plants (of the same or other species), animals, insects, and fungi.



Plant expression

Plants can get sick

Plants can get infected by different fungal diseases. A lack of nutrients like nitrogen, phosphorus, or potassium can weaken plants and hinder their growth.

There are lots of different diseases plants can get, and they can look different.



Plant expression

Plants "learn"

Plants "learn" and adapt based on "experiences". Young trees, for instance, gradually learn when to shed their leaves.



Plant expression

Plant cooperate and are intertwined with other plants and species

Examples of plants and other species cooperating can be found all around. For example, certain ants feed on the honeydew produced by aphids and may get protection in return. Plants also help other plants, for example by sharing resources with each other through fungal networks.



Plant expression

Plants don't have centralized organ systems

It may seem obvious, but if a plant loses 90% of its body, it might still survive. This is very different from other animal lifeforms.



Plant expression

Plants photosynthesize

Plants use sunlight, water, and carbon dioxide to create oxygen and energy in the form of sugar.



Appendix C: theme cards

Technology

Moisture detection

The moisture level in the soil can be tracked



Technology

Time-lapse footage

Watching plants grow in time-lapse footage can give us a sense of how plants move, adapt, and grow. We can't notice this by looking at them, since plants move on a different, a lot slower, time-scale



Technology

Air temperature and humidity

Different plants need different temperatures and air humidity levels to thrive. This can be measured.



Technology

Engaging with entanglements VS **Empathy towards individual plants**

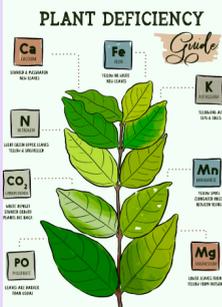



Many things are happening in individual plants that we don't notice. They move and grow in response to how we treat them. Another important philosophy of more-than-human design is designing interventions that help us notice and join the entangled world around us.

Technology

Nutrient detection

You can also measure and detect the nutrients in a soil



Technology

AI with plant data

Image recognition or other pattern recognition with AI can be used to detect disease, the concentration of certain nutrients, sun patterns, plant species, etc. Maybe there is other data about plants that we could gather as well?



Technology

CO2 sensor

It's also possible to measure level of certain gasses like ammonia and CO2.



Technology

Not understanding what plants express VS **Not noticing plants enough**

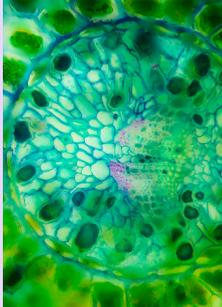



On one hand, you could say that it's hard for people to relate to plants because they are different from us. However, people who take the time to engage with plants notice them differently. Is the problem that we can't understand them, or that we don't take the time to learn to understand them?

Technology

Microscope

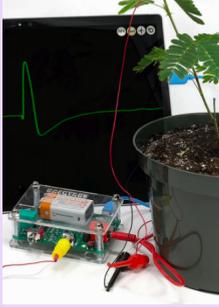
Putting plants under a microscope can be fascinating, but also help us learn about the processes happening inside them.



Technology

Electrical signals from plants

Plants generate small amounts of electricity for certain processes happening inside of them.



Technology

Using technology to come closer to plants

You could say that what brought us away from reading and understanding non-humans is the way we design our technologies.

Mutual dependency VS **Increased feeling of disconnection**




In our practices, we are far from connected to where what we eat and use come from. A lot of indigenous practices promote a direct dependency and interaction with non-humans to live. How do we install this sense of mutual dependency in a world that is growing in complexity?

Interspecies empathy VS **Capitalism**




It's easy to get discouraged and pessimistic by attempts to foster interspecies empathy in an industrialized society that functions by putting the needs of humans and plants at odds with each other.

Technology

Anthropomorphism can help empathy VS **Otherware needs otherness**




On one hand, anthropomorphizing plants can help people relate to and emphasize to their needs. On the other hand, plants are intelligent on their terms and not "simplified" humans.

Appendix C: theme cards

Approach

Plant-centered design

What: Approach that I invented. Design things that help the plant and only think about the plants needs.

Why: To help the plants do what they want to in a world where they don't have control. Make people aware of how they are being misused.

Examples of how: Giving plants their private waterer, pollinating for them, sending seeds away and dropping them.



Approach

Design for collaborative survival

What: Design tools to help people notice and join with entanglements and other species around them

Why: Humans are deeply intertwined and dependent on other species, but we don't notice this. Can we design interventions that push us to notice and engage with them?

Examples of how: Intimate ways of collecting and processing data, intimate acts of care.



Approach

Experimental

What: Explore new ways of relating and doing with plants. Ask fundamental questions about our relationships with non-humans and embody them into something.

Why: Opening perspectives of what non-humans are, the roles we give them in the Anthropocene, blurring divides.

Some examples of how: From PLAB: What if we do not know in advance what the implications of such relations are, what if all that we can do is to surrender, embrace the encounters and continue to play within them?



Approach

Living artefacts

What: Designing living artifacts with symbiotic mechanisms so that the living thing and the human are co-dependent on each other. Introduces three principles for the design of living artifacts: Living Aesthetics, Mutualistic Care, and Habitability.

Why: Direct co-dependency can increase sensitivity and awareness of non-human lifeforms. Can bring new ways of doing and living, raising critical questions concerning care, symbiosis, cohabitation, and adaptation.

Examples of how: A living thing as a "component" to help the human achieve something, and the human has to help it stay alive.



Approach

Education

What: Design interventions that help people learn about plants

Why: Learning about plants increases sensitivity and awareness about them. Which in turn can inspire people to protect other life forms more.

Some examples of how: Designing an exhibition for natural history museums, designing school education activities.



Approach

Human-centered design

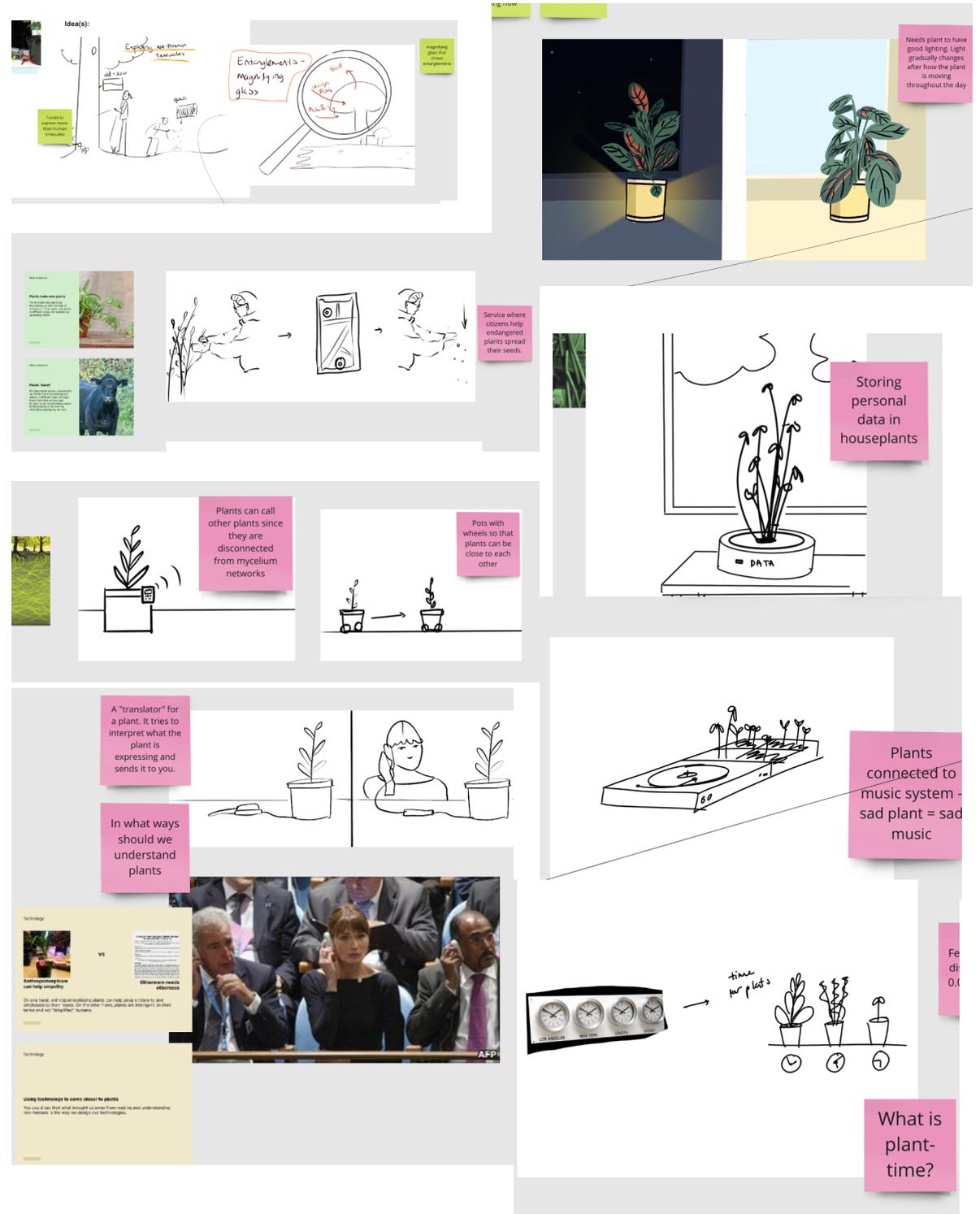
What: Design so that the living thing gets what it needs and stays alive in an easy way so that humans can use them either for aesthetic or resource purposes.

Why: Humans need plants for different things, so how can we make attending to their needs easier?

Examples of how: Automated systems that care for plants, add emotions to plants, apps, and systems that help us attend to them.



A few probes generated from the theme cards



Ideas: Exploring the human-plant relationship

Entanglements - Magnifying glass

Needs plant to have good lighting. Light gradually changes after how the plant is moving throughout the day

Service where citizens help endangered plants spread their seeds.

Storing personal data in houseplants

Plants can call other plants since they are disconnected from mycelium networks

Pots with wheels so that plants can be close to each other

A "translator" for a plant. It tries to interpret what the plant is expressing and sends it to you.

In what ways should we understand plants

Plants connected to music system - sad plant = sad music

Feeding plants

What is plant-time?

Technology

Autonomous human care-taking capability

Others are ready to embrace

Using technology to come closer to plants

The use of care that what brought us closer from needing to understand relationships. The use of technology and design.

Appendix D: co-speculation and DNA data storage interview probes

Structure:

1. Introduction. presenting project and DNA data storage in living organisms
2. Braindump exercise: dump all ideas, associations, thoughts and fears about the technology
3. Worlds-building exercise part 1: making statement cards.
4. world-building exercise part 2: making speculation
5. Presenting and summing up.

Probes made from co-speculation and other examples of dna data storage

co-speculation slides with main exercise

PART 1

"In a world where...[insert provocation], people [insert what people do in response], and [insert the effect on the plants/trees]"

Example:
"In a world where digital data can be stored in forests, people can visit their own family tree where they store memories, and forests would gain deeper spiritual meanings"

PART 2 - braindump

think about the following three elements that your fictional world might have:

- 1) Artefacts/Objects
- 2) Organizations
- 3) Rituals.

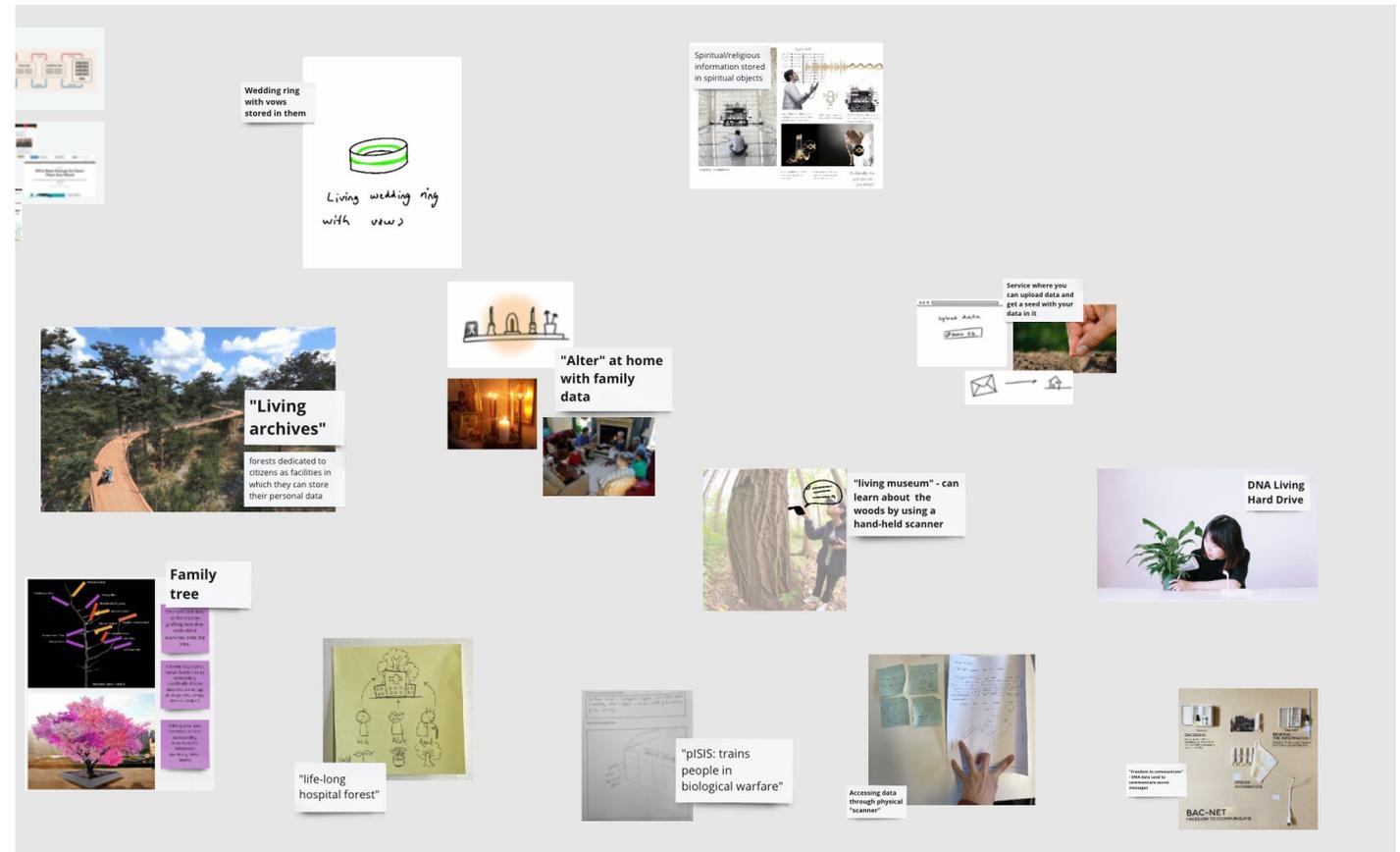
Participants

Workshop 1

Participant number	Gender	Nationality
P1	Female	Netherlands
P2	Male	USA
P3	Female	India

Workshop 2

Participant number	Gender	Nationality
P4	Female	Netherlands
P5	Female	Taiwan
P6	Male	Netherlands
P7	Female	Hungary



Appendix E: focus groups round 1

Plan with questions

Overall research goal:

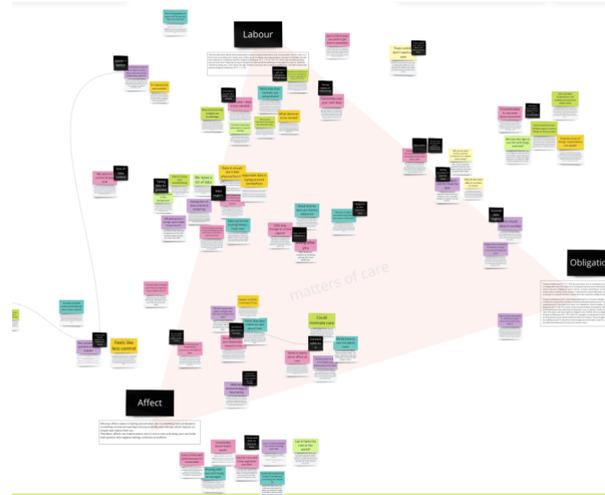
What are people's thoughts, ideas, and concerns about being directly dependent on a plant to store their data? (co-dependency) Why do they think this way?

Questions to ask during discussion:

1. On practical things: why
2. When you say....., what assumption or fact are you basing that on?

Time	Plan	Things to say	why	Todo
5-10 min	1. Consent forms, wait for people and welcome.	0. consent form 1. Welcome 2. I will record and take photos after 3. Introduce goal 4. Introduce plan: - the video provocations are just for starting a discussion, and I am interested in what thoughts they trigger in you. Not wether you like the prototype or not. 5. Get to know each other: introduce name, what you study and a memory you have with a tree. 6. Questions?	practical info and break ice. Tree memory exercise to get people to think about relationship with trees.	1. Have snacks available 2. Start recorder
15 min	2. Discussion about sensitising assignment	0. How was it to fill in the booklet? 1. What does data mean to you? 2. Did you notice something while thinking about where you store data? 3. What were your reactions to DNA data storage? 4. Would you store something in DNA? what would you store? 5. Why would you store those things?	Discuss participants relationship with data and thoughts around storing data in plants from sensitising. Want to find out what they want to upload to DNA and why they chose that file to understand their relationship to the medium.	Have booklets available and look at them
10-15 min	3. Discussion, first video: uploading DNA to a tree	1. First, are there any questions about what is happening in the video sketch? 2. So in this video, someone is uploading a file to a tree. Which most likely will be a plausible use-case that can work without harming the tree. It's obviously fictional and most likely we won't use DNA data storage like this. Still, what thoughts does storing data in a tree trigger in you? 3. What relationship would you have with a tree with data in it? 4. what would you store in a tree?	Go deeper into thoughts around materiality around uploading data to a tree. Natural vs. digital.	1. Play video 2. Introduce tinkering objects
10-15 min	4. Discussion: second video: having to attend to tree	1. First, are there any questions about what is happening in the video sketch? 2. What are your thoughts on caring for a tree data storage unit? 3. What do you feel about being dependent on trees?	Go deeper into co-dependency part. dilemma of dependence on plants and non-humans but not feeling it.	1. Play video
5-10 mins left	Summary	1. anything you want to add? 2. wrap up		1. Collect sensitising booklets OR get photos after. 2. Take photos of group discussing hehe

Analysis



Participants

Focus group 1

Gender	Occupation
Female	Design student
Female	PhD student, <u>microbiology</u>
Male	Design student

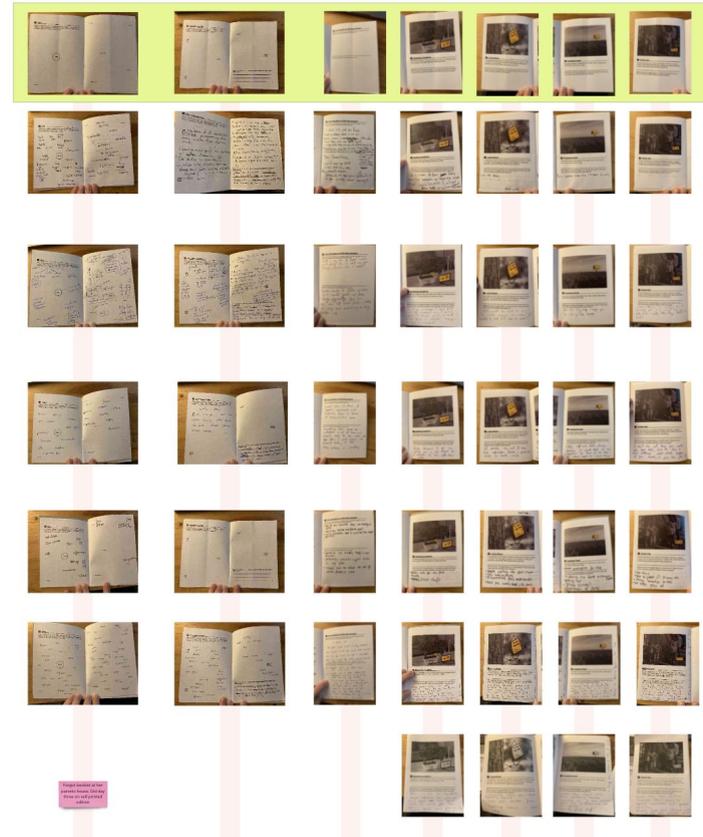
Focus group 2

Gender	Occupation
Female	Design student
<u>Female</u>	<u>Design student</u>
Male	<u>Design student</u>
<u>Male</u>	Design student

Links to videos

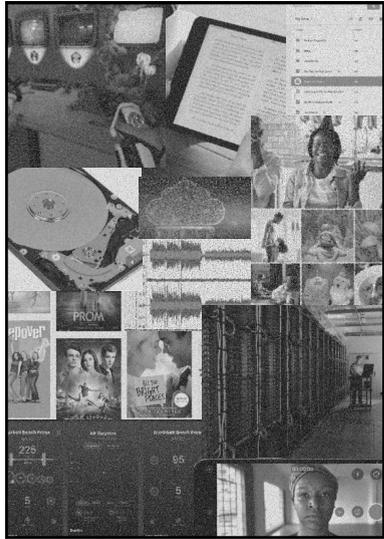
[Link to video sketch 1](#)

[Link to video sketch 2](#)



Appendix E: focus groups round 1

sensitising booklet



Day 1
Data and digital files

1 Data

Write down everything you associate with the word "data" on these pages. The words are there to inspire you but don't feel limited by them. Feel free to draw, write keywords or do whatever helps you think.

Data

archives

memories

public data

privacy

analog/digital

libraries

2 Your data and files

Where and how do you store your data, information, and files? The illustrations are here to help you think but don't feel limited by them. Again, draw, write, doodle, or do whatever helps you think about the question.

cloud

hard drive

server rack

Based on your thoughts, write your own personal definition of what "data" means to you:

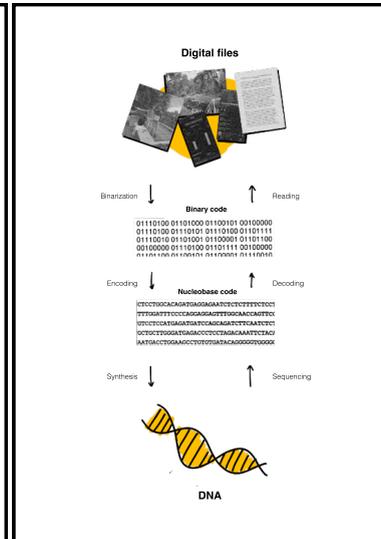


Day 2
DNA data storage

How does storing data in DNA work?

In short, digital data on a base level is a sequence of 0s and 1s. This can be converted to lines of H, C, G, and T, which form the basis of DNA, and can be synthesized into strings of DNA molecules. The DNA strings representing data files can be sequenced, decoded, and read back into a file later.

Watch this video to learn more:



DNA data storage - quick summary

Why store data in DNA?

High density
DNA is extremely dense. In theory, it could fit all the data on the internet in a shoe box.

Long-lasting
While hard drives and storage devices often need to be updated around every ten years, DNA can stay stable for centuries if stored in the right conditions.

Eco-friendly
Data storage currently emits more than the aviation industry, and the amount of data being stored is rising almost exponentially. With DNA data storage, we could store data densely, with very little energy required for storage.

Why are we not storing data in DNA?

There are several proofs of concepts and examples of data being stored in DNA. However, right now it's too expensive to be commercially available. Synthesising and sequencing also takes some time.

With DNA data storage, there is potential for...

1. Storing data in living bacteria
2. Storing data in trees or plants
3. Objects to be embedded with DNA carrying digital information

3 Your thoughts on DNA data storage?

What are your first reactions or thoughts about DNA data storage? You can dump your ideas/concerns/questions/thoughts here.

Would you store data in DNA? What would you store?

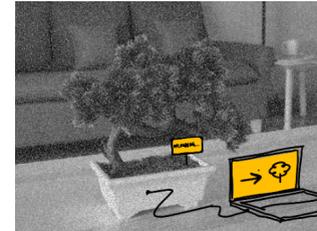
Appendix E: focus groups round 1

Sensitising booklet



Day 3 Imagining possibilities with DNA data storage

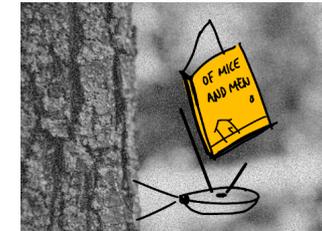
Today you get to react to four provocations imagining possible DNA data storage scenarios.
You can just write your gut reactions or thoughts, key words are fine.)



4. Breathing harddrive

Breathing harddrive lets you store your files in a bonzai tree in your house. If the tree dies you loose your files.

What are your thoughts/ideas on breathing harddrive? What do you think could be possible side effects of the concept?



5. Living library

Living library stores library stuff like books and movies in trees in a park. You can get a hologram of the files by using your personal, hand-held DNA sequencing machine.

What are your thoughts/ideas on living library? If this was real, what could be possible side effects?



6. Facebook forest

Facebook forest is Facebooks new data center. Data about their users are stored in trees.

What are your thoughts/ideas on facebook forest? If this was real, what could be possible side effects?



7. Family tree

Family tree stores your family information (photos, recipes, songs, ect) through generations. Adding new data becomes a ritual surrounding important life milestones.

What are your thoughts/ideas on family tree? What do you think could be possible effects of the concept?

Appendix f: workshop with sensitising kit and design fictions

Booklet assignments

Introduction

Thank you for participating in this study! I appreciate it a lot and I hope it will be interesting for you as well.

During the next seven days, you can care for a spirulina culture and reflect over some design fiction scenarios involving DNA data storage for about ten minutes each day before the workshop.

Have fun!

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Get to know your spirulina			Introducing DNA data storage	Design fiction 1	Design fiction 2	Design fiction 3

How to set up your spirulina:

1. Wash your hands and avoid touching the nutrient mix and starter to avoid contamination
2. Add the nutrient mix to the starter. This will help the spirulina grow.
3. Find a nice spot for it with a lot of sunlight. At night it should be kept in the dark. Optimal growing temperature is 30-35 degrees, but around 20 degrees is also fine.

How to keep your spirulina alive and happy

1. Keep the lid slightly open so that some air can flow in and out of it without leaving it directly exposed for potential contaminants.
2. Shake the spirulina a few times each day so that all the particles get some exposure to sunlight
3. You can track the growth of your spirulina by taking a photo each day and observing how it gradually grows more dense.

Participants

Workshop 1 participants

Gender	Occupation	nationality
p1	Design student	<u>dutch</u>
p2	Design student	Ukrainian
p3	Design student	<u>dutch</u>

Workshop 2 participants

participant	Occupation	nationality
p4	Design student	<u>german</u>
p5	Design student	<u>dutch</u>
p6	Design student	<u>korean</u>

Sensitising assignment day 1-3 (PH value was only on day 1 and 7)

Day 1

Remember to take a photo:)

Date and time: _____

PH value: _____

How was it setting everything up? What are you noticing/thinking?

Introduction to DNA data storage (day 4)

DNA - 1

DNA DATA STORAGE ALLIANCE

Introducing DNA data storage

BIOMEMORY

Brow Your Own Cloud

DNA: The Ultimate Data-Storage Solution

DNA - 3

DNA data storage - quick summary

How does storing data in DNA work?

In short, digital data on a base level is a sequence of 0s and 1s. This can be converted in lines of A, C, G, and T, which form the bases of DNA, and can be synthesized into strings of DNA molecules. The DNA strings representing data files can be sequenced, decoded and read back into a file later.

Why store data in DNA?

- High density: DNA is extremely dense. In theory, it could fit all the data on the internet in a shoe box.
- Long-lasting: While hard drives and storage devices often need to be updated/replaced every 10 years, DNA can be stored for centuries.
- Eco-friendly: Data storage emits around 2% of global greenhouse gases, which is more than the aviation industry. With DNA data storage, we could in theory store data nearly forever, at a very low energy requirement for storage.

Why are we not storing data in DNA?

There are several pros and cons and examples of data being stored in DNA. However, right now it's too expensive and slow to be commercially available. It's expected to become cheaper and more accessible in the future, and corporations like Microsoft and IBM are investing a lot in its development.

With DNA data storage, there is potential for...

1. Storing data in living bacteria
2. Storing data in trees or plants
3. Objects to be embedded with DNA carrying digital information

Sensitising assignment with design fiction day 5-7

Day 1

Remember to take a photo:)

Date and time: _____

PH value: _____

How was it setting everything up? What are you noticing/thinking?

DNA - 2

Watch this video:)

DNA - 4

DNA data storage in living organisms - quick summary

DNA strands that represent digital data can, through different techniques, be genetically modified into the DNA of living organisms such as plants or microalgae like Spirulina. This can be done in a way that does not harm the plant and where the DNA is permanently stored without being "used" by the organism to grow. These techniques are costly and time-consuming today, but might become more accessible in the future.

Brow Your Own Cloud company first experiments with growing data in plants

Experiment that stored data in a tomato plant

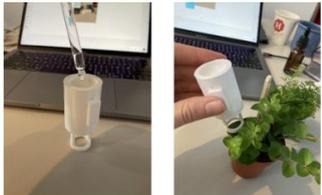
Appendix H1: prototyping

“Uploading” data to a plant

There are different techniques for “uploading” data to a plant. Data is first translated from binary to nucleobase code, then synthesised into a strand of DNA.

Practice	Early prototype embodiment
	 <p>Synthesiser connected to computer</p>
	

Examples of a DNA synthesiser machine and early prototype embodiments.

Practice	Early prototype embodiment
 <p>Agrobacterial syringe injection</p>	<p>ADD PHOTO</p>
 <p>Biolistic particle delivery (gene gun)</p>	 <p>This prototype was a simplified gene gun where the data-DNA is added at the top.</p>
	



The photo shows a nanopore sequencer



bluetooth handscanner





sample



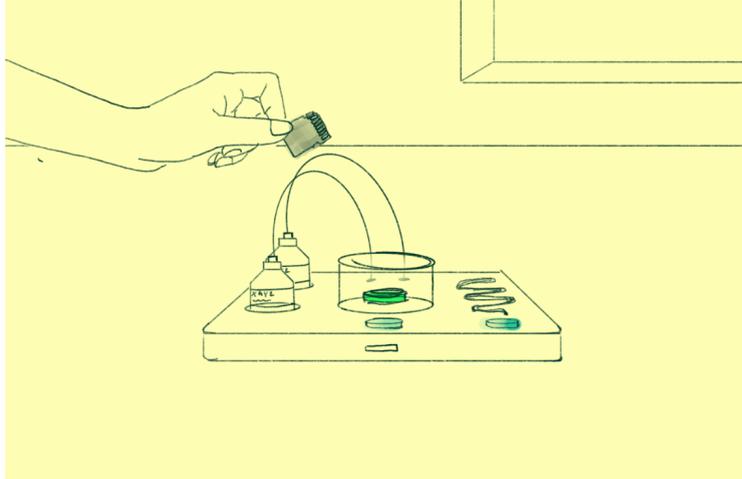
Adding to synthetic tissue



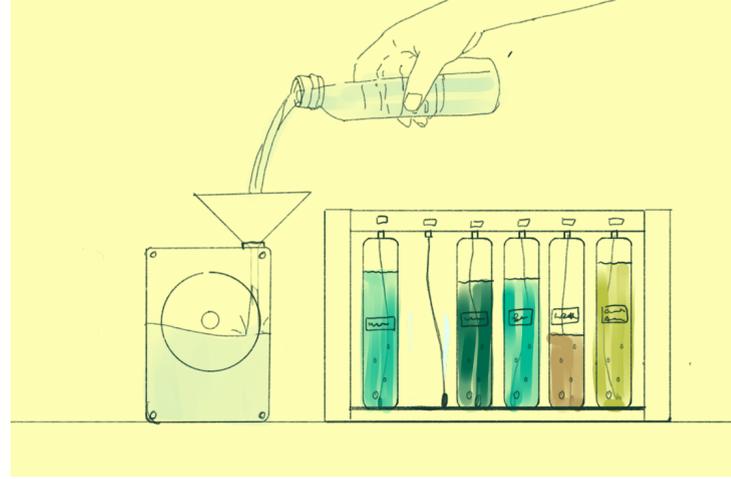
sequencing + uploading to computer

Appendix H2: prototyping

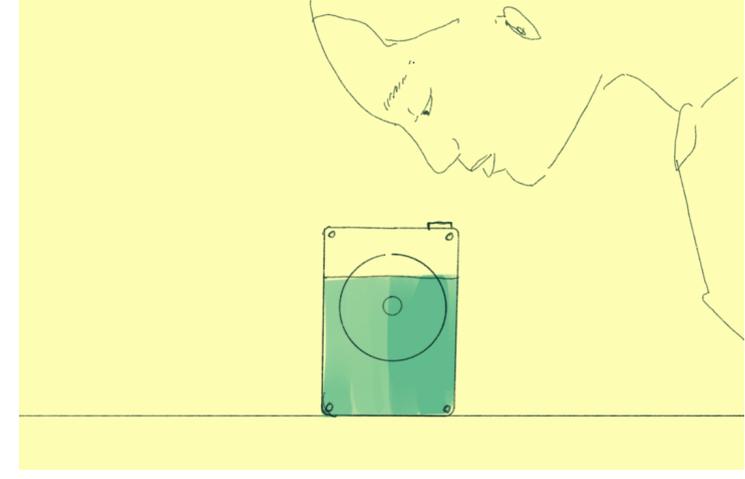
Story board video sketch



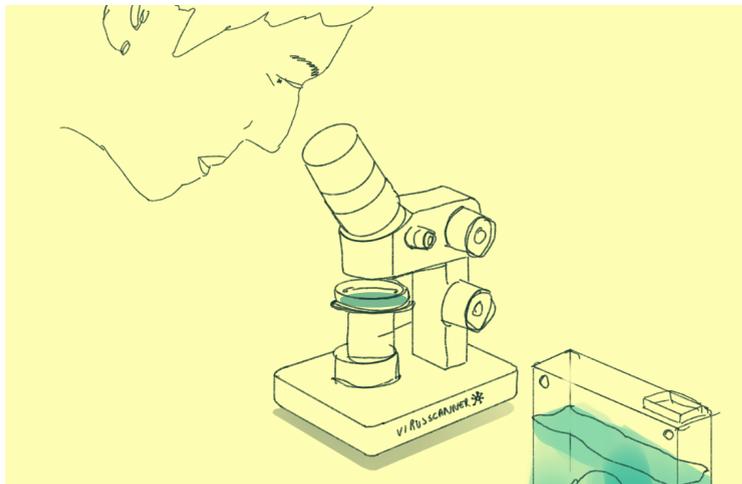
Uploading files



Adding nutrient mix to new data



Checking smell



Scanning for virus

[Link to story board video sketch](#)

Appendix H3: prototyping

Video sketching



Appendix H4: prototyping



An early idea was to make the storage containers look like harddrives. tested this with 3d printing.



Earlier versions of algae cloud

Appendix G: Algae Cloud story board

Scene 1: overview shot

An overview shot at the beginning was introduced after feedback from making video sketches and asking for feedback (see Appendix H2), to establish early that algae cloud is concretely a set of tools.



Scene 2: "Uploading" important documents

To give a brief understanding of how data is uploaded to a sample of algae, scene 2 includes a shot showing how data is transmitted via biolistic particle delivery to a small sample of the culture.



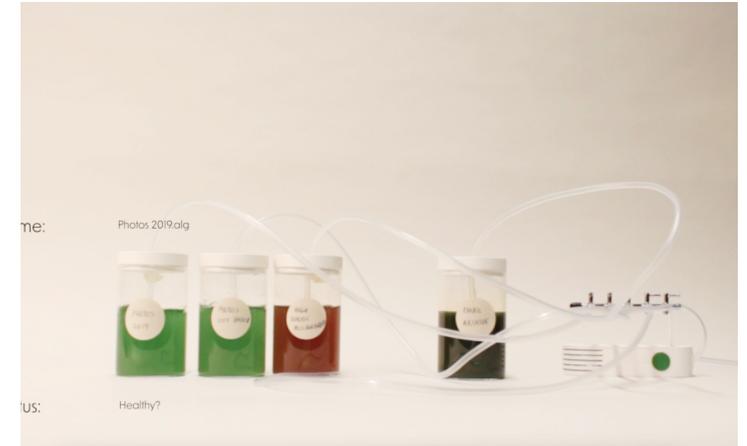
Scene 3: helping "important documents.alg" grow

This scene shows how to set up a data storing culture, "important documents.alg". The practices are similar to what is needed when starting to grow a regular spirulina culture, and was meant to underline the fragility and care that is needed to start growing data.



Scene 4: managing storage system

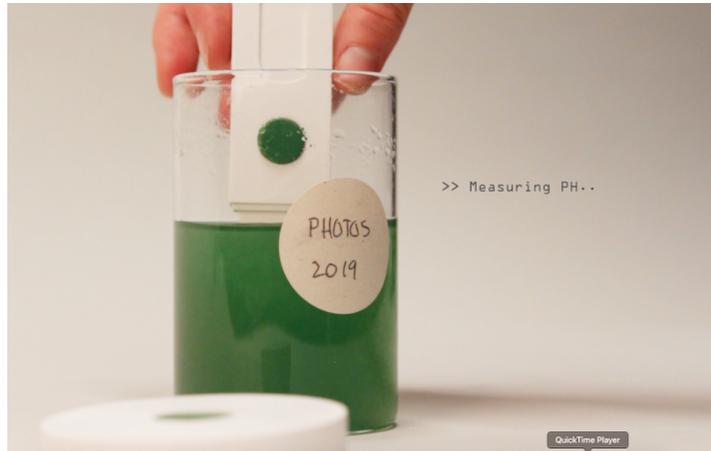
In this scene, the person adds the important documents culture to the storage collection, and the viewer sees how different algae data is treated with different levels of care. The goal of this scene was to encourage reflection on what data is worth caring and keeping and what data can be let go. In the scene, "email archive" is thrown in the trash, and "photos 2019" is taken out for a care routine.



Scene 5: care routine

Different care practices are performed to help maintain the algae. The care practices require human senses (smell, sight) and the help of digital and analog tools (PH value, light intensity, microscope).





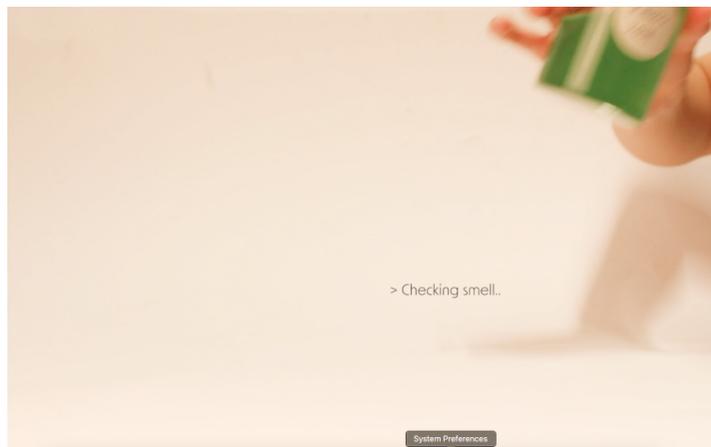
Scene 7: Downloading data

The uploading/downloading/synthesiser/sequencer is used to download files again. This scene was mainly introduced to reassure viewers that data uploaded to an algae would be accessible later, but in what ways the storage method might influence the data was left to the viewers to imagine.



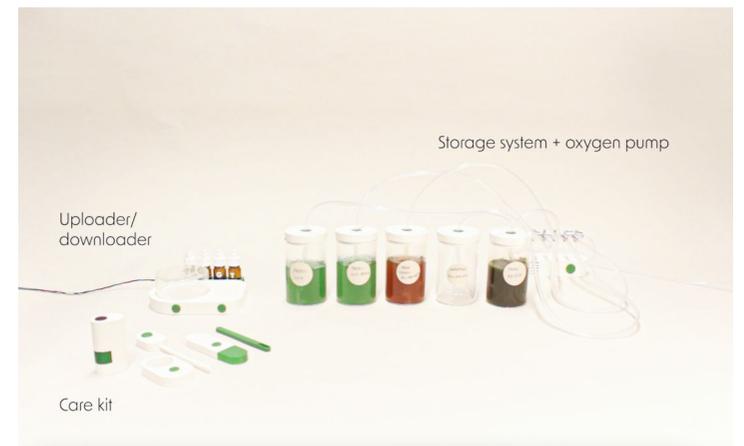
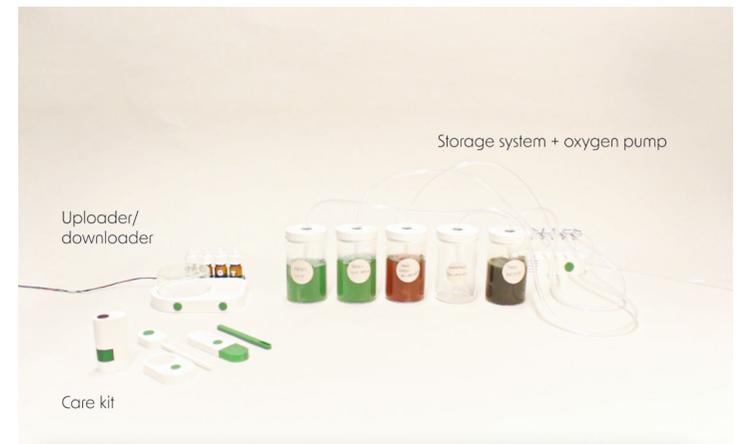
Scene 6: Finding solution for smell problem

When the person storing data realises that the culture smells weird (like ammonia), they search for a solution, and try adding more water.



Scene 1: overview shot

An overview shot at the beginning was introduced after feedback from making video sketches and asking for feedback (see Appendix H2), to establish early that algae cloud is concretely a set of tools.



Appendix H: final focus group

Focus group plan

Focus group goal

Examine what thoughts, ideas, and concerns come to people's minds when discussing "Algae Cloud," and see how these relate to original research questions.

Research questions:

1. How might Algae Cloud help imagine relationships of mutualistic care between people and living organisms facilitated by data storage?
2. How might Algae Cloud help imagine new relationships of mutualistic care between people and digital data?

Focus group plan and questions

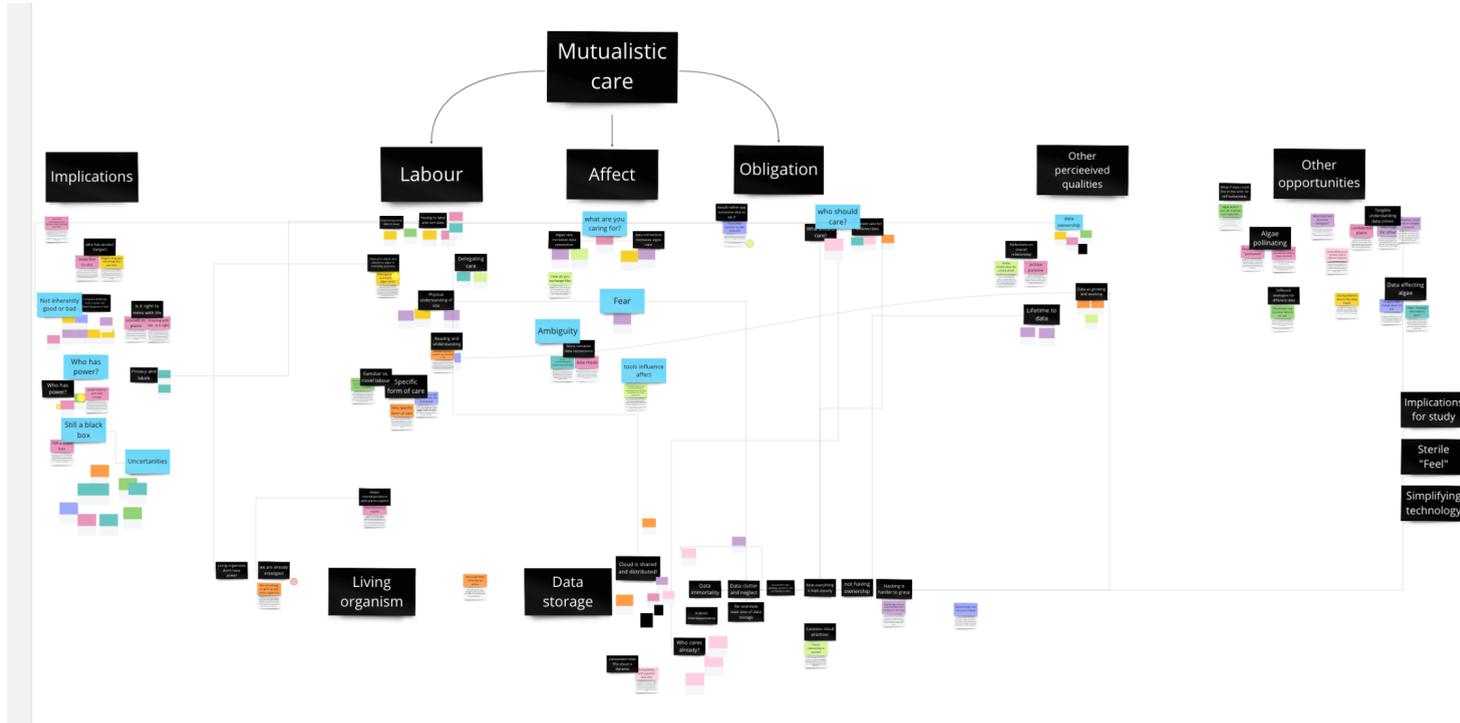
Part	Goal	Script + questions	props	Time
Introduction		Welcome. Before we start, I would like to inform you that we are filming and recording this session. Consent forms are here in case you haven't filled one in.	consent forms backup prototypes on the table backup projector	5 mins
Ice breaker	break the ice and get people comfortable talking	Everyone says their name, what you do, and what data/digital files are most valuable for you.		5 mins
Introduction	Get the group on	In this focus group, I will show a video of some prototypes, and you will		5 mins

	the same page for the focus group.	have a discussion about them. The prototypes are speculative, and they are based on a technology that is far from being practical in everyday life today or commercially available, so you don't have to think too much about if you would buy one yourself or the technical challenges. I'm interested in what the videos make you think about; what reflections you can draw from it, but also your worries, things that are not clear, or questions it brings to your mind. There are no right or wrong answers, and a wide range of honest opinions is great and will help me learn a lot. I have some guiding questions I want to go through, but all in all you can think of it as an informal discussion.		
Introduction discussion	Discuss themes without relating it to the video			
Showing video	Show video	Participants get a piece of paper to note thoughts down for		5 mins
Discussion		Clarify 1) Before we start the discussion. Was there anything in the video that was not clear or that I should play again? Intro: 1. In the video, algae (microalgae) is a medium for data storage. What is your initial reaction to the concept of storing digital data files in a living organism? Data storage relationships 2) In the video, "algae cloud" is a physical algae culture that is a data storage system. What does "the cloud" feel like now in comparison? a) If you imagine your cloud storage system as a room. So all your files are there as physical things. What does it look like?		40 mins

		<p>3) In the video, a person stores data in different physical algae cultures that need care in return for data storage. And if it lacks care, the algae with the data dies. In relation to what you discussed about the cloud, how do you think the feeling of the cloud influences our relationships with our digital files?</p> <p>Algae/plant relationships</p> <p>4) In the video, a person takes care of an algae culture in return for data storage. How could using microalgae for DNA data storage impact our relationship with other living things?</p> <p>5) In the video, a person depends on an algae culture to store data. What are your thoughts about having a relationship between people and plants that is motivated by data storage? a) What new opportunities do you think this could create?</p> <p>6) In the video, the person has to learn and engage with the algae for the data storage to work. So there's this mutual relationship of having to care for the algae to get data storage in return. Which in turn makes the person care more. How do you think the feeling of being directly dependent on plants or algae might influence relationships to them?</p> <p>7) Howd does it relate to data storage responsibiloty</p> <p>Other questions</p> <p>8) Do you think the use of microorganisms for DNA data storage could be used to address any current issues in data storage and privacy?</p> <p>9) How might the use of plants for DNA data storage impact our understanding of care, particularly in relation to the care of non-human entities?</p> <p>10) If all the data in the world was stored in algae, assuming that it works and is safe, what could be the consequences of this?</p> <p>11) Like discussed previously, data storage, although it can feel weightless and intangible, actually takes a lot of energy and physical space, and is bad for the planet. How do you think we could approach data storage with more care?</p>		
Sum up		Thank you all for taking the time to be in this focus group.		5 minutes

Appendix H: final focus group

Analysis in miro



Appendix H: final focus group

Results after first round of analysis (not clustering in relation to mutualistic care)

The opportunities from the participants will be presented here as themes. A discussion about what this could mean for mutualistic care and wider research opportunities this could entail is in the discussion section FIXME. The results present the perceived qualities of Algae Cloud (1), Algae Cloud ideas (2), and implications (3). and how it was used to reflect back on current data storage practices and relationships with living organisms (4).

There were discussions about the impracticality of the Algae Cloud in everyday life, which were valuable in highlighting potential opportunities. However, these comments have not been prioritized in the results because the primary goal of the Algae Cloud concept is not to be a commercially attractive device but rather to stimulate reflection.

1. Perceived qualities

Algae Cloud Ambiguity

This theme relates to Algae Cloud not really being data and not really being algae, but something in between. This could make it a bit mysterious and interesting but also makes classifying it and the care that comes with it confusing.

What do people care for?

This ambiguity also relates to what care means when caring for Algae Cloud. On one hand, caring could bring deeper inter-species bonds with algae, but it could also bring deeper bonds with data files. The incentive to care could be wanting to keep data, but it could also be wanting to keep the algae alive. In other words, why would people care for Algae Cloud, and what are they caring for? This question wasn't addressed explicitly in the focus groups but emerged through analyzing results and finding conflicting ideas on what care in this setting could mean. P1 and P2 discuss how people would be motivated to care to keep their data, but then there is a diffuse boundary between caring and exploiting.

"I mean.. as a human, you are unfortunately often motivated by self-interest and then this algae is very much serving that. So yeah, I think your average person would be more invested to care for that object." - P1

"But then is it really caring, I mean, it's still kind of exploiting." - P2

Who has power in a relationship with Algae Cloud?

Power is "capacity or ability to direct or influence the behavior of others or the course of events" (SOURCE), and is a bit more ambiguous with Algae Cloud. It is interesting in the sense that there are two living organisms (human and algae) who have agency in deciding how the data storage will go, which could impact the power balance. Still, humans have a long history of domesticating plants and living organisms for resource purposes, so this didn't seem like a huge issue. P1 reflected on how this power balance would play out if, for example, she stored her data in her cat.

"I would feel weirder about storing my data in my cat. That would take a power balance somehow, in some way. I guess she almost has more power over me. If she gets sick.. but then I'm kind of exploiting my relationship with her... I don't know." - P1

Algae Cloud livingness

This theme relates to Algae Cloud being experienced as evolving and changing rather than feeling "immortal" and static and how participants imagined opportunities and challenges in interactions with it.

Growing

Some participants, including P3, expressed how experiencing data as growing on two levels could be interesting. The living organism grows, but the data files might also evolve.

"You have to take care of an evolving file in a digital space. [...] the living matter evolves, grows, and is like to parallel growing; the file and living matter. And you can go back after a while, you know, to check how it evolved." - P3. P5 reflected on how this might make it an interesting artifact over time "I mean, like physical photos get more yellow.. [...] So maybe this is an interesting artifact over time."

Propagating

This relates to what might happen if different algae data mixes with other algae or other ecosystems. P6 discussed opportunities with this and what could happen if it could grow freely. "algae doesn't only die, it also propagates. It makes more of themselves; that's what life does. So what if you could just pour that into the ocean and then let them swim free without taking care of it, and then whenever you need to access it, you go to the sea again." Participants also discussed what happens when algae grows, and how data sets might mix and compete, and how it might create a mix of different data. P1 made a joke about this "How does the way the organism reproduces impact your data? [...] maybe you can put two files together, like your literature and your observational data, and then the organisms procreate and synthesize your result, and then you don't have to do that analysis." In other words, what happens when an Algae Cloud propagates and creates more of itself can be interesting.

Caring, noticing, adjusting, and attuning

Participants also discussed how the livingness could be beneficial in grasping its state and understanding when it might fail so that files can be saved. P9 said, "Sometimes my hard drive starts ticking and gives a warning, but it can also just fail. Whereas the algae, I'm hoping.. would give you a bit of warning as it changes colors slowly". Compared to conventional data storage methods, an Algae Cloud, being alive, can articulate its state and health. Still, participants also discussed that Algae Cloud being algae makes it more difficult to read. P5 discusses how caring for algae requires a specific approach, different from an empathetic approach "I feel like I would be taking care of this. It wouldn't benefit our relationship if I would try to take the perspective of that algae. Like.. empathy doesn't really help. Whereas, for example, a dog or something, then you can try to a certain extent to imagine yourself in their position and think about what they would need. But then, if you have this very scientific, lab-like interaction, maybe over time you can learn to take that perspective as well. But for now, it doesn't look so much like it yet." It should be noted that this might also be influenced by how the algae was presented in the video as a very sterile and lab-like interaction, which is discussed more in detail in FIXME. P4 discussed how learning to adjust to the needs of the Algae Cloud could bring new ways of relating to and living with "living data" and having to adjust practices at home to fit the needs of the Algae Cloud as well. "How would a house look like different types of bacteria, algae, and fungi that all have different functions and all need love and care? Then you also need to decide where to put your effort in which one to keep alive for which function. [...] Maybe I want to have the curtains closed one day, or should I still let the light in if that keeps my data healthy?" In summary, Algae Cloud involves living with it, and this could bring interesting opportunities.

Appendix H: final focus group

Results after first round of analysis (not clustering in relation to mutualistic care)

Growing

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Dying

The fact that Algae Cloud makes it possible for unimportant data files to die and disappear was mainly discussed as something positive, although impractical at times. P2 mentioned that it would be a good way of making sure files don’t just stay around unused. “A lot of things just linger around, and with this, if you don't take care of it anymore because you don't care about it, then it disappears.”

Algae Cloud tangibility

This quality refers to how Algae Cloud is a tangible, physical thing.

Not placeless

This theme refers to how Algae Cloud, unlike the normal “cloud,” can’t be accessed from everywhere but exists in a physical space where it can be accessed.

“for me, a big part of the cloud is also that I can not take my own computer to work because I would have a computer at work. [...] Maybe with this I would have to bring a small sample.” -P5

Physical understanding of storage size

This theme relates to how Algae Cloud takes up physical space and might therefore give people a visual idea of how many files they have.

“for me, the cloud is some ungraspable thing that I can't wrap my head around. And then if I would have cabinets or some storage room where I would keep all my containers, then yes, it would be more clear what I actually own” -P4

Labeling and sorting

Having Algae Cloud stored in physical containers might require different labeling and sorting methods than in the traditional cloud. “If your whole structure is a mess, you can just “control”-find your way through the document you need. I can imagine if it's all physical, you really have some necessary structure to get the algae you need at that moment.” -P4.

Tangible crimes

This theme relates to what hacking and crimes might look like when it is a physical thing. “I imagine this mission Impossible scenario where people try to break into this laser guided room with this one important algae in there. It's more tangible and easy to understand than thinking of encryption in the cloud. I don't know how it works, but it's massive.” -P2

2. Ideas for opportunities

These are some interaction opportunities that Algae Cloud could bring, as discussed by the participants. A lot of the opportunities are related to the previously identified themes.

conscious data storage practices

Participants discussed how having to care for Algae Cloud would make them think twice about what data to keep and what to throw away.

“if you wanted to store it [data] on the algae culture itself to keep alive, you might be a bit more critical of what you are saving and what do you throw away.. all those thousands of pictures on my iPhone that I’m never gonna look at again. I would go ahead and delete those if I had to take care of my data.” - P6

Appendix H: final focus group

Results after first round of analysis (not clustering in relation to mutualistic care)

Deeper non-human bonds

This theme reflects how Algae Clouds might be something that people form deep bonds with. "There's a certain caretaking aspect of it as well, which I think can kind of create more of a connection also." -P2

Feeling of ownership and responsibility

Participants discussed how caring for Algae Cloud might increase a feeling of ownership towards their files. P1 discussed this as bringing more responsibility to people, but also that it feels more fragile.

"Here it's all on me, which maybe makes it more fragile because I might be clueless and not know what to do, but it does put the responsibility completely in my hands, as opposed to the kind of distributed things that we have now." - P1

Mysterious and dreamy interactions

The ambiguity of what Algae Cloud is and the care practices that are involved can make interacting with it an interesting and "romantic" experience. "I might be able to hold by memories from 2010, etc.. This kind of collection can be a lot more romantic [...] it's like a message in a bottle." This theme reflects how ambiguity could also bring opportunities for rituals and ceremonies. "Maybe it performs an important part of a ritual in some way. [...] I send them a bottle, and they do a thing; maybe they'll see it together. This could be collaborated on to become part of a ritual of sharing memories." - P1

Different care and meaning to different species

Participants discussed how storing data in different types of organisms can impact care qualities and relations to it. P7 discussed how the tools themselves impact the perception of care; "if it is something more emotional or ornamental... you know, using tools that are associated with plants or gardening.. it would be an even stronger motivation for me to take care of a file or a cloud." P6 also discussed that he would like to keep his precious data in a tree; "When we're thinking in analogies, I would like my important data to be in oak. I would plant it somewhere, and then when it gets big enough, I will have new seeds which I can plant something else. So a little bit more robust organism than the algae"

3. Implications

Who should care?

Participants discussed that they would gladly give the responsibility to care to someone else, even if that means giving up on some privacy. They also discussed that there is some data that is important but that they wouldn't want to care for. For example, work files. The second group had a discussion about who should feel obliged to care about algae data. P8 and P9 discussed this.

"As I do now with my cloud, I would also like to set boundaries of when I access which information and, under which conditions, in what context. So caring is also very contextual." -P8

"Yeah, I would say it's TU Delfts' responsibility to care for my work algae. I'll care for my photo algae." - P9

In other words, caring for data also brings wider implications of who should care and in what context.

A new kind of Black box?

P1 discussed how Algae Cloud is still a black box in the sense that even though it is living and physical, it's not straightforward how the data is stored and how it works. "I felt like there's quite a lot of black boxing. [...] And I think most things, even if you really try and break them down, there's something invisible happening." There were also some questions from participants on details of how the data storage would actually work. For example, if it would impact the growth of the organism, how much memory storage space there was, and if the files would actually change or not.

Not inherently good or bad

This theme refers to how having data storage that needs care and generates oxygen wasn't seen as inherently good or bad by participants, but it matters how the technology is developed. Participants discussed this and how the technology could still be commercialized, and care would be outsourced. P4 mentioned, "If this will continue, it will be optimized the highest amount of data storage with the least amount of care."

Is it right to mess with DNA?

This theme relates to the ethical implications of messing with the DNA of living organisms and possible dangerous scenarios. P1 discussed what rights the living organisms have; "I just immediately thought like that slippery slope.. where the boundaries? what are the rights of these living entities?" The participants also discussed possible harmful side effects of giving everyone the opportunity to alter the DNA of living organisms. P4 discussed this "Not everyone is as experienced... Maybe you accidentally create something that will be damaging."

1. Reflections on current practices

This section presents reflections on current practices related to data storage and mutualistic care for living organisms. It should be noted that many of the qualities and ideas indirectly address these reflections by imagining new opportunities different from what people are currently used to now.

Data Ownership, immortality, clutter, and neglect

This category is not discussed in detail here, since the themes were identified in the previous focus group discussed on page FIXME. The themes were also present in this study. Data ownership refers to data storage not feeling like it belongs to people using it. Data immortality refers to data feeling like it will never die but can still suddenly disappear. Data clutter and neglect refer to data storage feeling cluttered and a kind of guilt that it should be cleaned up someday. These themes were also apparent in these focus groups, for example, expressed by P5 "My attitude towards the cloud, actually, is that I think it's quite careless. [...] I'm thinking with this kind of replica of files in a physical way, it makes me think that I could take care of the cloud in a different way."

Hidden non-human entanglements

This theme refers to discussions participants had about how humans are already dependent and entangled with non-humans like algae and data storage. P8 reflected on how there is already a lot of care happening to maintain the current data storage infrastructure. "There are some similarities in the sense that "the cloud" also grows and has people taking care of it. Just in a different magnitude." There was also a discussion around data storage already being entangled with humans and non-humans and how the prototype could highlight that. "what this could do is to bring more visibility to these things that maybe in a data center context are a bit obscure, like the human and non-human bodies that are part of us storing our data in a cloud versus here at least we are a bit more aware of these things, at least we see it." -P8. P1 also discussed how the prototype made relationships between humans and living organisms explicit "I suppose it makes it kind of makes explicit the interdependence that we have with living organisms like plants. You know, I keep it in my home because it looks nice. It supports putting oxygen into my house. But the plant also benefits from being in my house because it gets to exist."