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Entanglements of responsibility

On designing citizen science communication

PhD Thesis

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Entanglements of responsibility

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Colophon

Entanglements of responsibility:
On designing citizen science communication
Ph.D. Thesis, July 2022

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This dissertation is a result of the PhD Project Entanglements of responsibility: On designing citizen science communication –
in collaboration with Our Museum.

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Contents

Summary of the PhD Thesis

Resumé af ph.d.-afhandlingen

I afhandlingen “Entanglements of responsibility: on designing citizen science communication” undersøger jeg kommunikationens betydning for citizen science/ borgervidenskab. Nylige undersøgelser inden for borgervidenskab (citizen science) viser, at offentlig deltagelse i videnskabskommunikation kan øge borgernes demokratiske handlekraft. De peger på væsentlige forandringer af forholdet mellem forskere og borgere og stiller spørgsmålstegn ved hvem der kan skabe videnskabelig viden, og hvilke dele af verden der bør være genstand for videnskabelig undersøgelse. Eksisterende forskning fremhæver direkte kommunikation med og tilbagemeldinger til deltagerne som værende afgørende for succesfuld borgervidenskab der styrker deltagernes motivation, forståelse af og engagement i borgervidenskab. På trods af disse resultaterne mangler vi fortsat viden om hvad disse kommunikationsformater omfatter og hvordan man kan designe mere ansvarlige former for dialogisk engagement der fremmer borgernes demokratiske handlekraft. I ph.d.-projektet undersøger jeg denne problemstilling med afsæt i følgende forskningsspørgsmål: *Hvordan designes citizen science-kommunikation i projektet Lyden af Danmark med henblik på at styrke medborgerskab?*

I ph.d.-projektet undersøger jeg hvordan en participatorisk designtilgang og co-design aktiviteter kan anvendes til at skabe ny viden om, hvordan man designer citizen science-kommunikation der styrker borgernes demokratiske handlekraft. Ph.d.-projektet der er en del af forsknings- og udviklingsprogrammet Vores Museum, tager empirisk afsæt i citizen science projektet, Lyden af Danmark (LAD), som udvikles i samarbejde med Center for Makroøkologi, Evolution of Klima (CMEC). Lyden af Danmark er et citizen science projekt der gør det muligt for borgere at deltage i kortlægningen af det danske lydlandskab og derved bidrage til den naturvidenskabelige forskning på CMEC. Som en del af projektteamet bag LAD, hvor jeg medvirker som etnografisk designforsker, er formålet med ph.d.-projektet at bidrage til at styrke medborgerskab gennem participatoriske design workshops og lydkortlægninger der gør det muligt for deltagerne at få indflydelse på det endelige design. Formålet opnås ved at undersøge hvordan citizen science kommunikation designes, implementeres og evalueres ved at inddrage potentielle deltagere som meddesignere af citizen science projektet, med henblik på at styrke deltagernes demokratiske handlekraft.

Forskningsspørgsmålet er stillet og undersøgt i en kontekst der forener teoretiske og praktiske dimensioner som participatorisk design, citizen science, og videnskabeligt medborgerskab. Disse dimensioner redegør jeg for i kapitel 3. Herudover, præsentere projektet en analytisk dimension og teoretisk ramme der er baseret på Kare Barad's agential realisme. Mit argument i det der kommer, er at hendes koncepter og relationelle ontologi åbner op for nye forståelser af materialitet og non-human agens og hvordan materialitet i en citizen science kontekst har betydning, hvilken materialisering der finder sted, og hvilke analytiske konsekvenser denne tænkning har for videns produktion. Med andre ord åbner agential realisme og dens begreber op for en situeret forskningstilgang der beskæftiger sig med videns praksissers reale effekter, og som arbejder med viden som noget processuelt og skabende altid i tilblivelse. I denne tilblivelses proces er min egen forskning en del af tilblivelsesprocessen.

I kapitel 4 udfolder jeg ph.d.-projektets forskningsdesign herunder metoder, empiriske materialer, participatoriske designproces samt min rolle som etnografisk design researcher i projektteamet i Lyden af Danmark.

I kapitel 5 og 6 udfolder jeg mine analyser og diskussioner samt bidrag i tre retninger med henblik på: 1) at skabe ny viden om participatorisk design i en citizen science kontekst i samskabelse med potentielle deltagere, og videre hvordan danne proces kan bidrage til og styrke det overordnede design af LAD. Ved at forene en participatorisk designtilgang der inddrager potentielle deltagere i udviklingen af citizen

science-kommunikation i LAD, med citizen science-kommunikation og videnskabeligt medborgerskab, bidrager ph.d.-projektet til en bedre forståelse af hvordan man designer og implementerer ansvarlig citizen science kommunikation I projektet Lyden af Danmark.

2) I min analyse af Machinic agencies and technoscientific apparatuses undersøger jeg de teknologiske forviklinger af citizen science projektet (det implementerede design) som et videnskabeligt apparat for at skabe ny viden om hvordan mennesker og det non-humane aktivt rekonfigurere bestemte videns praksisser og agenturer gennem deres forviklinger. Jeg påviser at dette har åbenlyse konsekvenser for os som forskere og udviklere, fordi vi er en del af disse forviklinger, der bliver ved med at designe og producere usunde og uretfærdige udelukkelser, begrænsninger, og magtstrukturer. På det grundlag er vi nødt til at genoverveje og forstå konsekvenserne af vores designs, og hvordan de bliver ved med at designe agenturer og ekskluderinger, med henblik på at design mere ansvarlige former for borgervidenskabelig kommunikation. På det grundlag bidrager min brug af Barads agential realisme og dets begreber til ny viden om participatorisk design og hvordan man designer mere ansvarlige former for borgerkommunikation.

3) I den tredje del af analysen ”Enacting scientific citizenship: entangled responsibility and enactments of concern”, demonstrere jeg hvordan videnskabeligt medborgerskab udmøntes på forskellige tidspunkter gennem borgernes intra-aktive engagement med SOD. Jeg viser hvordan borgerne ikke blot bidrager til videnskabelig forskning, men snarere enakter medborgerskab gennem deres materielle engagementer som en integreret del af projektet i dets løbende udvikling. Jeg viser desuden at videnskabeligt medborgerskab i SOD bliver udformet gennem både menneskers og ikke-menneskers materielt-diskursive praksisser hvorfor videnskabeligt medborgerskab bedre kan forstås som både menneskelige og ikke-menneskelige intra-aktioner.

Endelig argumenterer jeg at for at designe mere ansvarlige former for borgerinddragelse vil det kræve en redegørelse for de forviklinger som vi er en del af medhenblik på at synliggøre de begrænsninger og udelukkelser som både projekt team, forskere og borgere har en rolle i at formgive. Jeg foreslår, at fremtidig forskning i krydsfeltet mellem citizen science, design og videnskabeligt medborgerskab

genovervejer de materielle-diskursive forviklinger som vi alle er en del af, medhenblik på at stille nye spørgsmål og undersøge vores relationelle ansvar i en mere end menneskelig verden der adresserer både de ”agential cuts” vi alle er den del af samt mere affirmative fremtider. Citizen science er et frugtbart rum for sådanne eksperimenter fordi det rummer en sammenfiltret mangfoldighed a lægmandsviden og ekspertviden der potentielt kan danne grundlag for udvikling af mere ansvarlige fremtider og samarbejdsformer.

Summary of the PhD dissertation

In the dissertation "Entanglements of responsibility: on designing citizen science communication", I investigate the importance of communication in citizen science. Recent studies in citizen science show that public participation in science communication can increase citizens' democratic ability to act. They point to significant changes in the relationship between researchers and citizens and question who can create scientific knowledge and which parts of the world should be the subject of scientific study. Existing research highlights direct communication with and feedback to participants as being crucial to successful citizen science that strengthens participants' motivation, understanding of, and engagement in citizen science. Despite these results, we still lack knowledge about these communication formats and how to design more responsible forms of dialogical engagement that promote citizens' democratic action. In the PhD project, I investigate this issue based on the following research questions: How can we design new forms of citizen science communication in The Sound of Denmark to strengthen citizens' democratic actions?

In the PhD project, I investigate how a participatory design approach and co-design activities can be used to create new knowledge about designing citizen science communication that strengthens citizens' democratic capacities. The PhD project, which is part of the research and development program Our Museum, is empirically situated in the citizen science project, The Sound of Denmark (SOD). The citizen science project is developed in collaboration with the Center for Macroecology, Evolution of Climate (CMEC). The Sound of Denmark is a citizen science project that makes it possible for citizens to participate in the mapping of the Danish soundscape and thereby contribute to the scientific research at CMEC. As a member of the SOD project/ developer team, I partake as an ethnographic design researcher. Within this context, the PhD project aims to strengthen citizenship through participatory design workshops that enable

participants to influence the final design. The purpose is achieved by examining how citizen science communication is designed, implemented and evaluated by involving potential participants as co-designers of the citizen science project to strengthen the participants' democratic actions.

The research question is asked and investigated in a context that combines theoretical and practical dimensions such as participatory design, citizen science, and scientific citizenship. These dimensions are outlined in Chapter 3. In addition, the PhD project presents an analytical dimension and theoretical framework based on Kare Barad's agential realism. What follows is my argument that her concepts and relational ontology can help us better understand materiality and non-human agencies in a citizen science context. Moreover, her concepts can create new knowledge on how materiality in a citizen science context matters, which materializations take place, and what analytical consequences agential realist thinking has for the production of knowledge. In other words, agential realism and its concepts open up a situated research approach that deals with the real effects of knowledge practices to work with knowledge as something processual and creative, always in becoming. My research is situated in this process of becoming.

In Chapter 4, I unfold the PhD project's research design, including methods, empirical materials, participatory design process and my role as an ethnographic design researcher in the project team in The Sound of Denmark.

In chapters 5 and 6, I unfold my analyses, discussions and contributions in three directions with a view to 1) creating new knowledge about participatory design in a citizen science context in collaboration with potential participants and further how forming process can contribute to and strengthen the overall design of SOD. By combining a participatory design approach that involves potential participants in the development of citizen science communication in SOD with citizen science communication and scientific citizenship, the PhD project contributes to a better understanding of how to design and implement responsible citizen science communication in the project, The Sound of Denmark.

2) In my analysis of "Machinic agencies and technoscientific apparatuses", I examine the technological entanglements of the citizen science project (the implemented design) as a scientific apparatus to

create new knowledge about how humans and non-humans actively reconfigure certain knowledge practices and agencies through their entanglements. I demonstrate that this has obvious consequences for us as researchers and developers because we are part of these intricacies that continue to design and produce unhealthy and unfair exclusions, constraints, and power structures. On that basis, we need to reconsider and understand the implications of our designs and how they continue to design agencies and exclusions to design more responsible forms of citizen science communication. From this perspective, my use of Barad's agential realism and its concepts contribute to new knowledge about participatory design and how to design more responsible forms of citizen engagement.

3) In the third part of the analysis, "Enacting scientific citizenship: entangled responsibility and enactments of concern", I demonstrate how scientific citizenship is implemented at different times through the citizens' intra-active engagement with SOD. I show how citizens not only contribute to scientific research but rather monopolize citizenship through their material commitments as an integral part of the project in its continuous development. I also show that scientific citizenship in SOD is shaped through the material-discursive practices of both humans and non-humans, which is why scientific citizenship is better understood as both human and non-human intra-actions.

Finally, I argue that designing more responsible forms of citizen involvement will require an account of the entanglements to highlight the limitations and exclusions that both project teams, researchers and citizens have a role in shaping. I suggest that future research at the intersections of citizen science, design, and scientific citizenship should reconsider the material-discursive entanglements of which we are all a part to engage in new questions and examine our relational responsibilities in a more-than-human world that addresses both the "agential cuts" we are affected by and more affirmative possibilities. Citizen science is a fertile space for such experiments because it contains an intertwined diversity of lay knowledge and expert knowledge that can potentially form the basis for developing more responsible futures and forms of collaboration.

01 Introduction

The notion of citizen science is often referred to as an approach to democratising science and supporting scientific citizenship through collaboration with the public. Despite this, few studies have addressed how this aim is realised and how citizens' democratic actions are considered and strengthened in a citizen science (CS) context. In order to address this gap, the PhD project pursued the following main research question: *How can we design new forms of citizen science communication in The Sound of Denmark to strengthen citizens' democratic actions?*

As an ethnographic researcher situated in the co-development process of the citizen science project The Sound of Denmark (SOD), I addressed this question through a participatory design research process, which unfolded in close collaboration with members of society, the Sound of Denmark project/research team at the Center for Macroecology, Evolution and Climate, and the research and development program Our Museum. As a member of the SOD project team, I worked on the digital development of the CS project and collaborated with members of society. Through my entanglements with the project, I aimed to make visible the complex practices, doings, and knowledges that constitute the ongoing reconfigurations of the science-citizen relationships to create new knowledge on how to design citizen science engagement that strengthens citizens' democratic and epistemic agencies.

In recent years there has been an increased focus on designing citizen science that leverage the potential of artificial intelligence in citizen science (Ponti and Seredko 2022) to strengthen the position of technoscientific research. Despite this, few studies have addressed how such a process can inform the development of new citizen science communication formats that strengthen citizens' democratic actions to reconfigure new understandings of the science-citizens relationships (Irwin 1995). Hence, research that questions the existence of so-called citizen science (Strasser et al. 2019) and how the scientific citizen is reconfigured (Dickel 2020) is necessary. In addition, there is little work done (Enric Senabre, Nuria Ferran-Ferrer, and Josep Perelló 2018), on how a participatory design approach can inform and advance new responsible forms of citizen science engagement.

Whereas previous studies of digital citizen science development focus merely on the role and engagement of human agencies, this study positions itself in a transdisciplinary context that draws together diverse fields such as participatory design research, citizen science, and scientific citizenship. Moreover, the PhD project acknowledges the importance of considering nonhuman agencies in scientific research by building on Karen Barad's agential realist ontology and concepts. From this theoretical position, it becomes possible to understand how nonhuman entities partake in the ongoing reconfigurations of scientific knowledge production, the formation of the scientific citizen (Alan 2001; Irwin and Michael 2003), as well as how these entities enact the CS project's boundaries, exclusions and constraints on citizens' agencies.

This project's contributions involve four articles I will draw from throughout the project's different chapters. The following section outlines a road map for the reader.

Road map

Chapter 2: Outlines the empirical context of the PhD project and my role as a design researcher within the technoscientific structures of the citizen science project and The Sound of Denmark project team, including my involvement and collaboration with the Center for Macro Ecology, Evolution and Climate (CMEC) at the University of Copenhagen research, and development program Our Museum, which has shaped both the empirical and theoretical focus of this project.

Chapter 3: Unfold the theoretical dimensions and framework of the project; these concepts and theories establish a foundation for understanding how we can design more responsible forms of citizen science that strengthen civic capacities by adopting a participatory design framework. Furthermore, it contributes to creating new knowledge about the enactments of scientific citizenship and the formation of epistemic subjects by recognising that nonhuman agencies take part in reconfigurations of the entire techno-scientific apparatus of which the analyst of this project is a part.

Chapter 4: Describes the research design of the PhD project, its ethnographic approaches, and methodological reflections, including its empirical materials, and citizen recruitment process. Moreover, it outlines the material practices and processes of my co-design workshops with prospective citizen scientists, including an overview on how the design experiments of the PhD project is interwoven in the development process of the citizen science project.

Chapter 5: Outlines the analysis and discussion of the PhD Thesis.

Chapter 6: Discusses key findings from my analysis. In addition I provide my critical reflections on my research in regard to my role as ethnographic researcher in the SOD project team.

Chapter 7: Concludes and summarises the PhD project's key findings and provides suggestions for future research.

Chapter 8: Provides a listed overview of the PhD project’s publications.

02 The citizen science project: The Sound of Denmark

02.01 Introduction

In this chapter, I describe the empirical case and context of the Ph.D.-project that unfold in collaboration with Our Museum (OM) and through the co-development of the citizen science project the Sound of Denmark (SOD) with me in the role as design researcher and ethnographer in the project team. By making visible the complex entanglements, doings and actions of the project/research team, external developers and members of society, my aim is to address these science-citizens relationships in later chapters, to create new knowledge on how to design citizen science engagement that strengthen citizens' democratic agencies. In the next I briefly describe the digital citizen science project that I was part of as co-developer from March 2018 until June 2020, and after that engaged with as participant and ethnographic researcher until its end in (2021).

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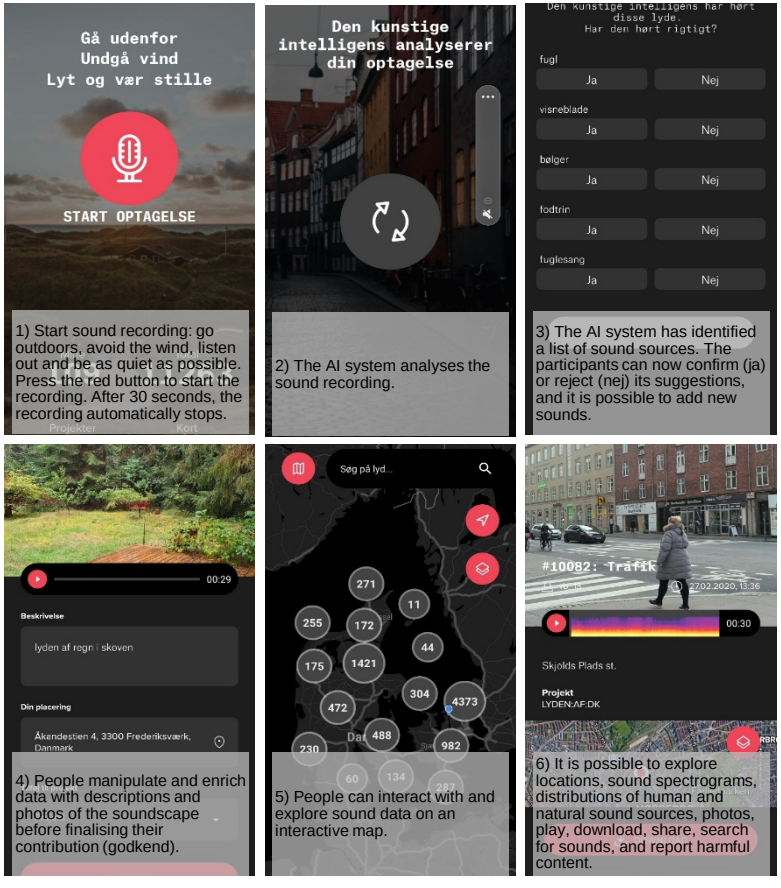

Figure 1. The Sound of Denmark mobile interface

02.02 The digital citizen science project: The Sound of Denmark

The empirical focus of the Ph.D.-project involves the co-development of the citizen science project the Sound of Denmark (SOD), through which I was a part of the project/development team in the period March 2018 until June 2020, and functioned as a researcher with a focus on how to design citizen science communication (engagement) that strengthens civic capacities, and codeveloper with the project team with a focus on codesigning and studying members of society and prospective participants in the SOD.

The Sound of Denmark was a digital citizen science project developed at the Center for Macroecology, Evolution and Climate (CMEC) at the University of Copenhagen. The project launched April 24 2019 in Dyrehaven with broad media attention and participation from the Crown-Princess Mary after one year of development. The CS project focused on researching the Danish soundscape by identifying sound sources, noise levels, and the distribution of natural and anthropogenic sounds based on large scale data collections enacted primarily by members of society (I will refer to them as citizens, volunteer contributors, citizen scientists or citizen listeners). The CS project invited citizens to help CMEC scientists map the Danish soundscape and contribute with sound data by recording, geolocating, processing, describing and classifying sounds by using their smart phones and the project's mobile application (see fig. 1). The SOD app was initially developed as a web application, however in later iterations of the project it developed into a native mobile app, in attempt to solve technical issues with inadequate GPS locations and problems with sound recording and sound upload in areas with none or unstable Wi-Fi connections.

The sound data produced by the volunteer contributors are enriched with descriptions of observations of the landscape, photos, tags and GPS locations before it is uploaded to the project. The sound data produced by the SOD community, is not only used for later sound data analysis by the CMEC scientists but is also used to train a machine-learning programme (AI system) that identifies sound objects/sources after 30 seconds of sound recording and provides feedback on the recognised sound sources in the recordings. The participants can suggest new sounds to the AI system and enrich the data set before they finalised their contribution to the project. In terms of participating in the CS project new participants decides

whether they want to create a profile and get full access to the community forum or if they prefer to contribute with sound data anonymously. Moreover, the project's communication channels involved a Facebook group, a community forum in the SOD app, and communication via mail. As a part of the communication plan and a focus in the project team to strengthen citizens engagement in the project, a team of communication officers were prepared to help the volunteer contributors with questions, reports on technical issues and other problems of concern. In addition, that Facebook group was also used to send out news and information about new campaigns that had a specific focus on sound collection, e.g. the Sound of Danish coasts and school competitions around the CS project.

In later chapters I will demonstrate, how citizens through their active engagement and contribution to the scientific research of the project, takes active part in shaping and reconfiguring the project's data collection and hence production of scientific knowledge, but also how they take part in shaping and reconfiguring the epistemic tool for data collection through their contribution to the training of the AI-system. At the same time, I will argue that people are themselves reconfigured and sometimes also excluded by the protocols and technological boundaries of the project. From this perspective, the CS project, the community members, project team, external developers, and AI system constitute an entangled techno-scientific apparatus that gives shape to epistemic practices and agencies iteratively. As I will argue in my theoretical framework and in my analysis of the research and development project, the researcher does not stand outside of this process but is deeply entangled in this process and shaped through his involvement in the project, its boundaries, and power structures. In my case I was entangled with the project both as an ethnographic researcher, citizen listener, and as codeveloper in the project. while at the same time he is also giving shape to the project and the possibilities for agency that emerge from it.

02.03 My role as researcher in The Sound of Denmark

As a design researcher I was involved in the co-development of the citizen science project and a member of the project team that shaped the initial design decisions of the project. Central actors in the project team includes scientists from The Danish technical University (DTU), who focused on the development of the AI system, micro ecologists and communication officers and PIs from CMEC who focused on project development and sound soundscapes, and from Our Museum me as Ph.D.-student in media science, and

ethnographic researcher. My focus as a member of the project team was to explore how we can design citizen science communication that strengthen citizens democratic capacities to engage with and influence the production and negotiation of knowledge in citizen science; these investigations unfolded from the concrete involvement of citizens through participatory design workshops. With a focus on people's needs, interests and desires for participation, we collectively explored through sound mappings and sonic engagements how people imagined themselves to participate in and engage with SOD. The outcomes of theses workshops included diverse forms of knowledges with different citizen groups, and include concepts, scenarios, sound maps, ideas, practices, sound recordings, observations and discussions and potential campaigns to be integrated in the SOD platform.

Through my ongoing involvement/entanglement in the project team, the knowledge from the workshops was discussed and shared with the project team and establish a focus on the importance of designing for citizen science communication and possibilities to engage with different aspect of the scientific research process to provide citizens a voice in the digital artefacts that they will later use and be influenced by. The outcomes of the workshops not only informed democratic/ethical practices for listening and participating in SOD, but also inspired/influenced my own experiments such as developing wireframes and interactive prototypes that take into account citizen voices and interests and makes it possible to participate in multiple ways and aspects of the CS project, across the digital platform e.g. by exploring and engaging with data on an interactive map, and communicating and engaging with scientists and other participants in the project's discussion forum. The knowledge from these experiments and investigation were shared within the developer team and directly with the external developers and worked as the means for pointing out the importance of strengthening citizens possibilities for engaging with the project and including their perspective and needs in the project.

To make ideas, knowledge, concepts and my research comprehensible for other members of the project team, my key findings - pointing out the importance of developing communication formats that strengthens citizens epistemic agencies and engagement with the project - unfolded through reports,

requirement specifications, and were often translated into practical wireframes and interactive prototypes, which was useful in my ongoing communication with and feedback to external developers.

Through these design practices I experienced how complexities from many diverse fields came together, transformed and influenced one another to produce knowledge that again took new forms through a process of negotiation and contestation, and under the influence of power and exclusion within the project team. The digital development process involved many different exchanges and creation of boundaries between different actors but central in this was the exchanges of knowledge between the project team and the external developers. Through this collaboration I learned that many different and diverse forms of knowledges, values, powers and practices are already taking part in shaping the digital citizen science project and its future productions of scientific knowledge before it even started.I also learned about the boundaries and exclusions that I as a member of the project team participate in enacting. This tells me that we need to be more critical about our own knowledge practices (Seaver 2019), and about the boundaries we participate in enacting and designing.

Within the project team central design decisions were discussed and negotiated collectively about such matters as defining the steps for the data collection process, the interface design, how to communicate and provide feedback to the volunteers, what information that is needed to incentivise people to participate in the project, development of news feeds and information about campaigns for the participants, advice to make quality recordings, protocols for participation in the project, feedback from the AI system, visualisation of data within the app, and ongoing tests and user experience reports between the project and the external developers.

During the lifetime of the CS project, the SOD project team collaborated with different developer teams, including several other collaborators around school and library programs, Danish Radio, influencers, media strategists, including the Danish Agency for Higher Education and Science. Exchanges with these different actors also played a part in the becoming of the CS project, not only through workshops and meetings with the different collaborators but also because they actively promoted and communicated the CS project to the public. In later chapters, this is important to have in mind when I begin to analyse the CS project as a technical apparatus of bodily production (Barad 2007) where many different human and nonhuman actors are involved.

02.04 Conclusion

In summary of this chapter, I have described the context of the empirical study of this Ph.D.-project and my role as researcher and member of the project team in the Sound of Denmark and the project teams collaborations with external developers, and collaboration with the research and development program Our Museum. I have argued that my role as codeveloper and researcher within the project team is crucial for understand the web of human and nonhuman relations through which the researchers has been actively involved in co-creative relations with the project team, prospective participants, researchers, communication officers, external developers, and public institutions. And how this process has affected and informed my own research practices, but also how I have influenced the production of knowledge through my engagement in the project team, and my collaborations with different members from society. In the next chapter I will continue with an outline of the theoretical framework and the concepts that is intertwined in the Ph.D.-project and my situated research practices.

03 Theoretical framework

03.01 Introduction

The following chapter outlines the Ph.D.-project's theoretical framework that involves three dimensions: citizen science communication, participatory design, and scientific citizenship. These three dimensions are situated in an agential realist framework (see fig.2). To capture the citizen scientists' entangled material and discursive practices and engagement in the citizen science project The Sound of Denmark, I work analytically with Karen Barad's (2007) agential realist theory. I start with a brief introduction of citizen science and citizen science communication, whereafter I move further to participatory design, and scientific citizenship, and finally I introduce my agential realist framework for analysing the citizen science project as a technoscientific apparatus.

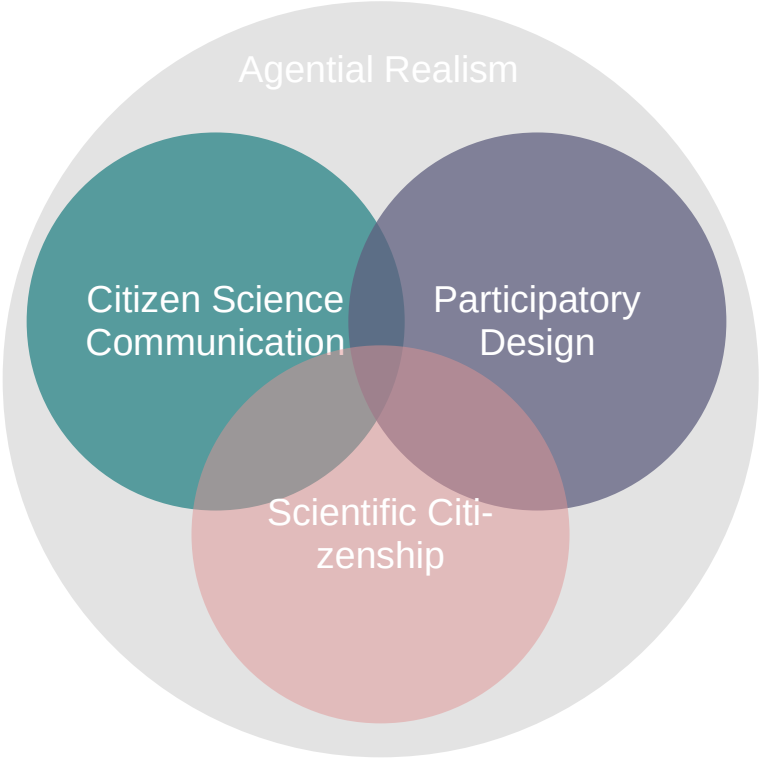

Figure 2. The dissertation's theoretical dimensions situated in an agential realist framework.

03.02 Towards a definition of citizen science communication

The notion of citizen science is often referred to as the active involvement of members of society in scientific research, and a practice through which scientists and citizens collaborate around the production of scientific knowledge for science and society (Skarlatidou and Haklay 2021). Together with other definitions such as the public participation in scientific research (Bonney et al. 2009; Shirk et al. 2012), civic science (Schmandt 1998), and community science (Wilderman et al. 2007; Wilderman, Barron, and Imgrund 2004) it broadly involves the scientific work undertaken by members of society in collaboration with a scientific community. The European Citizen Science Association (ECSA) has characterised ten key principles that underlies good practices in citizen science (Robinson et al. 2018). Some of these principles suggest that citizen science projects active involve citizens in scientific activities that generate knowledge and understanding and may involve that people participate as either contributors or collaborators. They state that both scientists and citizens can benefit from their engagement and that people may be involved in decision making processes concerning the use of data or societal outcomes. Citizen science according to these principles are considered a research approach, however it differs from other scientific approaches because it creates possibilities for "greater public engagement and democratisation of science" (Robinson et al. 2018, 29). Moreover, data and epistemic resources in a citizen science context are made available for public use and results are published in open-access format. Following from these principles the citizen scientist is clearly playing a contributory role in scientific research, however the model also suggests possibilities for democratising science.

In his recognized and often cited Citizen Science – a study of People, expertise and sustainable development, Alan Irwin (1995), proposes a citizen science that creates a meeting point between scientists and citizens, that brings diverse knowledge forms together, and involves the public in dialogue and decision-making. He states that:

> ‘Citizen Science’ evokes a science which assists the needs and concerns of citizens […]. At the same time, ‘Citizen Science’ implies a form of science developed and enacted by citizens themselves (Irwin 1995, xi).

Based on this definition the citizens’ need, and concern become central aspects of citizen science, at the same time participation in citizen science involves enactments of scientific citizenship where citizens follow their own agendas and experiments (see chapter 5). Citizen science can therefore be understood as an approach to democratise science and enact scientific citizenship. Wiggins and Crowston (2011) suggest that citizen science is a form of collaboration between citizens and scientific communities that addresses real-world problems (2011, 1). In my later analysis I challenge theses perspectives by demonstrating that human agencies are not the only active agencies that constitute the science-citizen relationships and the boundaries of the CS project. In a recent article by Shirk and Bonney (Jennifer and Bonney 2020) they propose the following definition of citizen science:

> Citizen science, in all of its diverse forms, is a means of public engagement in scientific work that can expand the scope, reach, and impact of research. Citizen science can provide opportunities to collect data at scales otherwise not feasible for professional scientists alone and can engage members of the public in compiling and using issue-relevant evidence to effect change. Taken together, these opportunities have the potential to bring new power to addressing major challenges in conservation and natural resource management, particularly those that require attention to both social and scientific aspects of a problem (Jennifer and Bonney 2020, 14).

Hence from this understanding we see that citizen science can include both contributory and democratic forms of public engagement (Hetland 2020), but also that civic engagement holds potential to enhance the

impact of scientific research. These examples suggest that definitions matter, and that definitions also matter for how we develop citizen science projects, and how we 'look at' the volunteer contributors in a project. Eitzel (et al., 2017) points out that "terminology can have a profound effect on participants and has the power to include or exclude" (2017, 16). They hold that unintentionally use of the term in ways that privileges the CS project over the volunteer contributors can affect the participants' engagement in the project and how knowledge is produced (Eitzel et al. 2017, 16).

Based on these initial definitions of citizen science we see that several studies associate citizen science with a movement that hold potentials to democratise science by bringing the public and science closer together, by facilitating active dialogue and involving citizens in the decision-making process (Irwin 1995, 33). In all this, citizens are not merely contributing to scientific research but through their active engagement with a CS project members of society can affect all facets of a project. In a later chapter I will demonstrate how citizens are themselves affected by the structures and boundaries of the CS project. The citizen scientist contributing to data collection, identification, and analysis of different species of fungi by using a digital citizen science project's image recognition system (AI system), are not only influencing the quality of their findings, but are also reconfiguring the training of the AI system. Through their communication with fellow citizen scientists and with the project/research team about their findings, it becomes possible for them to engage in and influence the scientific and technical dialogue, raise their matters of concern, and share their experiences as a part of the project's science communication.

The boundary between scientists and citizens, between scientific knowledge and lay-knowledge, and what is considered science communication is becoming increasingly blurred (Hecker et al. 2018, 448) as citizens become part of the larger technoscientific apparatus. Science communication cannot be reduced to the transfer of scientific knowledge between the 'knowing' scientists to members of society who 'must be educated', rather it is an integral part of society that changes areas such as welfare, democracy and culture (Horst & Davies 2016, 2). Hence, science communication is important for democracy and for making informed decisions as a citizen in modern society. Hence, citizens should know about scientific knowledge production and about its wider consequences for society and ecological matters.

Hecker et al. (2018) argues that communication and interaction in CS are key for the advancement of collaborative processes between scientists and the volunteer contributors, but also that these processes are "inseparable" from the scientific process (Hecker and Taddicken 2022, 2). Communication is critical to

motivating the community of volunteers in CS and goes beyond one-way dissemination of information (Hecker et al. 2018, 448). Hecker argues that there is a lack of communication between the scientific community and the general public (2018, 446) and suggest that new forms of interactions that challenge the scientist's perspective and create new learning opportunities requires new forms of multiway science communication (Hecker et al. 2018, 447). Citizen science communication, she holds should include issues of democracy, empowerment, and community identity (2018, 448). Therefore, science communication holds potentials for transforming scientific discourse and societal issues and debates (Bucchi 2008).

According to Horst's and Davies's (2016) the notion of science communication is better understood as a cultural phenomenon that is intertwined in culture, identity formation and citizenship, which makes it possible to understanding science communication as an integral part of people's lives (2016, 10) and more than the transfer of knowledge. Horst and Davies (2016) suggest that science communication holds potentials for enhancing science-citizen relations and for enhancing citizenship:

> Science communication offers many ways of establishing relationships between citizens and science that can form the basis of such inclusion and political involvement. We believe it offers opportunities to develop practices of citizenship that are active as well as passive, critical as well as appreciative, and outward looking as well as focused on personal experience (2016, 194).

Horst and Davies's (2016) notion of science communication in relation to Hecker and Taddicken's framework for citizen science communication (2022) is interesting because together they open up for new knowledge about the transformative relations between science, citizens, society and enactments of scientific citizenship. Hence, by understanding science communication as distributed through-out society, it becomes possible to analyse instances of citizenship and how it is enacted and reconfigured in a citizen science context. It also opens up for new perspectives regarding how bodily production of scientific

knowledge and technoscientific takes place and sees knowledge production as situated and entangled and related to the circumstances which it is a part of. Moreover, Horst and Davies (2016) argue that science communication: “should aim to empower citizens. It can and should equip them to perform citizenship” (2016, 207). Which raises the question: how does involvement in citizen science communication in The Sound of Denmark enhance or exclude particular civic capacities? And how can their engagement inform new forms of responsible innovation in a citizen science context? As Horst and Davies argue citizens should not only be capable of engaging with science but also to influence technoscientific development (2016, 207).

In all this, we see that science communication is deeply intertwined in people's everyday lives, which opens new forms of active engagement and reconfigurations between scientists and citizens that affects both technoscientific knowledge production and the lives of the citizens. Hence from this perspective, I also identify other forms of responsibilities, for instance, the necessity of designing responsible forms of citizen engagement that strengthen and enhance scientific citizenship. Later in this chapter, I will demonstrate that responsibility entails ongoing responsiveness to the relations of which we are a part (Barad 2007), and therefore also accountability for the exclusions and constraints we participate in enacting. In the next, I will elaborate on the notion of scientific citizenship, which we have seen is closely tied to citizens' capacities to engage in scientific research.

03.03 Scientific citizenship

In the preceding section I argued that citizen science communication can tell us more about how different forms of scientific citizenship are enacted and shaped in a citizen science context. I demonstrated that citizens play an important role in the production of knowledge and in the development of technoscience, hence from this perspective it is important to explore how citizenship is enacted and how the scientific citizen is “constructed” throughout the technoscientific settings in SOD (Alan 2001). Furthermore, if citizen science should assist the needs of both citizens and science, we need wider knowledge about the structures that partake in the formation of epistemic subjects and how these structures enable or excludes enactments of citizenship. In order to deal with such arguments, we need an understanding of the concept of scientific citizenship and how it is enacted in a technoscientific setting to realise that citizenship cannot

be reduced to the agencies of humans alone but must consider the involvement of nonhuman others (Irwin and Michael 2003).

Irwin (1995) argues that there is a need for reconstructing our understanding of science-citizen relationships and acknowledge the need for a meeting point between different forms of knowledges and epistemologies (1995, 79). He points out that citizens are their own capacities for enacting citizenship and for generating their own understandings about a given problem of concern (1995, 178). When talking about environmental citizenship and sustainable development he points out the potentials of an approach to sustainable development which is rooted in citizens' life worlds rather than in accepted institutional settings and unchallenged relations of power and knowledge (Irwin 1995, 180). In conclusion he suggests the need for reconfiguring the relationships between science, citizenship and society, because not only are matters of environmental concern channelled through these relations, "those relations also shape and construct our environmental awareness" (Irwin 1995, 182). As Irwin suggests these relations are productive hence, they have agencies and enact boundaries for the concepts that comes to matter and those who are excluded from mattering. So, my question is: how does one take responsibility for the effects of these exclusions?

Horst and Davies, as I referred to earlier, argues that citizenship can be performed through various instances of science communication (2016, 207). They suggest that citizenship can be understood as a capacity inherent to people and communities, and a capacity which can be nurtured through different kinds of activities (195). Hence, by exploring citizen science communication in SOD, I expect to make visible how citizens enact themselves as citizens (and also how they are prevented from enacting citizenship). Moreover, Horst and Davies (2016) argue that:

> Citizenship will be affective and embodied as well as discursive. To us the term designates the constitution of a meaningful relationship, focused on inclusion through political involvement or collective decision-making, between citizens and collective entities (such as the

> state or the science). Exercising scientific citizenship thus covers more than deliberative participation. Scientific citizenship is instead produced and negotiated within any space in which science is collectively encountered and its governance or direction debated (2016, 193).

Scientific citizenship is productive and constituted thought collective process of negotiation and decision-making between citizens and scientific institutions. Science communication then can help to make visible how relations between science, citizens and citizenship under the influence of the technoscientific apparatus effects different enactments of citizenship and how it conditions the scientific citizen. Understanding scientific citizenship as the affective embodied and discursive enactments of both humans and nonhumans enactments changes everything and demands an account of the agencies of the technoscientific apparatus that enable some forms of citizenship to be performed to the exclusion of others. Horst and Davies's (2016) notion of scientific citizenship is clearly focused on human capacities, and I will further engage and reflect on the affective, embodied and discursive engagement that drives citizenship in article 4 (Gommesen & Samson 2022). At this stage however, I will raise the question: How does enactments of citizenship and responsibility unfold when we consider the active engagements of nonhuman actors in a CS project? For that purpose, I will in the following draw from political theorist, Engins Isin's (2008) notion on 'acts of citizenship' within the disciplines of citizenship studies.

Isin and Nielsen (2008) argues that subjects constitute themselves as citizens through acts: what he refers to as the "process of doing, action or operation" (2008, 22) of human actors. For Isin to act involves a transformation of subject into a claimant (18). He suggests that "acts constitute actors who claim and assert rights and obligations […]. Acts of citizenship are those acts through which citizens, strangers, outsiders and aliens emerge not as beings already defined but as beings acting and reacting with others" (39). This example tells me that acts of citizenship are transformative processes of becoming through which citizens claim and assert their rights, and while doing so are formed and reworked through their acting and reacting with others. Furthermore, acts of citizenship are also political because they constitute citizens with claims, and ethical when they are responsible. Isin writes: "for acts of citizenship to be acts at all they must call established forms of responsibilization into question and, sometimes, be irresponsible" (2008, 39). In a citizen science context citizens have the capacity to hold the project/research team accountable for their

actions, by raising their voices about important problems of concern, or by following their own agendas that contest the protocols of the CS project. Finally, Isin argues that acts of citizenship are transformative, they can reconfigure technologies and modes of being political by bringing into being new actors.

In this regard, Kimura (2016) have demonstrated how citizen-led science can create subversive infrastructures that empower citizens who have been marginalised by the state. In all this, the concept, acts of citizenship, is useful to understand how citizens enact themselves as epistemic subjects, or activist citizens (Kullenberg 2015), and how their acts hold capacities for inducing technological and cultural change. Yet we have to go further to establish a concept that includes the nonhuman agencies that a human-centered concept of citizenship may lack.

Irwin and Michael (2003) provide a useful conceptualisation of a hybrid citizenship that considers the role of nonhuman agencies in the production of the scientific citizen (2003, 132). They argue that because of humans' deep entanglements with technology mankind can be understood as a hybrid (see Latour et al. 1993) emerging from heterogeneous relationships of humans and nonhuman actors: "what is to count as human and non-human is a complex, heterogeneous accomplishment" (Irwin and Michael 2003, 132). The implications of such an understanding of citizenship are that any analysis of the relationships between expert knowledge and lay knowledge, that is science-citizens relations, should involve analysis of human-nonhuman assemblages to account for the impact of different media and technologies on technoscientific knowledge production. Irwin and Michael write:

> These media (TV, IT, newspapers, telephones), which are simultaneously cultural and material, might well play a part in 'shaping' the ways knowledges – scientific, personal, experiential, ethical, economic, political – interact, come together, combine or polarize (2003, 133).

From this perspective technological environments in a citizen science context are understood as active nonhuman agencies that take part in co-constructing the volunteer citizen and the bodily production of

scientific knowledge. From Irwin and Michael's perspective follows that scientific citizenship is better understood as including the active involvement of nonhumans: "to think about people in terms of hybrids (or cyborgs; Donna Haraway 1991) is to ask how scientific citizenship includes technologies, environments, and animals" (2003, 134) (see article 3). While this understanding of scientific citizenship is controversial as it suggests that other-than human species have political agency and a democratic role to play in society, it is also a potential for establishing new and more responsible forms of relational citizenship that questions the anthropocentric understandings on human and nonhuman relations in citizen science. Moreover, by acknowledging humans' ethical relationships and entanglements with nonhumans, the researcher is seen as part of the technoscientific apparatus and the more-than human lifeworld that co-produces a given phenomenon (Barad 2007; Haraway 1988), thus the engaged researchers are actively involved in enacting and configuring the boundaries and constraints that constitutes the scientific citizen (Dickel 2020, 262) . Furthermore, the citizen scientist as well as the researcher is also in contributing to the discourses, powers and material movements that changes citizen science relationships – be it both the technoscientific situation and the more-than human relationships relating to the knowledge situation. Hence responsibility is not ours alone, it is extended and distributed as a part of the "participatory apparatus" (Dickel 2020, 261), and but must be understood as the relational enactments of humans and nonhumans, and in terms of what comes to matter, and what and whom are excluded from mattering.

Responsibility is also an underlying theme in the following section on participatory design, in the sense that I see participatory design as an opportunity to nurture a participatory apparatus in citizen science projects that are more aware of and responsible towards citizen engagement.

03.04 Participatory design

This Ph.D.-project's multidisciplinary research approach draws from a participatory and ethnographic design approach (Blomberg and Karasti 2012) in a productive encounter with citizen science development to open up for new ways to design citizen science communication that strengthens civic capacities. I propose that participatory design (PD) both theoretically and empirically can help to assert democratic values and agencies in a citizen context that is often strictly shaped and governed by technoscientific discourse. By adapting a participatory design approach, my aim is to open up to different ways of knowing, doing, and

reimagining CS beyond a mere contributory approach. PD may in this regard contest the technoscientific boundaries of the CS project and bring in dialogue and collaboration between the developer team and the prospective participants who are most influenced by the technoscientific structures (Dickel 2020). Building on citizens values, needs and concern, and acts of citizenship as explored in the previous chapter, this project seeks to contribute to new knowledge about designing more responsible and relational forms of citizen science. In the following I unfold the core concepts of participatory design, which will be central to my design process and later analysis. I will also address how participatory design can open up for experimental, ethical, empowering, and democratic potentials in a CS context.

Participatory design is recognised both as a field of research and a design practice (Bannon, Bardzell, and Bødker 2018; Robertson and Simonsen 2012a). Ehn (1988) argues that participatory designing is a political act because it often involves groups with different and often conflicting interests (Ehn 1988, 177). Ehn suggests that participation in democratic design should apply to both the users and the designers (Ehn 1998, 6). This makes it ideal to integrate in a citizen science context as it can balance dynamics of power in science-citizens relations and open for participation and inclusion of citizens in for instance citizen science projects like SOD. Ehn puts forward the importance of rethinking the design process to include structures that allow ordinary people to contribute with their interests and competencies (ibid, 8). Moreover, Ehn states that participation in the design process is insufficient in the context of democratisation (1988, 32). Furthermore, he proposes that the design process should make it possible for the users to actively utilise their practical skills (1988, 366) in the design or through prototyping (1988, 206), e.g. to enable the uses of the mobile app to express their competencies and anticipate the artefact's future usage.

According to recent studies in PD (Bødker et al. 2022), participatory design is understood as a constructive way of engaging with people and digital technologies in their social relations (Bødker et al. 2022). As Bødker et al. argues: “It [PD] aims to empower people to take an active stance toward the digital technologies that affect their everyday life by offering them a legitimate place for negotiating future technologies. Their possible futures. It is as simple as that” (2022, 111). As Bødker states, a central focus in

PD is to enable citizens to gain a voice in the design of technologies that affect their lives (Kensing and Greenbaum 2012). In a similar vein, Simonsen and Robertson (2012b) argue that PD concerns the direct involvement of people in a co-design process of a technology that will end using Simonsen and Robertson (2012b, xix) e.g. around the collaboration and design of digital citizen science. Hence, by involving users in the development of a digital citizen science project, the co-design process not alone have the potential to make new voices heard, it also engages people directly in the design of the artefact, thus from this perspective citizens can increase their capacities to influence the structures of the CS project. Sanders & Stappers (2008) suggest that co-design has the potential to challenge power structures in a design process:

> Co-designing threatens the existing power structures by requiring that control be relinquished and given to potential customers, consumers or end-users (Sanders and Stappers 2008, 9)

In that regard, co-design holds potentials to question the power structures in a digital citizen science context, because it involves users int the design process, gives them a voices in the design decision, that is likely to challenge the protocols of the CS project and question the agendas of the project/ research team behind the project. Sanders and Stappers argue that Co-design involves that collective creativity throughout the entire design process of both the designers and the citizen non-designers around a common development process (2008, p.6). In a co-design process the users who are expected to use the service or product are involved in the process as co-designers because they are experts of their own experiences and are empowered through their participation in and making of knowledge production, idea generation and concept development (Sanders and Stappers, 2008).

In the codesign workshop that I will describe in the methodology section, citizens are involved as experts of their own experiences and knowledge of the local environment. Through a co-design process that involved experimental, collective and practical hands-on engagements, citizens are involved in the development of new ideas, concepts, knowledge, practices, and mappings. According to Kensing and Greenbaum (2012) the importance of the design practice in PD calls for the need of providing people the means to be actively involved in the design process, e.g. through prototyping, sound mappings and

listening practices in order to create ideas and concreate concepts, and to start a conversation about their experiences, practices and understandings about sound. Such material practices might also help the exchanges of different voices and bring forth opinions and differences within a community (Kensing and Greenbaum 2012, 41).

The prospective users are often seen as co-designers in the design process (Bratteteig and Wagner 2016; Bratteteig et al. 2013). However, the design process, methods and practices must be organised in ways that allow the users to take on this role (Sanders 2008). In this regard design workshops have demonstrated strong results as venues for joint design collaborations by creating a shared understanding of a situation and possibilities for participants to express themselves through their actions (Westerlund 2007) and conflicting conversations (Buur and Larsen 2010).

Co-design makes people come together through their actions and use of language (Lindh Karlsson and Redström 2015). The overall design process and dialogical culture in the design team are developed from people's actions (Binder et al. 2015) and explorations with materiality, as well as from talking and listening to one another (Wright and McCarthy 2010), which make them more prone to expose themselves and their opinions (Lindh Karlsson & Redström, 2015, 9). Several authors suggest the idea of considering co-design experiments and practices as design laboratories (Binder 2007; Binder et al. 2011) or a "set of labs where vision making and codesign meet, resulting in organized conversations for action" (Escobar 2018, 195), and as valuable factors of "democratizing democracy" (Binder et al., 2015, 153).

As mentioned earlier, it is by giving the end user more control, that co-design and participatory thinking can question the "expert mindset" and technoscientific power structures that build on hierarchies and control (Sanders & Stappers 2008, p. 9). From this understanding "we may think of design collaborations as the making of things that explore forms of emerging publics, and thus enrich the current repertoire of democratic engagement and expression" (Binder et al. 2015, 153). Björgvinsson et al. (2010) suggest that a central challenge for PD is to explore alternative perspectives on participation and democratisation:

> This challenge means actively exploring alternative ways to organize milieus for innovation that are more democratically-oriented than traditional milieus that focus on expert groups and individuals. It also means moving from the dominating technocratic view of innovation; a move from things [object or service] to Things [socio-material assemblages] where differences and controversies are allowed to exist, dilemmas are raised and possibilities explored (2010, p.50).

I see a potential context for democratic design experiments in CS. With its strong separation between the scientific community and the people participating in scientific research, there is a need for a more collaborative and participatory approach. The challenge is not only to move away from the dominating technocratic view but also to move toward more collective and relational ways of designing and being. Here in in particular draw from design thinkers such as Arturo Escobar and Tony Fry who calls relational ontologies and design practices grounded in communities and their ontological designs (Escobar 2018; Fry 2020). While relational and ontological design may welcome a more collaborative and community-based design approach, they may also make design processes more complex and unpredictable. To capture this heterogenous complexity, Björgvinsson et al. (2010) argue for a shift in perspective from “design projects” to “design things” (see Binder et al., 2011) because things are not cut off from human relations but comprise socio-material “collectives of humans and non-humans” through which “matters of concern” (Andersen et al. 2015; Latour 2004) or controversies are handled. For instance, Binder et al. (2015) write:

> We argue that participatory design practices are particularly well suited for renouncing the obsession with ‘objects’, so dominant within design, and replacing it with things or thinging as socio-material assemblies that evolve over time. [...] we suggest a shift from a focus on users and representation towards citizens and publics, including not only human, but also non-human participants (2015, 152).

What I find interesting in Binder et al is that socio-material assemblages seem to become important catalysts in the process of democratisation because they dissolve power structures and decentralise power. Thus, in the CS context, the democratic design experiments and how the engage with “thinging” and socio-

material assemblies are particularly interesting because design “work by making issues experientially available to such an extent that ‘the possible’ becomes tangible, formable, and within reach of engaged yet diverse citizens” (Binder et al. 2015, 163). From this, the democratic design experiment can work as a platform for dialogue, disagreement, imagination and exploration of alternative futures and new forms of “emerging publics”. As we shall see later in the account of my own co-design workshop with the community, Friends of Amager Commons, the collaborative experiment with sound was exactly an attempt to bring in citizens imaginations and alternative futures into dialogue with the SOD project.

Escobar (Escobar 2020) argues that design is ontological and emerge from our everyday practices, which moves the discipline of design away from expert knowledge and professional design. In that sense, we are to some extent all designers, and we are all designed therefore we must take responsibility for the worlds we co-creating (Escobar 2020, 40). How then, can we take responsibility for our designs and the world we partake in enacting, when we are so deeply entangled with the technological environments we design? This is one question to raise when thinking with the design ontology of Escobar, and also following the participatory and collective ethics inherent to co-design. In framework of this study, responsibility for the worlds we are co-creating also becomes a matter of agencies, for instance whom and what matters in research and design processes

Therefore, in the next section I will discuss whether responsibility is better understood as the relational enactments of both humans and nonhumans. We shall see how this will have crucial implications for the design of citizen science.

03.05 Agential realist framework for analysing technoscientific apparatuses

Karen Barad’s (2007) agential realist framework can provide the current study with a useful and ethical framework for understanding the boundaries and limitations of the citizen science context in The Sound of

Denmark. More specifically, how the citizen science project understood as a technoscientific apparatus of bodily production partakes in reconfiguring the citizen scientist's capacities to enact scientific citizenship (see chapter 5). Barad notes, how we need new knowledge on the boundaries, constraints and exclusions that operate through different material practices (Barad 2007, 212). To a large extent the CS project SOD was a development of the technological environments and machine learning systems (AI system). Therefore, I find it relevant to understand how enactments of citizenship and processes of epistemic agencies are formed and come to matter through technoscientific apparatuses, and how it influences citizen science.

Barad's agential realist ontology states that the researcher or analyst does not stand outside the phenomena in question, rather the researcher is an emergent part of the technoscientific practices and apparatuses that constitute the phenomena (Barad 2007). Hence, to understand the nature of the phenomena, and to be able to take responsibility for the worlds we enact and co-create, we need an account of the technoscientific apparatuses, and the processes that produce them (Barad 2007, 203). According to Barad apparatuses are themselves phenomena (2007, 170) that materialises in intra-action with other apparatuses. Apparatuses are not pre-fixed entities rather they are coming into being through specific material practices that are open to manipulation and re-configuration. Barad writes:

> Material-discursive apparatuses are themselves phenomena made up of specific intra-actions of humans and nonhumans, where the differential constitution of human (or nonhuman) itself designates a particular phenomenon, and what gets defined as a subject (or object) and what gets defined as an apparatus are intra-actively constituted through specific practices (2007, 446).

From this understanding apparatuses and phenomena are constituted through the dynamic intra-actions of both human and nonhuman doings and their active engagements with the citizen science project. What gets defined as apparatus and phenomena are not predefined but are constituted through specific material-discursive practices that is intra-actions. For example, a citizen scientist who makes changes to her sound recordings with the SOD mobile app by adapting a microphone to her mobile phone will not only reconfigure her epistemic practices, data collection, training of AI system, and knowledge production and produce

better sound quality; her changes will also reconfigure the entire apparatus of bodily production and therefore the observed phenomenon. From this perspective the citizen scientists, the project team, the SOD mobile app and me as researcher takes part in the intra-active production of the apparatus and the phenomena. Hence, the concept of intra-action acknowledges the inseparability of the observer and the observed. As Juelskjær et al. (2021) writes:

> Thinking through agential realism, the researcher is an emergent element of the specific research apparatus through each intra-action. The specific research apparatus and intra-actions partake of and co-act in these re-configurations through agential cuts, which also implies that both the researcher and the explored phenomenon are mutually re-configured through the research process (2021, 154).

In later chapters I will reflect more on my own entanglements with and impact on the research project and the researched, as a member of the SOD project team, to account for my own enactments in this context, and my own ethical responsibilities as a researcher. Moreover, I will demonstrate how the technoscientific apparatus and specific intra-actions reconfigure, enable and exclude epistemic agencies in the project.

As the examples above demonstrates, Barad's notion of *intra-action* is key in her agential realist framework, as it describes the "mutual constitution of entangled agencies" (2007, p.33), that is humans or nonhumans capacities to act. While the term replaces 'interaction' that presumes there are individual agencies that precede their interaction, the concept of intra-action acknowledges that agencies do not pre-exist but are co-constituted and emerge through human and nonhuman intra-actions. Intra-actions in material discursive apparatuses enact agential cuts that effect what comes to matter and what is excluded from mattering, as some opportunities are realised while others are foreclosed (393). From this perspective, the possibility to enact citizenship and question the CS project's scientific approaches, emerges through the relationships of the project team, volunteer contributors and SOD mobile app rather than between them (or

contrary it does not emerge at all). In my later analysis of citizens intra-active engagement with the project, I will demonstrate how this capacity to act changes with citizens' different enactments in the CS project.

Barad's notion of *agency* is important for our understanding on how responsibility entails an ongoing responsiveness to the diverse entanglements of a citizen science project of which volunteers and project team are a part. As I suggested in the examples above, agencies are reconfigured through material-discursive practices in the apparatus and do not pre-exist as either human and nonhuman actions. Consequently, agency according to Barad, is a matter of intra-acting, and it is neither an attribute of subjects nor objects:

> Agency is not held, it is not a property of persons or things; rather, agency is an enactment, a matter of possibilities for reconfiguring entanglements. So agency is not about choice in any liberal humanist sense; rather, it is about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices (interview with Barad, Dolphijn and Tuin 2012).

Agencies are the relational enactments of humans and nonhumans in material discursive apparatuses. As I argued earlier agencies are not predetermined but are shaped through our intra-actions within the technoscientific apparatus. As a consequence our intra-actions as developers and project team and citizen scientists matter because they are part of the material discursive apparatuses that reconfigure, constraints, and exclude some knowledge processes and agencies over others. Therefore, our research practices are never without consequences we are responsible for the knowledge we seek and the consequences of our research (Juelskjær, Plauborg, and Adrian 2021, 143). According to Barad responsibility involves an ongoing responsibility to the entanglements of which we are part (2007, 394). Barad writes:

> We are responsible for the world within which we live, not because it is an arbitrary construction of our choosing, but because it is sedimented out of particular practices that we have a role in shaping (2007, 203).

Thus, as a consequence of our intra-active engagement in and reconfiguration of the technoscientific apparatus both as developers and scientists and volunteer contributors, we are responsible for the knowledge we seek but also for what exists or are excluded from existing. As Juelskjær et al. (2021) states, “everything we do matters, and matters in its specificity, because knowledge production contributes to producing realities” (2021, 143). However, responsibility is not ours alone (Barad 2007, 394). Responsibility is relational, it is a doing and an integral part of the world (Barad, 2010, p.265). Suchman (2007) suggest that accountability is entangled and emerge through our intra-actions with the world (Suchman 2007, 285).

To design more responsible forms of citizen science engagement that strengthen citizens democratic capacities. I will argue that we need another knowledge about the performative effects of the technoscientific boundaries, epistemic exclusions and constraints that operate through material-discursive apparatuses (2007, 219) and new understandings on how they configure and reconfigure science-citizens relations and the production of a particular phenomenon. Drawing from Barads agential concepts such as agency, intra-actions, apparatus, and responsibility as relationally enacted, I will demonstrate that the design of successful citizen science engagements can empower citizens and may also contribute with new knowledge and understandings of the nature of nonhuman agencies and how they change with agential cuts in a citizen science context.

03.06 Conclusion

In summary of this chapter, I have established the theoretical framework of the Ph.D.-project and its three dimensions: citizen science communication, scientific citizenship and participatory design research. In my analysis of the entire CS project as a technoscientific apparatus of bodily production, I draw from Barad’s (2007) agential realism to create a framework and further knowledge and understanding about how the

scientific citizen is reconfigured through her engagement in SOD, and how citizens capacities to enact citizenship are enabled and/or excluded from being engaged (chapter 5). With this framework, it becomes possible to analyse instances of science communication in SOD and how citizenship is enacted. It becomes possible to analyse and follow materiality in throughout the design process to see how citizen science can be elaborated to include people in the design process in ways that enhance their democratic capacities. Finally, by using Barad's concept of relational 'responsibility' and 'intra-action', I aim to make visible the exclusions and boundaries that scientists and project/ developer teams participate in enacting. Finally, I will demonstrate how these enactments reconstruct science-citizens relationships and make possible ex-changes of broader forms of knowledge, to bring forward new understandings of responsibility in citizen science. In the next chapter, I will outline the research design of the Ph.D.-project.

04 Research design and methods

04.01 Introduction

This chapter outlines the research design and methodology of the Ph.D.-project. In chapter 2, I described the empirical setting of my research and my role in the SOD project team. In the following I will elaborate on this with a deeper focus on the design experiments and digital development process in which my research is situated. I continue with the participatory design process of the PhD project and demonstrate how it relates to the overall development process, starting with the preliminary pilot study, over participatory design workshops, implementation with the SOD project/development team, to the iterative evaluations of the implemented design (see article 1 for an analysis of the design process). I continue with the methodology of this study and my ethnographic approach to data collection and analysis. I conclude with my reflections and discussions of the methodological implications of this study.

04.02 Entangled in the digital development of the Sound of Denmark

The overall development process, also referred to as the design programme, (Redström 2017) involves two intertwined processes, or better material practices that mutually affect and shape one another (see fig 3). One is the digital development process with the SOD project team at CMEC, where I have been involved as an ethnographic design researcher. The other is my participatory design workshops and design experiments throughout the process. The latter process is better understood as small design experiments that create tensions throughout the design process. As a project member my focus has been specifically on creating knowledge through a participatory design process and sonic explorations with prospective citizen scientists, and to contribute to their integration into the digital development process and into the SOD mobile application. As mentioned in a previous chapter, this project team consisted of people from CMEC, DTU and OM (SDU), each with their individually and specific focus throughout the development of the SOD mobile application. Moreover, the concrete digital development, programming and design of the mobile app was undertaken by an external design bureau A15 (pseudonym), and their team of designers and

programmers but in close collaboration with the SOD project team and project investigator at CMEC. The digital development of SOD involved weekly developer meetings internally in the project team, but also with external collaborators and the developer team from A15. As design researcher in the project team, I was involved in all aspects of the iterative design phase, from ideation to concept development, over prototyping of interactive prototypes, testing, usability test, feedback and reports to A15, developer meetings, internal workshops, outline of specification lists and reports and recommendations for designing for digital engagement and communication in citizens science.

Through my direct involvement in the SOD developer team, it became possible to use my research and findings throughout the process as a practical tool for making informed recommendations on how to develop responsible communication in citizen science, but also to question a technoscientific development process that was strictly focused on developing a digital tool for data collection that makes it possible and simple for most citizens to participate in the project with their mobile phones, and to contribute with large data sets to the training of a machine learning programme that will eventually automatise the analysis of sound.

While my participatory design workshops and interviews with citizen scientists and researchers enabled me to raise questions about the technoscience-centred design process and ethical issues that otherwise would have remained unnoticed, all design criteria and decisions made with the SOD project team passed through new rounds of consultations and negotiations with the external developers from A15 before implementation. Throughout the lifetime of SOD there was a close and necessary dialogue between the project team and A15 that unfolded around the iterative development of the citizen science project.

04.03 The participatory design processes

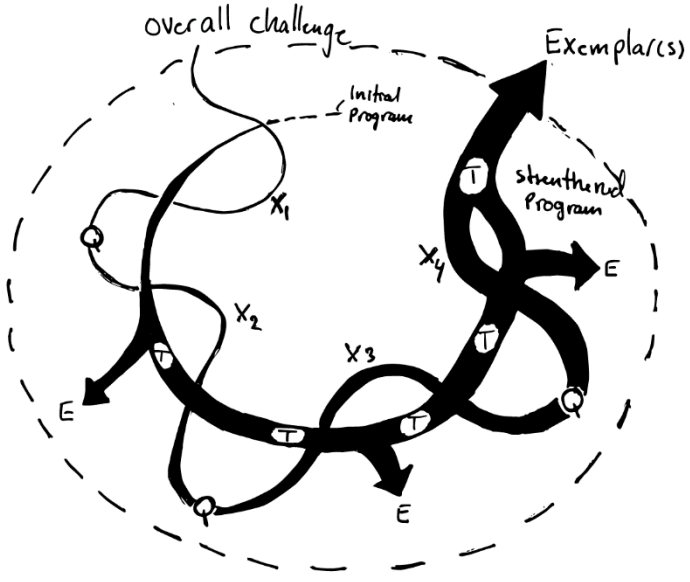

Figure 3. the participatory design process in intra-action with the overall development process (adapted from Bang 2010; in Markussen et al. 2012). The diagram demonstrates that as the project evolves the overall objective unfold new research questions (Q). As Markussen et al. (2012) writes: The theory is embedded in the program and refined in the dialectics between program and experiments and in the process of answering the research questions in a way that forms exemplars for critical knowledge dissemination" (2012, 9).

The participatory design and research process of the Ph.D. project unfolded within this already complex design collaboration of many different actors and is best understood as exploratory design experiments and material practices that iteratively influence and inform the overall design process (See fig. 3). As such

the design experiments (X1, X2..) articulated new questions (Q, Q..) and contributed with new knowledge (as examplars = examples) about how we can design citizen science communication that strengthens citizen democratic actions. However, at the same time my own design practices were mutually shaped, designed and reconfigured by the overall design process, and my exchanges with the project and developer team. The participatory design process involved four different phases that I will outline in the following:

- **The preliminary field work** involved a qualitative pilot study which initiated the ideation and formulation phase of the participatory design process.
- **The participatory design process** with prospective participants commenced the reflection and reformulation phase.
- **Implementation and experimentation** in collaboration with the SOD project/ developer team.
- **Evaluation of the implemented design** throughout the design process and in collaboration with citizens.

These processes are neither separate nor linear but must be understood as the entangled practices of the prospective citizen scientists and the researcher through which different forms of practices, knowledges, concepts and doings take part in the shaping and co-constitution of the SOD mobile application. However, the design process is also affecting and constraining the participants within a design framework that builds on specific questions and approaches that are defined by me as researcher and a part of the SOD project.

04.03.01 The preliminary fieldwork – a qualitative pilot study

A primary goal of the preliminary fieldwork was to advance my knowledge about citizen scientists' engagement in scientific research while sketching out the importance of communication in citizen science. To increase my knowledge and understanding of the citizen science field, and to establish mutual trust and exchange relationships with key contacts and experienced amateur scientists, I situated myself as a

volunteer contributor and ethnographer in the citizen science projects Naturbasen and Svampeatlas and their communities. According to (Flyvbjerg 2006) , situating oneself in the context under study is crucial for one's understanding of the viewpoints and behaviours of social actors (Flyvbjerg, 2006, p. 236). Through the CS communities and researchers at CMEC who works with the CS project Svampeatlas and the Ant Hunt (Myrejagten), I got in contact with experienced amateur scientists from Svampeatlas and the Association for the Advancement of Fungi (Foreningen for svampekundskabens fremme), including less experienced families from the Ant hunt community.
In detail, the preliminary pilot study had three aims:

- To obtain knowledge about citizens dialogical interactions by investigating how people and epistemic agents participate, communicate, and engage with people and epistemic resources in a citizen science project (if at all), in their everyday lives, and across online communities. How do people communicate when they are doing citizen science? How/why do people share epistemic resources with the CS project and other participants?

- To obtain knowledge about citizens' prior experiences with citizen science, their epistemic doings, practices, and agencies, which can inform the design research process (Malmqvist et al. 2019), and contribute with knowledge to the project team and external stakeholders.

- To produce rich qualitative data which can create a clearer understanding of the focus and research questions in my research (Doody and Doody 2015). This allowed me to foreshadow potential pitfalls and reflect and iterate on gaps in my research before commencing the more considerable parts of the research and design programme.

The preliminary field work involves my activities and practices in the research process and goes beyond the pilot study's semi-structured interviews to include all activities that inform the research process and produce knowledge of the fields of investigation. This includes the literature review that took place prior the pilot study where initial concepts and ideas begin to take form. But also, the follow up questions following the semi-structured interviews and later workshops.

The interviews then not only functioned to inform the latter part of the research but were also important for establishing a closer relationship with the informants, and for understanding their everyday practices and experiences with citizen science, which made it easier to follow up on central questions after the interview. Moreover, it helped to connect the researcher with the unknown field under investigation.

The qualitative pilot study builds on my literature review of citizen science communication to provide critical information about the field of investigation. According to Hargraves (2006), the literature review is valuable in establishing the theoretical framework from which primary research can be conducted, but it can also serve to improve the quality of the analysis throughout the research project (Hargrave and Van De Ven 2006, 258). In my context, the preliminary fieldwork aimed to create new knowledge about the importance of communication in citizen science and how prospective participants in SOD want to participate, communicate, and engage themselves in the CS project, contributing to the production of scientific knowledge production in collaboration with the scientists and other participants.

The participants

Table 1. demographic characteristics

Gender	Interviews: 4 female 4 male Workshops: 7 woman and 5 men
Age	16-68 years
Race	White
Education	Unemployed, pensioner, students, academics
Social class	Middle class

The design programme's preliminary field work commenced with a qualitative pilot study involving 8 semi-structured qualitative interviews with experienced and prospective citizen scientists and citizen science researchers that is: 3 citizen scientists (people who are experienced and active in citizen science), 2 family members and 1 non-scientist (person who have not previously participated in CS), including 2 expert interviews with researchers in citizen science. My selection and definition of these groups is based on well-known participant groups in citizen science. The criteria for selecting these participant groups were to gather a diverse group of people in the subsequent co-design workshops and to make possible dynamic exchanges of ideas, knowledge, skills and perspectives between diverse citizen groups (Bratteteig and Stolterman 1997). These groups also met the interests of SOD who wants to involve all members of society in a National sound mapping of the Danish landscape. People who participated in my interviews and co-design workshops were mostly white, Danish, middle class, 16-68years old, Copenhagen and Jutland based, with an equal distribution of woman and men in my interviews, and 7 female and 5 males in the workshops (see table 1). People were recruited via mail, citizen science communities, Facebook groups (e.g. Friends of Amager Commons (Amager Fælleds venner)), and citizen science projects such as the Ant Hunt (Myrejagten) and Svampeatlas. In later analyses I will refer to people who participated in this study, as participants, citizen listeners, citizen scientists (if experienced), scientific citizens and citizens.

The participants in my interviews, workshops and evaluation process have consented to their information being used in my research. As this information is anonymous and kept on my drive at the university, no one will be able to tie it to a participant or see any other information which identifies them. I also refer to participants by pseudonyms to safeguard their identities in any publications resulting from this study. In addition, users of the SOD app accept that their contributions to the project are used for research purposes. These contributions include sound recordings, metadata, and communication on the CS project's forum. However, since the excerpts of the data I use do not reveal who the participants are, I did not obtain additional consent for everyone who took part in the communication across mobile forums, Facebook groups, and emails.

The semi-structured interviews

Were conducted face-to-face at CMEC and via Skype between Maj 2018-June 2018 each with a 45–60-minute duration. The interview guide (see appendix 1) was designed with open-ended questions, prompts and follow-up questions to increase breadth and depth in the dialogue and the responses (Brinkmann 2014, 38). After a short introduction of my research and how I asked the interviewees to answer questions under four categories: the importance of communication for involvement, citizen science communication and citizenship, digital technology, and democratizing science. My main aim was to create a deeper understanding of their everyday lives, experiences with citizen science, engagement and communication across social media, and online communities. The CS researchers helped me to get a deeper understanding of the field of citizen science and allowed me to ask more theoretical questions around the importance of communication in citizen science. In summary, the interviews helped me unpack the descriptions and the knowledge gained from the interviewees, as well as increase the possibilities to follow up on “conflicting” opinions (Brinkmann, 2014) or specific aspects of the interview that were important to the interviewee (2014, 38). The interviews served as basis for exploring the concept of citizen science communication and as inspiration for the participatory design workshops.

The interviews were conducted face-to-face at the CMEC and via Skype, each with a 45–60-minute duration. The interview guide was created with open-ended questions, prompts and follow-up questions to increase breadth and depth in the dialogues and the responses (Brinkmann, 2014, 38–39). I asked the interviewees to answer the questions under four categories: the importance of communication for involvement, CS communication and citizenship, digital technology and democratising science. My aim was to establish a clearer understanding of their everyday actions, engagement and communication across social media, online communities and in CS. The semi-structured interviews helped me unpack the descriptions and the knowledge gained from the interviewees, as well as increased the possibilities to follow up on “conflicting” opinions (Brinkmann, 2014, pp. 42–43) or specific aspects of the interview that were important to the interviewee (p. 38). Hence, they were used as the basis for an explorative approach to the concept

of CS communication, helped me formulate an early hypothesis and the research question and served as an inspiration for the subsequent workshops.

04.03.02 The participatory design process with prospective participants

The participatory design process was informed by key findings from the pilot study and involved 4 participatory design workshops with prospect citizen scientists of 4-5 participants in each group. These design workshops were arranged in four different locations. The first one was taking place at the CMEC in Copenhagen, the next two were executed at Amager Commons (Amager Fælled), and finally one was arranged in Skive in Jutland. The different settings created different constraints and boundaries of the design space that shaped the possibilities of the design process (design space). While the design space of the workshop at CMEC made it easy to go directly from the initial sonic experiments, and indoors to a room with design materials for prototyping and sketching out ideas, the workshops at Amager Commons were a bit more challenging as there were not tables and boards that would be useful in the prototyping phase. Hence, to compensate for this I had prepared a design journal to provide an overview of the participatory design process, its different phases, actions and objectives. This journal was meant to make it simple for the participants to follow the different phases of the design process (see design journal appendix 2), make sound maps, notes, sketches, and descriptions, and document the participants' doings, and enactments and thoughts in movement. In other words, the journal was both a way to materialise citizens' thoughts and the means for the ethnographer to follow how ideas, thoughts and concepts materialise throughout the participatory design process.

In relation to this I brought materials such as paper, pen, post-its, design journal, and paper for sketching out ideas to make it possible for people to concretise their ideas in action. Furthermore, I used my field recorder to capture the sounds of the workshop setting, our actions and discussions throughout the entire design process and the 3-4 four hours we spent together. My sonic engagement with the workshop and people, were not only the means to document the proces but also involved me closely in the participants experiments. Doing listening as an ethnographer (Gerard Forsey 2010) and member of the workshop, is here understood as an active way of engaging with the world and its possibilities (Voegelin 2010, 3). Hence, sonic engagement and listening with citizens can help to advance new ideas and open

the discussion and collective reflection about our soundscapes and what they mean to us in our everyday lives (See also article 1). Furthermore, listening can enhance creativity in the participatory design setting: “listening allows fantasy to reassemble the visual fixtures and fittings, and repositions us as designers or our own environment” (Voegelin, 2010, 12) Furthermore, it can be a catalyst for creative actions (Taylor and Fernström 2019, 245). Listening is a form of engagement with the world that creates awareness to the invisible potentials of the landscape. As Vogelin (2018) reminds us: “a sonic possibility produces awareness for blind spots and demands participation. It affords capacities to act and become an actor; to invent the circumstances of one’s own audition and listen out too for those voices that remain impossible” (2018, 38). Hence, in the workshop our collective sonic explorations worked as the means to open up a conversation about sound and soundscapes, our sonic experiences, and to create new meanings about the possibilities of sound and listening. Hence, listening in this understanding worked as a process for creating another knowledge about the world, a possibility for listening beyond oneself and beyond the interests of the scientists in the Sound of Denmark. In that sense I regard our collaborative sonic engagements as “the possibility for knowing otherwise”, as stated by sound artist Brandon Labelle (LaBelle 2018, 48), and an exploration welcoming another kind of embodied knowledge.

To experiment, imagine and to know otherwise was perhaps the most important qualities of the participatory design workshops because through these practices it became possible to create new understandings and knowledge about designing for more responsible science-citizens relations. In the next I will unfold the five phases of the participatory design workshops (see fig.4), that is an empathy phase, a define phase, an ideation phase, an iteration phase, and finally a prototyping phase:

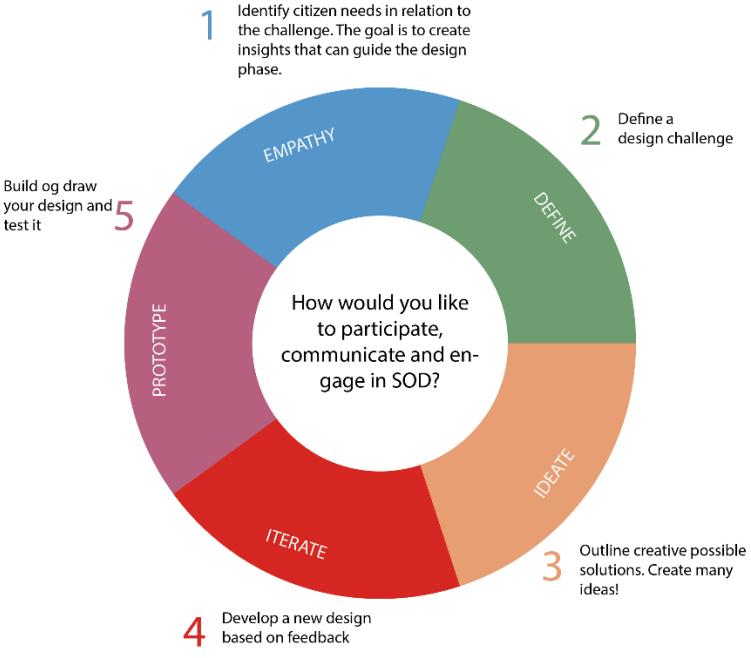

Figure 4. the five phases of the participatory design workshops

The empathy phase

Initialised the participatory design workshops. In this phase my aim was to identify the participants' needs and interests in relation to the main challenge and uncover possible insights that could guide the design process and the subsequent design phases throughout the workshops. Informed by the outcomes of the

pilot study, the main challenge of the workshops was formulated as a research question: *How do you want to participate, communicate, and be involved in the Sound of Denmark?* This question was collectively explored through all the four workshops in collaboration with the participants and set a direction for our initial conversations about sound and soundscapes and what they mean to 'us' (I use 'us' to point out that the ethnographic researcher is deeply entangled in the workshops design practices and therefore its outcomes). Another constraint that guided the design process was the scientific purpose of SOD that states:

> The sound recordings will form the basis of a database that can be used to convey the meaning and composition of Danish sound environments. It will be an invaluable tool for analysing topics like human impacts on the soundscape and the economic and health effects of environmental factors.

During my initial interviews, I found that people had difficulty expressing their interest in sound and their experiences of everyday soundscapes. Hence, to initiate the workshop and our conversations about sound, I defined an objective for the workshops that raised the question: what sounds are you interested in? This question guided the participants in the following sound mapping exercise and made it possible for them to get started with their own sound explorations, and to put more words and reflections into their sonic engagement with their surroundings.

One of my workshops took place at Amager Commons in Copenhagen, a protected natural area in Copenhagen, an also a habitat for a number of red-listed and EU-protected species comprising plants, fungi, amphibians and insects. This space initiated a fruitful discussion about the participants' relationships to sound and nature. After a brief introduction to my research, the scientific purpose of SOD and the objectives of the workshop and design process, all the participants were asked to initiate their sound mapping of the area.

In the sound mapping exercise, people went out individually or two and two for approximately 15 min minutes followed by a collective discussion in the group about their findings and collective listening to some of their recordings. People were asked to use the design journal and make a sound map of the area with notes and descriptions about the sounds they heard. On the map they added the location, date, time and weather conditions. In the first step, people were instructed to use some time to emerge themselves in the environment, starting with closed eyes for a few minutes before they started their sound mapping. Next, they were asked to describe the sounds they heard in detail on the map. Hereafter they described five sounds they like and five sounds they felt were unpleasant. In the fifth step they described how the sounds made them feel. The sound mapping was repeated twice and elaborated with questions for our collective discussions between the two sound mapping sessions. In our discussion people shared their sonic explorations, thoughts, ideas, whatever came up during their sound mappings. The sound experiments, sound mappings, and people's sonic experiences helped to inform and guide the following define phase.

The sound mapping exercise was an important enactment that enabled people to explore their opinions and experiences related to sound and sound mapping and served as a platform for envisioning different sonic possible worlds (Vogelin 2021) and what the SOD project might become. Oliveros (2005) argues that the act of listening is an active and attentional process of changing and being changed that works as a catalyst for cultivated reception and creative actions. From this perspective the sound explorations in the workshop, field recordings, practices of listening and the sound mappings can tell us rich stores about the world and how it changes over time. Sound and the act of listening I therefor regard as a relational activity that connects people and things (LaBelle 2018; Voegelin 2018), and can serve as potential for activating a plurality of different voices (Lacey 2013). Listening has an explorative, political and democratic capacity (Voegelin 2018, 47) and makes it possible for people to collectively discuss sounds, ways of doing listening, and process their uncertainties about sounds and soundscapes. Essentially, citizens' sonic engagements and shared conversations about their sonic experiences served as vivid narratives describing the participants' inner sound worlds, passions, motives, and motivations. Their collective sound recordings and mappings provided insight into how people want to engage each other through sound and active listening in SOD.

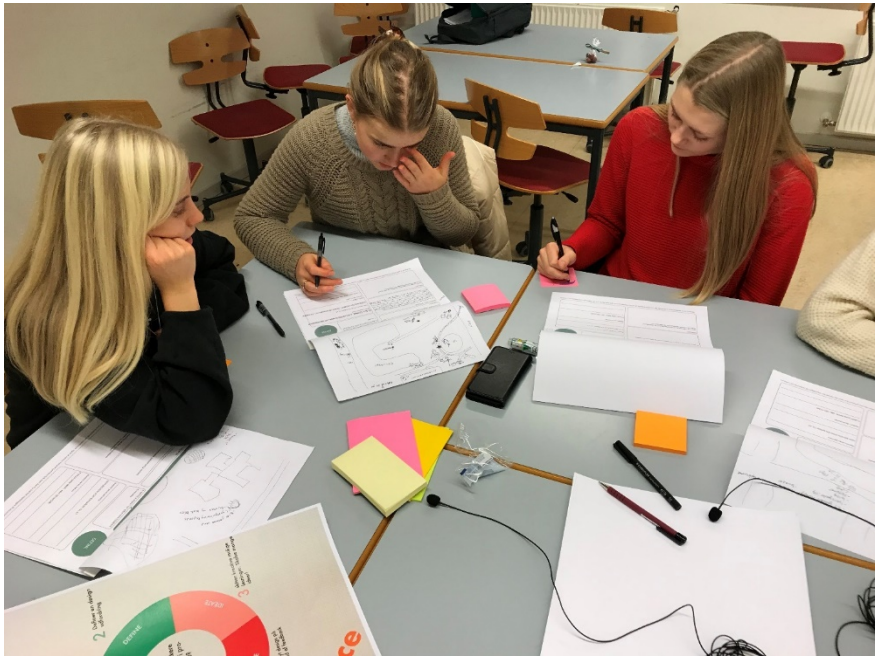

Figure 5. The group is working on their design challenge: how can we design a space of freedom for a 16-year-old student interested in natural science, who wants to have fun?

Define phase

The following define phase builds on the insights and sonic explorations from the empathy phase, people are trying to formulate more concrete ideas to work with forward, that is a design challenge and/ or working hypotheses that participants can address and question in praxis through the workshops design experiments (fig. 5). Focus in this phase is to help the group with discussing and elaborating on each other's ideas to formulate questions that can move the process forward. The workshop participants started the define phase by capturing their main findings from the empathy phase, by visualizing, reflecting on and collecting the sounds and listening experiences from their sound mappings and our discussion. In this step we also return to the main challenge of the workshop concerning how people want to participate and engage themselves in SOD. Based on their sonic experiences, sound maps, and our discussions they attempt to formulate a problem statement that is based on their personal needs, goals and wishes, and how they can fulfill these needs. In the workshop at Amager Commons the participants define the following design challenge to continue with: "How can we develop a sound community that connects us with other people and nature so we can be free?". In another workshop the participants have defined a prototypical persona to continue with: how can we design a space of freedom for a 16-year-old student interested in natural science, who wants to have fun? In this phase the group continues with adding notes and questions and sketches to the design journal, they discuss their thoughts and ideas with one another. In this phase people are using a lot of effort to formulate a question they want to explore and continue with. Through their questioning and reframing of the situation at hand the codesign setting opened up for the possibilities to create and formulate shared understandings of the situation at hand, and gave opportunities for the participants to express themselves through their actions (Westerlund 2007). Also more conflicting conversations (Buur and Larsen 2010) can be brought to the table because the codesign setting is not necessarily one of mutual agreement but also of thinking and negotiations. This is also an example on how codesign can make people come together through their actions Binder et al., 2015), discussions, sonic engagement and their talking and listening to one another.

Ideation

In the ideation phase people are asked to reframe the problem statement they work with, based on the user need statement and design challenge concretized in the define phase. The challenge is reformulated into actions to inspire and initiate the ideation phase. The participants both individually and collectively try to formulate a point of view statement that describes who they are designing for and what their needs are? In one of my workshops, the participants defined the following problem statement to inform their designing: “how can we create a free space in the nature that relieves high school students from stress?”. With this in mind the next steps in the process were to sketch out as many creative and radical ideas as possible that addresses the problem statement. The aim is not to develop detailed protypes but rather to gain new insights, get feedback and formulate new questions about the design. The easily accessible design materials make it possible for the participants to take an active role in the design activities, and to manifest ongoing design ideas and solutions. Furthermore, it is an effective tool for dialogue between different stakeholders (Bødker 2021, p.67). All members in the group were asked to sketch out as many ideas as possible in this stage and not think too much about the quality of the design. For some, this resulted in individual creations that addressed the problem statement; however for most of the workshops it often ended with collective interpretations, discussions and designs of the final concepts. After a period with designing the group presented their concepts and discussed them in the group. Hence their design created dialogue and made it possible for the small group to share and build on each other’s ideas.

Some of the ideas and concepts that emerged from the different workshops was a “sound museum” that makes it possible to: “Learn more about our soundscapes”, “raising [public] awareness of the necessity and conservation of nature”. But also, to “create understanding of health-promoting sounds”, and “sound travel with others”. In their design process, people used words, text, sketches, and made scenarios to express themselves. Because of the low-fidelity prototyping (Ehn and Kyng 2020), for instance sketches and drawings that illustrated their designs and potential actions and usage, it was straightforward for everyone to participate and contribute on their own terms. In a different workshop the concepts demonstrated

that it was important for the group of participants to develop a digital tool that created new opportunities for “socializing and competing in small teams”, and a “free space from work and everyday tasks”, and finally “health” and “passion for nature”.

The ideation phase made it possible for the participants to move beyond their ideas at get practical experience with design things such as sketches, mockups, and sound maps from the earlier phases through the involvement of participants in the development of more tangible concepts which can provoke new thoughts, feelings and desires of the users (Björgvinsson, Ehn, and Hillgren 2012) .As we heard above, the process sparked a series of reflections, discussions, contestations and elaborations of the problem at hand, and created a unique and uncertain situation. The sketches created throughout the workshops build not only on their sound and design experiments but also on their prior knowledge and experiences. In this process no standard understanding or knowledge of the situation is being used, rather it is constructed and materialized as a result of all the intra-actions between the different actors in the design assemblage. These new ideas set the criteria for the further process. From this perspective the collective work of the participants in collaboration with the ethnographic researcher is theory-creating (Zimmerman, Stolterman, and Forlizzi 2010) and can potentially contribute with new knowledge on how to design citizen science engagement in SOD.

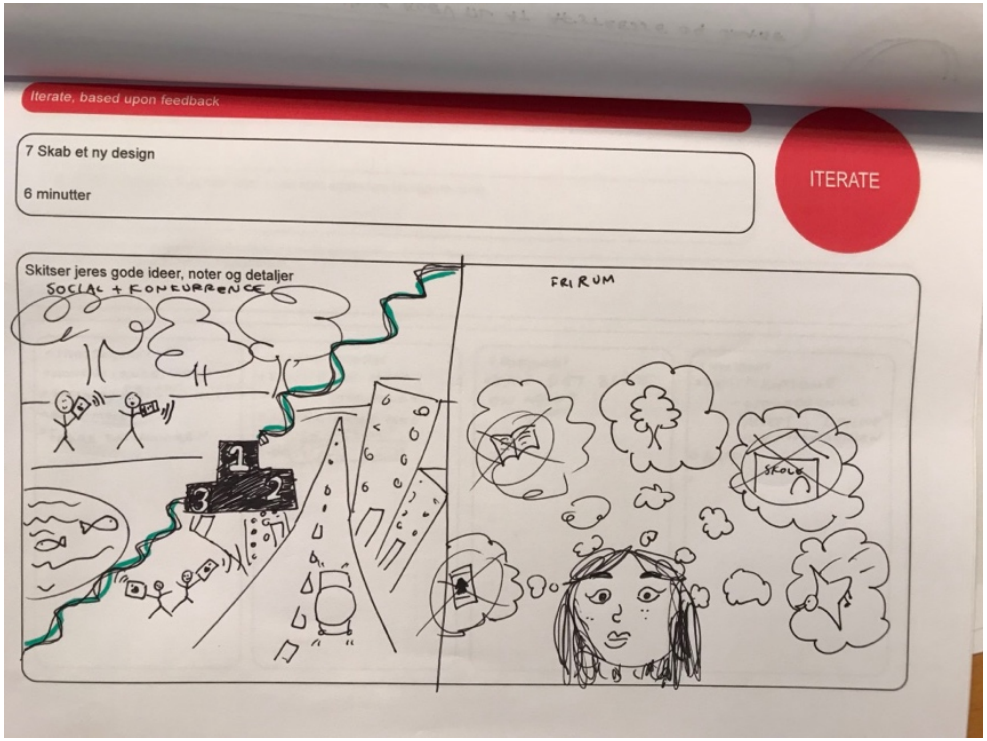

Figure 6. In the iteration phase. People create a new design based on their earlier work.

Iteration

In the iteration phase the volunteer participants are preparing a new design which is based on the concepts, knowledges, sketches, scenarios, experiments, field work and discussions that emerged through the previous phases. Central for this part of the process was that people had found a shared language and understanding of the problem statement they work. Through their development of sketches, mock-ups and discussions, they collectively sparked new thoughts, feelings and desires around the ideas that they wanted to proceed with. Following the design iteration of the new concept the group presented and discussed their concept.

In (fig.6) we can see the group have developed a concept and scenarios that satisfy and come up with a solution to their self-defined problem statement. The concept demonstrates that for this group, it is crucial with different opportunities to socialise with others during their participation in the citizen science project. Moreover, it is essential that they can engage in nature with their friends and compete and have fun while participating and contributing to SOD. As one of the participants mentioned, she would not even consider participating if she could not socialise with her friends. On the right side of the photo, we see that the concept satisfies their initial statement, which sounds: “how can we create a free space in nature that relieves the stress levels of high school students”. Finally, the concepts reveal that the participants are passionate about nature; therefore, trees and animal life are voted in, while consumption of media, homework, and studies are voted out.

My experience of this phase was that most groups have already settled on an idea in the earlier phases, so the concepts from the ideation phases did not change fundamentally between the iteration and ideation phase when considering merely at the designs, however when including the discussion and dialogues and experiences and the collective knowledge produced, the designs convey another story. The concepts developed in the different workshops demonstrate that PD and design collaborations hold potentials to strengthen ethical concerns in the development of artificial intelligence and in nurturing more responsible forms of human-machine engagements. The PD design space holds potentials as a space for conversation, negotiation and contestation of different forms of practices – in other words PD creates tensions between non-experts and experts and these tensions, if they are acknowledged, hold capacities to contribute with other forms of knowledges and engagements which for instance can acknowledge people’s

desire to strengthen their relations with nature, the need for advancing social relations when participating in citizen science, and the need for meeting with others around a joint adventure. The first step in a possible transformation of CS and more responsible forms of engagement is acknowledging that people are resourceful and skilful (Bødker 2021) and that they should have a voice in the design process.

Prototyping

Participants continue developing their prototypes during the prototyping phase. In this phase, the goal was to either create a prototype or develop an elaborated concept based on the participants' skills. The next step was a short presentation and a final round of feedback and discussion. People design prototypes, offer critiques, discuss what works well and what could be improved, and through this process, come up with revised suggestions, elaborations, and changes to their concepts, mockups, and ideas in negotiation with the ethnographic researchers - in other words, they create knowledge through their design practices. The design process often challenges people's design skills, so my emphasis in the workshops has primarily been on citizens' dialogue, their sonic enactments, their discussions, and how they developed knowledge through their sonic explorations in the environment: what did they do? Are they passionate about any particular sounds? What does their behaviour look like in different settings? When recording and listening to sounds, what techniques do they use? How do people interact with each other? What concepts do they find interesting? The purpose of this phase, and the entire participatory design process, is not to arrive at a superior final product that developers can implement in SOD. Instead, I aim to create original knowledge and hypotheses about how citizens wish to engage with the citizen science project. Moreover, the workshop will allow citizen agencies to contribute to the co-designing of the SOD digital design and foster a new science-citizen relationship that will benefit citizens by giving them a voice in the scientific outcomes.

04.03.03 Implementation and experimentation

As mentioned earlier in this chapter, the knowledge from my codesign workshops, pilot studies, design experiments, and ongoing evaluations and feedback has been integrated into the technoscientific structures of the CS project through my role as codeveloper in the project team.

I have contributed to the project through such diverse practices as: co-design workshops with prospective citizen scientists, reports pointing out recommendations for designing for communication and engagement in CS, design experiments and prototyping of interactive interfaces that demonstrate communication and engagement possibilities (digital prototypes forum, acts), but also through internal workshops in the project team, and involvement in the CS project's ongoing iterations and evaluations with feedback to the developers from A15 (see appendix 3).

The insights from the participatory design workshops established a foundation for my continued work and explorations on how to design successful CS communication that makes it possible for the community of volunteers to raise their voices and ask questions about their data collections, the AI system and who their data are being use forward. Hence, ideas, concepts, scenarios etc. created a foundation for further explorations in terms of transforming the knowledge from the workshop into digital and interactive prototypes that can be used in my negotiations and discussions within the developer team, as the means for communicating key findings from the different workshops.

These micro contributions throughout the co-development of SOD are a result of my material practices, design collaborations with citizens and experiments in the overall design development process and works as a tension within the SOD project team of which I am a part, that contests a particular technoscientific perspective and its primary focus on data collection, technoscientific development, and the production "solid" science. From this perspective the participatory design process and citizens, are challenging the power structures and expert mindset of the project (Sanders & Stappers, 2008), not only in the later participation phase as citizen scientists, but in their role as codevelopers of a possible project to come throughout the different design phase and the evaluation of the project. As Binder et al. argues, design collaborations can therefore be seen as the making of things that explore new forms of democratic engagement (2015) and potentially a move away from the dominating technocratic view of innovation Björgvinsson et al. (2010, p. 50). However, this change in perspective is no easy task, and the design process

in SOD was no exception. As I will later argue, a democratic engagement of citizens demands a total reconstruction of technoscience's view on lay-knowledge and our ways of developing citizen science projects. Democratic innovation in citizen science does not start with participation, rather it starts with the formation of the initial ideas and knowledge and values that take part in the shaping of the technoscientific apparatus. Therefore, I see a need for new knowledge on the entanglements of citizen science from its deeper levels in the development phase through its implementation and actualisation.

04.03.04 Evaluation with citizens and during development

The evaluation process throughout the development of SOD was an ongoing process that started from the very early phases of sketching out ideas. In the following, I will outline three evaluation processes related to my participatory design process. The first process considers the iterative design process of the digital CS project that took place within and as part of the SOD project team. This process involved an iterative design and evaluation process and collaboration between the project team and the external developers from A15. However, external collaborators involved in SOD's concepts and educational programs also had a hand in design decisions, such as interface design. As we see here, many actors are involved in this significant collaboration, each with their own skills and abilities to influence the project's direction. However, I will avoid going to far away from the technoscientific apparatus of SOD, even though it intra-acts with many different apparatus and power dynamics, to focus on the exchanges between the project and the developers. This co-evaluation with the external developers builds on regular exchanges between the project team and me as the person responsible for providing weekly reports on things and features that need to be changed or fixed.

An example of this can be seen in (appendix 3) where I am providing ongoing feedback on the forum modul in the app, about features that are missing or needed to be changed in order to distribute more agency to the participants. As I argue in the document: "registered participants must be able to create a new thread themselves". There should be an: "opportunity to edit / delete posted comments and threads,

preferably participants and at least for administrators". Finally: "you should be able to respond to a specific comment (reply), e.g. participants must be able to comment on each other's threads". My brief feedback to the developers build not only on my own usability tests of the forum but the entire project and its collaborators who provided ongoing feedback about things that did and did not work well. They often sent this feedback to me, so I could gather all the feedback and deliver it in weekly dumps to A15. However, the feedback I provided A15 can also be seen as the result of my findings from my co-design workshops and what the literature stresses, particularly that communication between scientists and volunteer contributors are crucial for successful citizen science and ongoing participation and involvement in the project.

Evaluation in the project also happened in co-evaluation with former participants in the codesign workshops, different members of the SOD project team, and with me as ethnographic researcher. This meeting with prospective users was on one side focused on improving the implemented design, but also to create a meeting point between different voices. In my notes I have describe the purpose with the evaluation:

> With this evaluation we seek to create an understanding of the participants' interactions and knowledge exchanges with each other. In addition, the project seeks to create insight into the current version of the web application, in relation to functionality, content, structure, layout. Finally, the project seeks to open up a dialogue between potential participants in the project and members from the SOD project team and the research environment at CMEC.

The evaluation session in Fælled Parken in Copenhagen served as a meeting place for different understandings and knowledge forms; on one side, the lay knowledge, and on the other, the scientific perspective of the project team. However, also, it made it possible to follow what people did with the SOD app, how they interacted with each other, what they were curious about, and what they thought about the app. Hence, rather than evaluating the technology's functionality, the evaluation session created a possibility for making different voices heard and opinions and agencies to come together. E.g. one of the participants tell us that she finds it disturbing that she could not control for how long she could record sound:

Christine: My dictaphone allows me to control how long I can record sound, so I find it a little annoying that I cannot do the same with this app. The microphone on my mobile is not very good, so I prefer to use an external microphone.

Niels: do you think that recording poor sound quality will prevent you from participating?

Christine: I will feel that my contribution is insufficient because I am contributing with inadequate sound material compared to what I experience.

This example demonstrates that feedback from prospective users is critical for improving the ongoing designing of the CS project. Christine is used to record sound of proper quality and she is used to have more control with her sound recordings, hence she feel somewhat disempowered using the SOD app for sound recording. Moreover, she points out that being capable of contributing with proper sound quality is essential for her involvement in the project. From this perspective the example suggests that long-term collaborations with citizens hold potentials for thinking outside of the technoscientific frame of the CS project through which the project team and the participants are all shaped and modified. In addition, it allows participants (and the project team) to see themselves within the design they have a stake in. Furthermore, there are new possibilities for making immediate changes to the prototype. Finally, the evaluation demonstrates that digital artefacts are never finished even one month after project launch.

The third example with evaluation in the project considers co-evaluation with a dedicated citizen scientist Louise (pensioner and data collector) who have been engaged with the project from its very beginning to its end, and experienced most of its flaws, exclusions and possibilities for participating in meaningful scientific research. In chapter 5 I make an analysis of this process, so here I will just point out how it

was arranged and what the benefits are in terms of learning about the implemented design, and how it effects citizens possibilities for enacting scientific citizenship, and for contributing to scientific research.

During the development of the project, I had noticed the participation from some of the main contributors in the project, Louise was one of them, and in the summer 2021 I took contact to her, initially just hear about her experiences with the project, and why she participated in the project. Hence in my first email I just asked a few questions concerning her participation. This however started a small dialogue which ended with me asking if she would participate in a collaboration around evaluation of the project and participation in writing a paper about it. My idea was to follow how the projected materialised from the perspective of the participants, and how their engagement and agencies or possibilities for agency was influenced by constraints and boundaries of the project. Moreover, Louise provided me notes form her diary that described her experiences and experiments through the project's lifetime, both the things that worked well and what was interesting, but the diary also demonstrated that the project had technical issues that excluded particular practices from materialising. Hence, it opened up a process of relational evaluation where new relationships between the researcher and the participants started to be established from their mutual engagements. To me it demonstrated that there is still much to gain in terms of learning to develop more responsible forms of citizen science engagement. Perhaps I see the very idea with collaborative research is "to be in touch, in ways that enable response-ability" (Barad 2012, 208), and to ask questions at every phase of the technoscientific process. In that regard there are many situations and processes in the development of the Sod project that could be questioned and rethought. I will further reflect upon that throughout my analysis in Chapter 5.

04.03.05 Empirical materials and data collection

Data collection

Tabel 2. Participatory design and ethnographic methods

semi-structured interviews
ethnographic observations + listening

sound recordings
field notes (design journals + sound maps)
participatory design practices
netnographic studies

The combination of participatory design with ethnographic methods provided the opportunity to study the practices and contexts of prospective citizen scientists in a co-design context (Blomberg and Karasti 2012), and as codeveloper and member in the SOD project team, to explore and experiment as part of the material-discursive practices in the digital development process. The participatory design context created a setting and meeting point between expert knowledge and lay knowledge in which it became possible explore and describe the material practices and actions of the participants (Bødker and Kensing 1994) e.g. what people did during their sound explorations at Amager Commons, what they talked about, how they engaged with one another and the environment, which helped me to explore different approaches to sound mapping, listening practices, mobile “use” (Redstrom 2008) and engagement in the citizen science project. My entanglement with the specific co-design process made it possible to explore citizens’ actions, doings, decisions, thoughts, ideas, expectations, their disagreements, their concern and passion for nature, their enactments, makings, expectations, and participate in their discussions as part of the group’s participatory design and sonic practices. Hence, my ethnographic approach in the PD context opened for new possibilities to follow the material, affective and relational doings of the group. I documented this process through sound recordings, participant observations, by asking questions and elaborating on findings from earlier workshops, through engaged and “participant listening” (Gerard Forsey 2010), and through my engagement in and enactments with the group.

As detailed earlier in this chapter my involvement in the SOD project/ developer team and therefore the digital development process, made it possible to explore the digital development from close and gain ethnographic knowledge about the material and discursive practices that co-constituted this process and

shapes the becoming of the digital mobile app. With a focus on studying how to design citizen science engagement that strengthen civic capacities through co-design activities, my role in the project team became one of acting “as a bridge” between the project team and the citizens (Hughes, Randall, and Shapiro 1992).

Knowledge and practices from the participatory design workshops of people’s sonic engagement and concept developments, was interpreted and transformed into more tangible prototypes such as digital and interactive protypes of the mobile app’s interface and the forum. By focusing on peoples’ actions and doings and their engagement and designing with one another, knowledge of their epistemic practices, needs and curiosities was developed which guided my own design activities and the knowledge I shared with the project team. Hence from this perspective, I was acting on behalf of the participants around the development of more responsible forms of citizen science communication.

In my explorations of the implemented design and the citizen science communication in the project, I adapted a netnographic research approach (Kozinets 2017; Kozinets 2015) combined with virtual ethnography (Hine 2000), as a general approach to study the techno scientific apparatus of SOD and how people communicate with one another across SOD’s communication channels. What are people talking about when they participate in CS? How do they participate and communicate in the project? What technologies are they using in their engagement with the project? Hence the netnographic approach allowed my to study the material discursive practices of the entire technoscientific apparatus and the possibilities for human and nonhuman agencies and how these are reworked throughout the project.

The netnographic approach allowed me to explore and focus on instances of citizens’ communicative actions and how this communication unfolded across SOD's communication channels: a community forum, a Facebook group, and email correspondence with participants, and between members of the SOD community. By analysing the citizens’ digital communication, it became possible to explore how the technoscientific structures take part in shaping the bodily production of knowledge and the formation of epistemic subjects. The descriptions and experiences described by the contributors revealed their agencies, epistemic practices, experiments, social ties, and different styles of reasoning (Mahr 2021, 38). They allowed exploring, identifying, and making comprehensible the technological environment's affordances, the possibilities, and limitations it introduces in the CS project, as well as its influence on people’s epistemic practices.

Empirical materials

The empirical materials of the Ph.D.-project (see table 3) include 8 transcribed interviews (1 hour duration). Extracts from a citizen scientists' notebook. Transcribed sound recordings from the design workshops (12 hours). Design journals + sound maps from the workshops. Field notes from participant observations of the sound explorations in the participatory design workshops, including video and photo materials, and finally interactive digital prototypes.

Tabel 3. Overview empirical materials

Empirical material	**Format**
extracts of diary notes	document
transcribed interviews (9 hours)	document
design journals + sound maps	documents
field notes from participant observations	Video + photo + documents
transcribed sound recordings workshops (12 h)	documents
interactive digital prototypes	digital artefacts
digital communication across SOD	documents
field notes as co-developer in SOD	documents

04.03.06 Data analyses

My data analysis is based on data collected in my participatory design workshops, semi-structured interviews, and netnographic studies of SOD's communication channels. I am interested in the significant

events that capture intra-actions and communication between citizens and communication officers across the CS project's communication channels since they can reveal how volunteer contributors' communicative actions and epistemic agencies are constituted, shaped, or excluded in intra-action with the mobile platform, project protocol, and AI system. My analysis draws on Braun and Clarke (2006) and their inductive thematic analysis, which presents an organic approach to data interpretation by allowing theming across the entire dataset and by naming themes based on the data themselves. To illustrate how the data are qualified for each theme, I use direct quotes (translated from Danish) based on coded data sections. The coding process consisted of 1) orienting myself to the data and categorizing it early on. 2) creating codes for each theme through preliminary open-coding in NVivo. 3) searching for themes and making notes around potential main themes and initial thoughts. In keeping with a grounded theory approach, I used memo-writing to reflect on my data, ideas, and emerging categories throughout the design process (Charmaz 2014, 162). Early examples of my codes include anti-programs, technological limitations, exclusion, data quality, and uncertainty. From this process, I created closed codes (Charmaz 2006), categorised, and reduced the codes; 4) reviewed themes: comparing codes with coded extracts for each theme and across the data set. 5) Define each theme. 6) Write an analysis based on selected examples.

04.04 Critical reflections on methodological approach

Reflecting on the entire digital development process in which my participatory design experiments unfolded, I see three directions for improving my methodological approach that could improve the outcome of both my own research but also the outcomes of the SOD. Firstly, my participatory design workshops could have strengthened the democratic capacities in the overall design process to a higher extend if its integration in the digital development of SOD had been prioritised alongside technoscientific development. One of the strengths of adapting a participatory design approach is it capacity to establish a meeting point where different knowledges and understandings can meet, recalling from Binder et al. (2015) the democratic codesign experiment can work as a platform for dialogue, disagreement, exploration of alternative futures, ways of being and directions for “emerging publics” (se eART1).

Hence, a better integration of the participatory design approach with technoscientific development would have created new possibilities for long term collaborations, more quality intra-actions between

members of the public and the project team, which could have challenged and questioned the technoscientific priorities in the project. Which can be summarised as follows: 1) the system must be capable of fulfilling the project's research goal. 2) the collected data should be consistent and of direct use for improving the AI system. 3) the mobile application should be simple to use, and user activities should be meaningful to sustain user involvement.

Following from this understanding, the entire technoscientific apparatus is designed and configured to serve the production of scientific knowledge and technoscientific development, through the creation of meaningful digital engagements members of the public becomes gears in the apparatus of bodily production that reconfigures the scientific citizen as functional parts of the CS project according to the project protocols of the project and to accomplish specific research goals. In this context more participation in the scientific process is not the solution to enhance citizens democratic capacities. However, increased possibilities for influencing the very decision-making from the inside of the digital development process through codesign activities, and as follows the very production of scientific knowledge, hold crucial potentials for rethinking science-citizen relations by reducing the gap between expert and lay knowledge, and for establishing more responsible forms of scientific engagement.

Secondly, establishing closer relationships between the CS project and the participants in the CS project, could contribute to a reconfiguration of the scientist's perspective on the users in order to acknowledge the strengths of lay knowledge and see it as a potential for developing new futures, rather than something that should be constrained and organised according to particular protocols and research questions. Moreover, the scientific citizen could have gained more knowledge and a better understanding on their own participation and direct involvement in scientific knowledge production and digital development of the SOD mobile app and created better understandings on how their data is beings used in scientific research, how their contribution matters. If we can accept that the entangled apparatus of which we a part are reconfiguring our very being, practices, or imagination and institutions and possibilists for acting as

citizens in a modern knowledge society, then the scientific citizen should be involved in more aspect of the design of the citizen science project as they can ask questions that would otherwise be missed.

Thirdly, inclusion of underserved groups in different aspects of the codesign process could have opened for a more diverse discussions on and experiments about how people would like to engage with scientific research in a national citizen science context, which is somewhat neglected in my participatory design process even though I have focused on gathering people from different social groups in the recruitment process. such a reframing in the recruitment process could potentially contribute with new perspectives on CS development and especially ion the very participation in citizen science where white middleclass people are the most represented groups.

04.05 Conclusion

In this chapter, I have outlined the Ph. D.-project's methodological design approach and described and discussed how it unfolded as part of the design collaboration with prospective citizen scientists and the SOD project team, and external developers from A15. Based on my involvement as part of the participatory design workshops in collaboration with citizens, it became clear that a participatory design holds potential for integrating other forms of knowledge and matters of concern that otherwise would have been missed if citizens had not been involved in the material practices that constitute the design process and the implementation of the design. However, my critical reflections also suggest that the co-design process could have been elaborated to later phases of the design process to ensure that citizens' voices, ideas and concerns are integrated into the implemented design. However, co-design could have helped elaborate on the concepts and ideas in their initial state instead of being pushed to the final prototypes to implement directly. Moreover, the coevolution with a citizen scientist, if it were undertaken earlier in the process, could have helped to make the project's technical issues and shortcomings visible; furthermore, it could have helped to make citizen voices visible and their problems of concern. Finally, an increased focus on diversity in the group of invited participants could have been elaborated to consider underserved social groups to enhance diversity in the co-design workshops and support other voices that are otherwise missed. In the next I will continue with the analysis and discussion of the Ph.D. project.

05 Analysis and discussion

In the following analysis, I outline the Ph.D. project's key findings based on my embodied experiences as an ethnographic researcher and co-developer in the citizen science project Sound of Denmark. I am to present key findings and new knowledge and understandings on how to design more responsible forms of citizen science communication in a citizen science context that serves both contributory and democratic interests. I start with an analysis of my participatory design process that builds on my design collaborations with citizens. Through the concepts of Karen Barad I continue with an analysis of SOD understood as and technoscientific apparatus. I continue with an analysis of the scientific citizen. The different themes are analysed and discussed as follows:

- Designing with citizens (see article 1, for elaborations)
- Machinic agencies and technoscientific apparatuses (see article 2)
- Enacting scientific citizenship: entangled responsibility and enactments of concern (article 3)

05.01 Designing with citizens

05.01.01 Introduction

The purpose with this section is to investigate and discuss how a participatory design approach and co-design activities with prospective citizen scientists can create new knowledge on how to design more responsible forms of citizen science engagement. In the following I will analyse and discuss key findings from my codesign workshops and sonic explorations with citizens to demonstrate the potentials of adapting a participatory design approach in a citizen science context and create knowledge on how such an approach can contribute to new knowledge, practices and insights that strengthens citizens capacities to act. Key findings emphasise that design collaborations with citizens can activate a plurality of critical voices that raises questions about participation and democratisation of science.

05.01.02 Exploring sonic engagement through codesign activities

Throughout the design workshops my focus was on following citizens material-discursive practices during the workshops, that is during their sound explorations and sound mappings, dialogues, negotiations, sketching, scenarios creation and collective processing of ideas. I wanted to understand what constitutes citizens different forms of engagement and communication in citizen science, specifically how new dialogic relations, exchanges and voices are constituted through design collaborations. In the workshop, I wanted to investigate how a participatory design approach can empower citizen agencies and contribute to the development of more responsible forms of citizen science (see article 1).

As stated in the methodology section, citizens participated in a five phase codesign workshop that made it possible for them to concretise their ideas about sound, sound mapping and also to put words on sound, discussing sounds, and soundscapes, play and exploring with sound, because through these practices and people's engagement with sound my hope was to open up for a broader discussion about sound and soundscapes that goes beyond the interests and protocols of the CS project to challenge the scientific perspective and understandings of sound within SOD. My focus was to explore new possible forms of sonic

engagement and epistemic practices that both enhance people's capacities to act and contributes to the scientific process.

Throughout the workshops, my role as participant ethnographer provided me with an opportunity to learn how sound and sonic practices can act as a medium for our collective discussions, ideas, interests, and imaginations about sound, local soundscapes, and how we interact with sound in everyday life. From this perspective, the workshop and our design collaboration opened new opportunities for sonic engagement. In this relation Voegelin (2021) argues that listening and soundscapes, can propose alternative views on how we live in the world and suggest possibilities for inhabiting the world differently. She writes: "sound slices through the visual frame and organization to propose others: temporary, invisible, and ephemeral re-framings that demand our participation and re-frame the listener also" (2021, 22). Sound then, holds capacities for engaging and reframing the perspective of the listener. Voegelin declares that: "Sound as a concept invites us into the materiality of things, not to deny the visual but to *augment how we might see*" (Voegelin 2018, 47).

For Voegelin (2021) sound is an aesthetic practice and a possibility for seeing the world differently. Not only does it reframe the listener, *but the listener is active engaged in inventing temporal sonic places things and environments*:

> Listening as an innovative and generative practice, as a strategy of engagement that we employ deliberately to explore a different landscape other than the one framed by vision, and it is cultural vision that I refer to here, grants us access to another view on the world and on the subjects living in that world. It shows us the possibilities of sound, that which could be, or that which is, if only we listened (2021, 12).

Hence, from this perspective citizens' sonic engagements and agencies suddenly propose other ways of thinking about and exploring the possibilities of sound, listening and soundscapes that on one side holds

potentials for designing new forms of participation in SOD, and on the other challenges and contests the project protocols and the project's scientific focus (see article 1).

During the early steps of the design process, our focus was on exploring the local soundscapes with our mobile phones, doing listening, collectively and individually and not only to explore possible forms of usage (Redstrom 2008), but rather to develop new ideas, concepts and alternative forms of knowledge concerning sonic engagement in SOD. As part of this activity, the participants were asked to explore the local soundscapes and create detailed sound maps with descriptions of the sounds and the soundscape they found exciting or disliked (fig. 7). As part of this activity, participants described how sound affected them and what thoughts and sensations they experienced. In this context, the objective of the empathy phase was to establish a base for subsequent discussions about sound and what sound means to people as a prelude to thinking about possible concepts and sonic forms of engagement in SOD.

Some of the initial ideas that emerged from our sonic explorations and mappings of the landscape at Amager Commons (Amager Fælled) was that the participants wanted to "learn about their local soundscapes", "raising [public] awareness of the necessity and conservation of nature", "create understanding of health-promoting sounds", and "sound travel with others". For others, sonic engagement was about social aspects and playfulness with their friends (see fig. 6). Throughout our sonic engagements with the landscape, collectively through our discussions, materially though the making of concepts and sketches and scenarios, our different forms of sonic engagement became a way to express, discuss, contest, and negotiate ideas and knowledge collectively and relationally in exchange and under influence by the sonic landscape.

During the workshops at Amager Commons, through our intra-actions with the environment, its sounds and soundscapes, our discussions during and following the sonic explorations and sound mappings, it became obvious to me that some of the participants had a special relation or affinity for the natural environment at the commons that emerged from their desire to protect the species and the natural environment. Hence, as I will demonstrate in the following section, their association with the commons involves both political and ethical forms of epistemic practices and engagements.

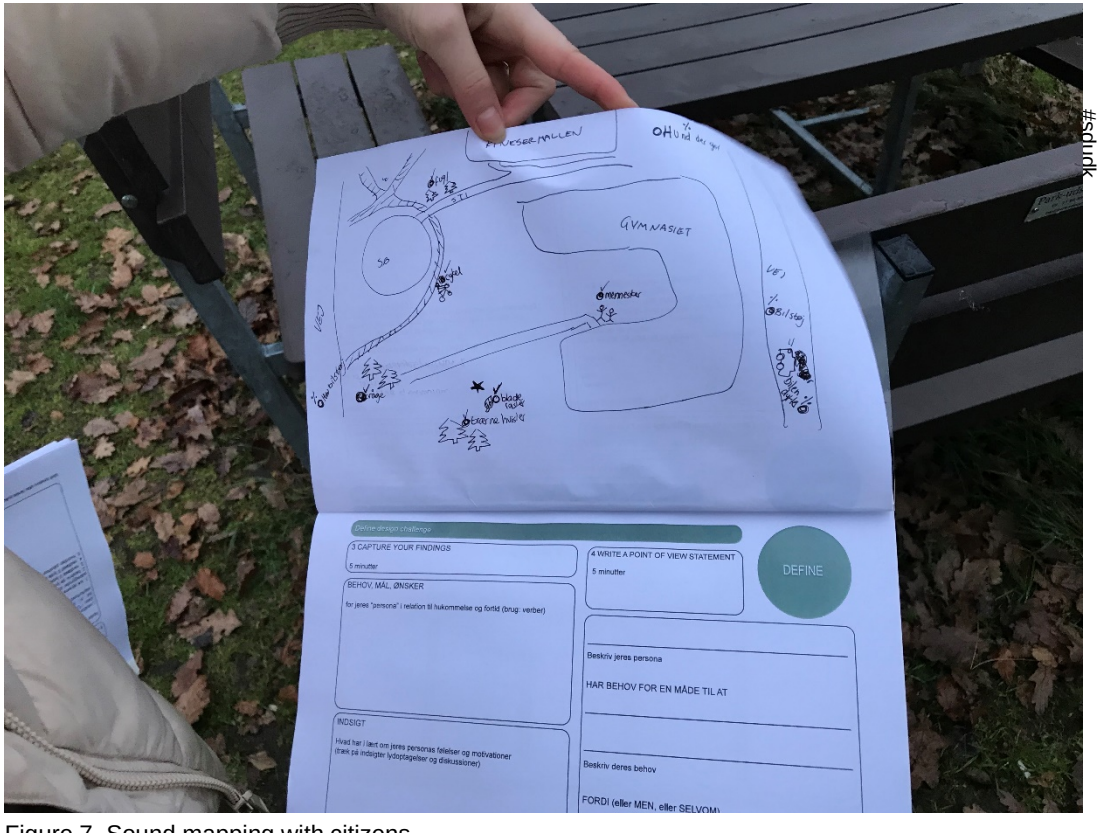

Figure 7. Sound mapping with citizens.

05.01.03 Citizens bring attention to public matters of concern and care and responsibility for these

Throughout the workshops and the sonic experiments, I learned that citizens bring attention to different matters of public interest and care and concern for these. Making sketches and listening to the participants' actions during our sound mapping of the local landscape led them to ask new questions and explore new directions. As Mads comments: "How can we be together around this?" – and emerging from our concepts and sketches: "How can we develop a sound community that connects us with other people and nature so we can be free?". Finally, as stated by Joanna during our sound mappings at Amager Fælled:

> It was great going out again [second round of sound mapping] because you get the opportunity to go one step further into the sounds again, and [asks herself] what do these sounds mean to me? In the end, I have experienced and accepted that I am not [walking in the forest] in Gribskov; I have to accept that I am in Copenhagen [Joanna uses the forest's soundscape as relaxation]. That is also the reason why we must preserve Amager Commons because we need this place. How would it be to live in Copenhagen without Amager Commons, without this natural area? It is terrible if we do not preserve nature and other breathing spaces like these, I will not be able to survive without them.

The participants' questions and engagements to protect the commons initiated new discussions and negotiations. They shared their thoughts, experiences, feelings and interests, and expressed their concern about public matters, and why it was important for them to preserve the natural areas in Copenhagen. One of the participants Joanna suggested, that listening can open for new ways to connect with the natural world and participate in SOD: "If you establish a relationship with the nature around you, then perhaps the feelings [desire] to protect it are also awakened; it should be locally anchored so that people take more responsibility".

Design collaborations and practices of collective listening can encourage citizens to express and discuss their concerns to bring their personal interests, perspective and local knowledge into play. Citizen listeners bring attention to important and local matters of concern, as well as care and responsibility for

these, such as protecting the natural are Amager Commons, which is threatened by the municipality-led urban development and de-conservation. Their epistemic practices are opportunities to go beyond the focus of the scientists and the CS project. Materialised through practices of listening, citizen agencies hold the potential to be politically active in the world. This is not my argument for abandoning expert knowledge but one of challenging scientific objectivity. According to Irwin scientific objectivity needs to be challenged, hence we need to reconstruct our understanding about science-citizen relations and acknowledge the possibilities of wider sources of knowledge and alternative understandings (Irwin, 1995, 95).

05.01.04 Activating new voices and ethical practices through co-design

Key findings from the workshops at Amager Commons demonstrated that co-design can be and active and collective way to speculate on, negotiate and rearticulate ideas and develop responsible ways to protect and reconnect with nature through collective forms of listening (see article 1, for elaboration). Christina (Activist, Friends of Amager Commons) reflects on the political and ethical possibilities of sound:

> If more people become aware of the soundscapes out here [at Amager Common], then it could be a legitimate input into the political debate, where right now it is money that is the input [shaping] factor, [...] but only if there's also a part of the political conversation that's about what kind of soundscapes we'd like to have in our city. I often think that within the next 10 years, we will become more aware of the energy landscapes we have. What kind of landscapes do we want? What kind of energy and soundscapes do we want in the city? It is not legitimate to talk about [it] in the political debate today.

This statement emerges from a passion for nature and community work with Friends of Amager Commons, through which she and others (e.g. Extinction Rebellion) fight for the protection and the conservation of the natural area Amager Commons. Christina suggested listening as a form of engagement that increases

citizens' awareness by bringing public attention to Amager Commons, and that serves as a critique of the municipality's plans to de-conserve parts of the commons, to activate a plurality of different voices and asks new questions: "What kind of soundscapes do we want in the city?".

These key findings underpin that a co-design approach in a citizen science context can help to activate new forms of engaged listening, new ways or reconnecting with and protecting the natural environment at Amager Commons, and new ways of doing and bringing about possible futures and ethical forms of engagement. Taken together these examples reveal that design collaborations can help to initiate citizen-led forms of ethical listening and engagement that strengthen both citizens' democratic capacities, scientific agendas, and cultivate new sites of communication. Finally, co-design might be recognised for its potential to create and image new ways of enacting citizenship.

The examples in this section demonstrated that meeting points between communal agencies and a co-design approach could serve as spaces for actualising new democratic possibilities that intra-actively influence and moves the conversation and new visions forward. Dialogical perspectives on design collaborations with citizens holds significant potentials for enhancing participatory, critical and collective thinking in CS, that consequently challenge the expert mindset by giving participants more power to influence the early decisions in the design process (Bratteteig and Stolterman 1997), the design outcomes (Sanders and Stappers 2008), technoscientific development, and ultimately what is considered factual knowledge. Co-designing with citizens can advance alternative forms of listening and ethical engagement and help to nurture affirmative relations with other participants, researchers, and the natural world. Consequently, it can help to inform new ways to activate a plurality of different voices (Bickford 1996), cultivate new spaces for communication, strengthens citizens' democratic actions and finally contribute to new areas of citizen-led research.

The key findings emphasised that citizens bring attention to different matters of public concern and care and responsibility for these (see article 1), accordingly they are involved in the shaping of social and cultural life, local communities, institutions and the broader society. Citizens bring different matters of concern and ways of knowing and doing into the design process, which include embracing the situational, uncertain and difficult aspects of co-design and participation (Andersen et al. 2015). As a result, design collaborations offer vital possibilities for exploring alternative perspectives on participation and democratisation (Björgvinsson, Ehn, and Hillgren 2010) in the CS context. They are opportunities for exploring

"conflicting intentions" (Buur and Larsen 2010, 136) and for developing a new "emergent public" (Binder et al., 2015, 153) of critical listeners who challenge and question dominating and repressive structures in society (for elaborations, see article 1). Hence, citizens' epistemologies and epistemic practices can contribute to the transformation of more governing technocratic and scientific views to more collective and relational ways of designing and being - of being communal (Escobar 2018, 225–26).

05.01.05 Learning from citizens critical engagements

Key findings demonstrate that citizens sonic engagement with the CS project from the initial design phase throughout the lifetime of the project can create new insights for the SOD project team about the design of the project, how participants engage themselves in the citizen science project, that is: how and why they participate, communicate, and involve themselves in the project and contribute to the production of new knowledges and understandings in the project, but also how they are epistemically constrained from contributing to the project. Following citizens material and discursive practices across a citizen science project can shed a light on how to design more responsible forms of engagement by incorporating the volunteer contributors' diverse insights.

The following examples draw largely from citizen scientists' diary notes, their descriptions, emails, and communication with the project. They highlight how citizens ongoing questioning, contestations, and critique of the project's issues and shortcomings – throughout the design iterations of the project – hold important resources for developing more responsible forms of citizen science engagement that functions as a critical voice and part of the project in its ongoing development. In all this I take the perspective of the volunteer contributors to clarify the apparent potential of forming stronger relationships and collaborations and co-evaluations with citizens.

In an email to the project's communication officers, Sine describes her experiences and problems with sound recording and data uploading to the project, and how these issues affected and restricted her options for contributing to the project's sound registration:

> Dear Sound of Denmark, I have had a lot of problems both with recording and uploading sound over the last weeks – I guess that it has costed me 30-50 recordings with the following two errors: Sound recording: I start the sound recording, but it does not record and instead of a 30 second countdown it just says 00:00:00 and nothing happens. Upload: When I have recorded and tagged and then press 'upload your sound', the image [processing image] just spins for several minutes until I give up the sound registration and press cancel in the top corner and leaves. I let it try for 2-3 minutes with nor result. This is both when I have wi-fi and when uploading mobile data. I have a OnePlus 6.

The examples demonstrates that the volunteer contributors' feedback can be helpful in identifying technical issues concerning sound recording and uploading to the project that have not been solved across all mobile devices. For Sine the implications of the technical issues were that all her work and time spent sound recording were lost, because of this she was unwarrantly excluded in her epistemic practices and possibilities for contributing to the project's data collection and for sharing epistemic resources with others.

While the example demonstrates how several participants have experienced the use of the SOD app, and how technical issues have prevented or limited their possibilities for engaging with the project. It says les about the potentials of establishing stronger relationships with dedicated citizen scientists and how these can make visible not only a project's technological issues and shortcomings that affects citizens capacities to act, but also how citizens' active engagement with the project involves questioning, contestation and critique of the scientific process, data quality and project protocol. To establish a meeting point between different forms of knowledges and understandings we first of all need to acknowledge the diversity in citizens knowledges, practices and understandings, and secondly, we need to establish communication channels that makes science-citizens exchanges possible.

In attempt to establish closer relationships between citizens and the design of the project, I tried to involve citizens in the design process from the early start of the project to integrate their diverse forms of knowledges, understandings, needs and values in the overall development process; but also in the later phases of the project, aiming to evaluate on the implemented design and how it gives shape to epistemic agencies, exclusions and create boundaries and takes part on the formation of epistemic subjects.

I contacted one of the more dedicated participants in the project who have participated in the project since is its beginning and launch in Dyrehaven in Denmark April 2019 until its end in 2020 when the Covid19 pandemic was spreading worldwide. In the beginning I was merely curious to hear about her experiences with and participation in the project. Nonetheless, our mail correspondence led to further exchanges and with Louise's acceptance my examinations of selections from her diary notes that documents her participation in the project with all its deficiencies, thoughts, experiments, and communication with the project.

Through Louie's communication with the project and her documented experiences, I learned that Louise is not merely a dedicated citizen scientist but also a former geographer who participates in other CS projects as well. Her engagement with the project demonstrates that she is tirelessly questioning the project's approach and practices and regularly providing feedback about her experiences with the SOD app and the different technical issues she is discovering:

> Another example of discrepancies between my personal sound map files and the overall sound map. I was in Dyrehaven yesterday and on my way from the station to Bakken I recorded two sound files, just inside the garden where a guy was playing the accordion. I immediately deleted the two sound files because the sound quality was poor. My personal map has no sounds on this location; however, the overall sound map has the two sound files that I deleted. The screenshots show that it is me who is user: rb_13 on the overall map. I have just made the two screenshots and I have cleared the cache in advance [to prevent upload from freezing]. Hence, there are inconsistencies between the two maps. In addition, I cannot delete my personal sound files again.

Louise's sonic engagements with the SOD app makes visible that there is a mismatch with the project's data visualisation on the overall map, that there might be a problem with poor sound quality in the project, but also Louise's actions demonstrate that participants are not provided the options to delete the files on

the overall map themselves. These findings demonstrate that citizen's experiments and following feedback to the project can be crucial for identifying technical issues and improving the user experience, which demonstrates that there is a need for direct communication between the project and the citizens. However, designing for citizen science communication is also crucial for strengthening citizens voices and agencies as the following two cases demonstrates:

> In my case, the motivation for participation was that I thought it could be fun to find typical Danish sounds. It was what the title: "The sound of Denmark" inspired me to. I tried to ask that question to other users in the forum, but there was no response at all. So, it was obviously just me who had that curiosity. It could have been fun with some ideas or suggestions from others, but there was obviously no interest in that. I do not know if it would have gone better on Facebook, I doubt it though (notes from Louise' diary)

> I was not happy with the quality of the sound recordings with the phone's built-in microphone, so I purchased some external microphones that significantly improved the quality. I posted a photo of my Boya microphone in the project forum, but there were no reactions, neither from other participants nor from the people behind the project; that was probably a little strange for me to experience. As if you would rather have recordings where you just used the phone's microphone. Why is that? (notes from Louise' diary)

These examples suggests that citizens have a need for raising their voices and concern about the project's shortcomings and inadequate sound quality that affect their engagement with the project, and for sharing their interests, motivations and participation in the project. While people share their experiences, interests and their epistemic practices and the tools their use for participating, they also expect or hope that someone from the community including the scientists will respond to their questions. The lack of responses to Louise's questions and threads in the community forum, not only suggests that the communication with the community of volunteers needs to be strengthened; the participants are also constrained in their epistemic possibilities for being heard, and for sharing epistemic resources with others because no one responds to her requests. The lack of feedback from the community is likely to reduce her motivation and participation

in the project over time. Because as Hecker points out: “Long-term citizen science projects need ongoing collaboration and, therefore, communication to inform, motivate and engage participants” (Hecker et al. 2018, 448).

The poor sound quality that affects participants engagement with the project, and Louise’s purchase of microphones suggest that there is a need for more dialogical interactions between the participating citizens and the scientists, to avoid that volunteer contributors start following their own agendas that diverge from the protocols of the project that specifically constrains people to use their mobile phones for sound collection only. Direct communication in form of feedback from the communication officers can not only help people to stay motivated but also inform people about the importance of following the project protocols. On the other hand, citizens actions and the tensions, they create by following their own agendas (Kasperowski and Hillman 2018), also challenge the science and data quality of the project because the participants want to do better and contribute with data of higher quality.

The examples discussed so far demonstrate that citizens, through their epistemic practices, experiments, and engagement with the CS project, can provide essential information about the shortcomings of a project. They show that citizens are making their voices heard and communicating and sharing their concerns, interests, and participation with others around a joint venture. By following their agendas to improve the data quality in the project, citizens not only create tensions in the project but challenge and question the project's scientific approach. Moreover, the results point out that citizens' feedback is crucial for developing more responsible forms of CS that potentially strengthen collaborations and exchanges between the citizen listeners and the scientists to enhance data quality and knowledge production. Finally, key findings demonstrate that by establishing stronger ties with the people we study in a citizen science context throughout the design of the citizen science project, it becomes possible to further our knowledge about citizens' engagement and their epistemic capacities. Finally, the cases demonstrate that by establishing closer relationships with the people we study in a citizens science context, throughout the design of the CS project, it becomes possible to further our insights about citizens' engagements and why these

need to be accepted as essential resources and contributions to scientific knowledge production and for designing more responsible forms of citizen science engagement.

05.01.06 Conclusion

In summary, my key findings showed how participatory design could be combined with an ethnographic approach to sound and listening (see methodology chapter) to strengthen both civic capacities and scientific research by utilizing citizens' agencies, their concern and care about local matters, and their diverse epistemic practices. With regard to citizens' diverse forms of sonic engagement and their capacities to raise their voices and draw attention to public matters of concern as well as their responsibility for these; my results point out the need for establishing more substantial and more responsive relationships with communities that not only acknowledge their diverse forms of knowledge and practices but starts from citizens desires and their awareness for blind spots. Furthermore, this study has demonstrated how participatory design can advance new democratic possibilities and affirmative relations in citizen science by involving citizens in creating tools, processes and communication that are central to scientific knowledge production. Furthermore, these results illustrated that citizen insights, experiments, questions and critiques are crucial in pushing a CS project's ongoing development in a more sustainable direction since they can help capture how different boundaries and structures exclude or limit peoples' epistemic agencies. Furthermore, all the examples point out the importance of developing strong citizen-science relations that make it possible for people to contact communication officers about their matters of concern and their technical issues. Thus, participatory research can benefit scientific communities and equally empower a plurality of critical voices among the public, contributing to the protection and the conservation of natural environments.

In the next section, I will switch to an analysis of the citizen science project's performative agency to show how the project's design both enables and unwarrantedly excludes or constrains people from participating in scientific knowledge production.

05.02 Machinic agencies and technoscientific apparatuses

05.02.07 Introduction

In this section, I will analyse and discuss how machinic agencies are reconfiguring and intra-acting with human agencies to inform their engagement with the digital platform of SOD. Hence, I will elaborate on key findings mainly from (Article 2 + 3). My aim is to make visible the unjust epistemic constraints, exclusions and boundaries that are produced/constituted and takes part in shaping community members' capacities to act and enact as citizens and epistemic subjects in the project. Overall, I argue that we need new knowledge about the different human-nonhuman material-discursive practices that takes part in this shaping of epistemic agencies, and the production of subjects and scientific knowledge.

05.02.08 The technoscientific apparatus of bodily production

In the following I will investigate and refer to the citizen science project The Sound of Denmark as a technoscientific apparatus of bodily production through which different agencies, desires, knowledges and practices are intra-actively being reconfigured through human and nonhuman material-discursive practices (see agential realism, chapter 3). By focusing on 1) the entanglements of the CS project, 2) the production of human and nonhuman boundaries and relations, and 3) in order to create new knowledge on how human-machine collaborations intra-actively reconfigure the scientific object (sound) of the study, epistemic practices and subjects in the community, and finally the production of scientific knowledge.

My aim is to emphasise that human-machine intra-actions reconfigure what is made possible and impossible by enacting cuts that define what concepts, ideas and knowledges will be realised and which ones are excluded (Barad 2007, 234). I want to make visible the unjust constraints, exclusions and boundaries that are integrated into the design of the SOD's digital platform, to better understand how the performativity

of the design are taking part in the reconfiguration of bodily productions and epistemic agencies. To reconstruct our understandings of science-citizen relations we need an account of the entangled materialisations of which humans are just a part (Barad 2007, 384).

Key findings show that citizens' active and material engagements with the project involves diverse forms of intra-actions with SOD's digital platform (see article 2 + 3). Such as sound recordings of the city sound scape, active engaged listening, enriching data sets with descriptions of the sound scape, helping the AI system with correct tagging of sounds and suggestions of new sounds, uploading sound data, sound mapping, selecting, downloading, deleting, relocating and sharing sounds with the community through the interactive map, and community forum. Moreover, citizen scientists are reflecting critically on the project's sound quality, they share their sounds and discuss sounds with the project's community of volunteers, scientists and communication officers.

These different epistemic practices and distributed agencies are realised and extended through citizens' intra-active engagement with the SOD mobile app. As exemplified by Louise in her dairy and email to the project:

As a diligent sound recordist, I will single out three areas that can improve the data quality of the sound recordings: 1) Speed, the amount of time that passes from hearing an exciting sound to being able to record it. 2) Reliance on stable internet connection 3) GPS accuracy – i.e. spatial data location of the recorded audio.

> 1) I often become aware of a particular sound that could be fun to record but where I still cannot manage to make a recording. Although my mobile is ready with a small Boya microphone, and although I have a shortcut to the Sound of Denmark on my mobile display, starting the sound recording seems incredibly slow when you are waiting to get started. Often, I have to poke away at the recording button to get it going, and I hit too far down on the display, so it changes the campaign instead. This inertia when starting the recorder function is quite unbearable.

> 2) If you are in a location where the mobile internet coverage is vague, the recording is even slower, or it does not start. If you finally get the recording going, it takes a vast amount of time before the robot has finalized the sound recognition. Moreover, once you have provided your answers, it takes a long time to upload and finish the recording – sometimes, you do not succeed. Hence, exciting sound recordings can easily be lost.
>
> 3) I am a geographer specializing in cartography and spatial data, and GIS. Therefore, it bothers me to see incorrectly located data, and not least, where I collect data myself. I have researched many of the sounds I have recorded myself; quite a few are misplaced, but I cannot move them to where they belong. But it could be done because I have often taken a photo and described in the text where the recording took place. I want to sign up as a test subject if you want to develop the user functions further.

Louise is a dedicated sound recordist in her daily life, and she spends a great deal of time exploring local soundscapes with her small Boya microphone and the SOD app on her phone. Based on her sonic engagements she points out three areas that she would like to improve in the app: 1) the app should start up faster to make possible capturing interesting sounds. 2) when there is no internet coverage it takes longer time to finalise a sound recording and upload the sounds; sometimes it is not even possible to get the recording started, hence the interesting sound recording is lost. 3) finally, the GPS location data are incorrect which is disturbing for a geographer. Based on her explorations, most of her data is incorrectly placed on the map and she cannot move their location (in a later version of the app this is possible). Finally, she offers her expertise as a citizen scientist to help with testing of the app.

As a citizen scientist in the project, it is possible to be engaged with the project in multiple ways that goes beyond sound data collection and processing of data. Louise shows the outcomes of her experiments and how technical issues and shortcomings of the project are either preventing or constraining her from

making or finalising a sound recording, and other times it results in missed sound recordings of loss of data because the app will not continue with processing the data upload without internet coverage. In this perspective her epistemic practices and options for sharing and using epistemic resources are limited or excluded from the project. When she finally gets a recording accepted the GPS location of the sound object is sometimes inaccurate which is disturbing for people who care about data quality and accuracy in the data they provide to the project; moreover, she is not capable of changing the location of the data and because of this she is again limited in her epistemic agencies with the project.

Nevertheless, Louise's experiments not only demonstrate that people are epistemically constrained or excluded in their engagement with the project, they also reveal that citizens follow their own agenda that diverge from project protocols and the interest of the scientists (Kasperowski and Hillman 2018), as a way to enacts responsibility and care for the project because they wants to contribute to the improvement of the project and the quality of the data they are providing. In all this, Louise has been consistent with sending smaller reports to the project about her experiences and the shortcomings of her experiments even though the project has not asked her for help about these matters. Moreover, Louise use of the small Boya microphone to improve the sound quality of the project, is also an example of her enactments of concern about the poor audio quality in the project (article 2).

Louise's, feedback points out major issues that other participants have reported in the early but also later phases of the project. Issues that prevented epistemic agencies and participant engagement to fully unfold. Because of citizens intra-active engagement with the mobile app and their ongoing communication with the project it has also been possible for fixing many of the early issues in later version of the app to improve problems with delayed sound recordings, problems with GPS locations and misplaced data points including crucial constraints and exclusions that happens when there is no or vague internet connections. If not all, most of these issues were solved in later versions of the app when the decisions to move from a web application to a native app were decided. From there on people could record anywhere without signal and upload the sounds later when connecting to the internet again.

The possibility to move and sound object on the interactive map was implemented to enhance citizen capacities and opportunities to act. From this perspective, the example emphasizes the importance of strengthening science-citizen relations, and dialogical communication as citizen scientists have capacities to contribute with other perspectives that might be ignored by the scientists (Davies and Horst 2016).

Hence, as Irwin (1995) has pointed out, we need to reconstruct our understandings of the science-citizen relationships and acknowledge the wider sources of knowledge and understanding. And if I may add to this, we need to acknowledge the materials discursive entanglements of which we are all reconfigured in intra-actions with human nonhuman agents. Humans are not the only active beings to account for to reformulate new understandings on how to design for more responsible science-citizen relations. We need new knowledge about the exclusions that intra-actively produced in the CS project and how it gives shape to epistemic subjects and agencies, to the exclusions of others. In the next I will elaborate on this.

05.02.09 Reconfigured though human and nonhuman entanglements

This leads me to the following section that demonstrates how human agencies are reconfigured, constrained and excluded in their intra-active engagement with the project. As we recall from earlier, we are all a part of the entangled phenomena that are materially constituted in the technoscientific apparatus, the scientific tool, that is the SOD mobile app, is inseparable from the apparatus of bodily produce (Barad 2007). Hence a better understanding of how some concepts come to matter to the exclusions of others, can provide new insights on the performative capacities of the digital citizen science project and further, how it keeps on designing unsustainable futures (Fry 2020), epistemic exclusions, that determines what is made possible and impossible because of human nonhuman interactions.

The following mail correspondence between Morten (field recordist) and the communication officers in SOD points out that the project protocol as a structure in the project not only constraints citizen agencies but unwarrantly excludes certain forms of epistemic agencies and knowledges to be shared in the community:

> **Morten:** I have made some sound recordings in Bulbjerg (with a good ORTF stereo mic system not with a mobile phone). Would you be interested in such material for your project? You can listen here [link to his Soundcloud]

Communication officer: Thank you for your contribution and interest. We would like to have your sound recordings, but you will need to use the website www.lyden-af.dk (SOD started as a web app). The website is in Danish, and you need to record outside somewhere in Denmark. You need to stand still and “tag” the sounds you have heard.

Morten: Thanks for your mail. I am not interested in using an app on a Smart Phone to record audio since the quality is very poor compared to the high-end mics I use.

The examples demonstrate that people who are passionate about soundscapes and field recording want to contribute to the project using their own sound archives and personal high-end microphones. However, the project’s protocols set a boundary for this form of engagement because the machine learning system is trained on sounds of lower quality, such as YouTube videos, hence the project does not accept the sound recordings and data collection that involves personal equipment and sound contributions of high quality, hence all participation in the project is constricted to sound recording with the SOD mobile app.

For amateur fields recordists this is a huge limitation on their fully engagement with the project, as another participant Pete confirms: "I do not have a smartphone, but a Zoom H5 sound recorder and a PC. It will be an unnecessary limitation if only those with a smartphone can participate". These examples emphasise, together with the experiences from Louise, that people want to participate and contribute to the project. While the project protocols permit participation, they limit their options for engagement by rejecting the more diverse forms of sonic engagement and contributions with high sound quality. Consequently, this constraint enacts cuts that may exclude participants who wish to share their experiences, sound archives, and knowledge about sound with the community.

The poor sound quality, which is also hight lighted in the examples above demonstrate that people are experiencing insufficient sound quality in their recordings, which is a major issue that not only influence peoples sonic experiences in the project but also their epistemic practices. As Louise, declares based on her sonic experiments with the SOD app:

> When I got home, I listening to the results and ended up deleting 3 out of 4 of the audio files I had recorded - the quality was simply too poor. On the recording of the train's arrival, it was completely impossible to recognize what was going on. So, I deleted that too.

The quality of the sound recordings is insufficient in relation to the preferences of the participants. Whether they are amateur field recordists of ordinary citizens curious about sound, my findings show that people want to contribute with data and sound of high quality. People are familiar with the lower sound quality produced with their phones compared to their personal sound devices. Hence they either decide not to participate in the project or they start to delete their sounds, because they cannot differentiate the sound objects in their recordings from each other.

In addition to the poor sound quality several members of the community point out that the SOD AI system is incapable of recognizing the sounds in the sound recordings and as a result it provides inadequate feedback to the users. Karin writes:

> Hey, how about telling your computer what the different bird voices sound like. If necessary, use fuglestemmer.dk, so the result will be more accurate. When I recorded the sound of bird voices, the artificial intelligence suggested:
>
> Green Irish = Fenderrhodespiano
> Lark = African music
> Chiffchaff = Jazz muzic
> Blackbird = Harmonica
>
> When sound is recorded by someone who does not know about bird voices, there is quite a large margin of errors and misinformation in the data. But thanks for an entertaining gimik :)

Another participant Louise confirms instances of inadequate sound recognition from the AI system, and describes how it affects her engagement with and possibilities in the project:

> Once the AI has analysed the recording, it makes different sound suggestions. However, there are regular descriptions of sounds that I do not recognize, so I have to use the no-button, even if this means that I do not recognize the sound. Many of these sounds are unknown to me and cartoonish sounds. I cannot recall them, but I miss a sound dictionary where I can listen to the AI system's unusual sound suggestions.

Throughout their intra-actions with the app, the volunteer contributors experienced that the sound recognition feedback from the AI system was incorrect. Not only did the poor sound recognition constrain the quality of their contributions, in combination with the poor sound quality it caused immense confusion for several participants and limited their opportunities for sharing epistemic resources and engaging themselves fully in the project the community.

Louise's descriptions of her sonic explorations in the forest, demonstrate her critical thinking and concern about the limitations that operate through the project, and how citizen's epistemic practices are constantly reconfigured trough their entanglements with the project:

> I tried to record more sounds with the app. It works best when recording offline. It simply takes way too long with the artificial analysis. I am losing my patience. It is easier to add the description of the sound yourself. However, maybe that means the robot is not getting smarter? There is a conflict between user interests and project interests, and I do not like the long waiting time – after all, the AI cannot provide a reasonable description of the sounds.

The example demonstrates how her engagement with the mobile platform and AI system intra-actively reconfigures her epistemic practices and capacities to act. Louise discovers the app works best offline because of the AI system's time-consuming data processing. She expresses her dissatisfaction and is about to lose her patience with the system's slow data analysis and inadequate sound recognition; hence

she finds it easier to add sound descriptions manually. The shift from automatic to manual sound description, a reconfiguration of practice, makes her reflect on how it will affect the training of the AI system.

The technological issues and shortcomings of the project was often something that was pointed out by the participants in the project. While the poor sound quality and inadequate AI feedback was a constraining factor in the project, there were other technical issues that that also affected, constrained and excluded citizen agencies. As Louise points out in a mail to the project, there were also security issues that affected people's engagement and anonymity in the project:

> I see that my email address is the same as my username, freely visible to anyone who sees my sound files. I do not see how I can change this and get a more neutral username. I would like to have resolved this for me personal security soon. If you cannot change my username to something more discrete, I would like to be deleted as user. It seems like I do not have that option myself. I hope you will solve these data security problems soon.

The example demonstrates that people's email addresses are sometimes set as their username when a new profile is created, as a result their identity and personal contact information is revealed to the public. Louise points out that she does not have the options to change it herself and hide her information for the public. This issue is a major limitation of her agencies to act and stay anonymous in her engagement with the project, and enough for her to demand her profile deleted if the security breech is not handled.
Another issue that influences citizens agencies and their possibilities for contributing and sharing their findings, is the possibility to relistening and check the sound recording before it is uploaded, as pointed out by Britta:

> Hi, I think it is a fantastic idea (project), and I would very much like to be part of it. I have already recorded some sounds. In most occasions, unfortunately, *it will not play the recorded*

> *sound, hence I have to write tags from memory*. This means that I might be emphasizing something that does not sound particularly good on the recording. However, I cannot continue without saving and therefore, I can no longer add new tags. I suggest you change the setup and make it possible to add tags for 10 minutes after a recording, so you can listen to the sound after it has been uploaded, and then add the extra sounds.

The mobile app with is technological issues are deliming the participants' epistemic practices and agencies. Participants cannot relisten to their sound recordings before uploading their data, as a result they are prevented from analysing the data, acting and contributing to the project with good quality because they have to add tags from memory which means that the AI is intentionally receiving flawed data from the users; at the same time there are not getting any feedback on their actions and why the play function is not working. The experience is unsatisfactory for the participants, because it affects the quality of their contribution, the uploaded sound recording with metadata, and there for the training of the AI system.

In discussion with the concepts of Barad (2007) who argues that phenomena are inseparable from the scientific tools and the technoscientific apparatus of bodily production (Barad 2007, 208). This chapter has demonstrated that humans alongside machines are intra-actively reconfiguring one another. On one side that the participants help the project with data, analysis, data processing, data collection and enriching data, and they provide important insights about the usability of the mobile app, and important contributions that help to reconfigure the AI system through their sound recordings, suggestions of new sounds and corrections of the AI system, and when they are enhancing the sound quality in their recordings by using their personal microphones with their mobile phones. On the other hand, their bodies, practices and agencies are also intra-actively reconfigured though their material discursive practices of the project's technological environment.

As barad reminds us, the material and discursive operates through one another including the exclusions that are enacted in the technoscientific apparatus of SOD:

> Since the material and the discursive are intra-twined in apparatuses of bodily production, material and discursive constraints operate through one another (the same is true for exclusions), and hence a full consideration of the limits to materialization needs to include an

> analysis of both dimensions in their relationship to each other, that is, as material-discursive constraints (exclusions) (Barad 2007, 212).

As researchers and developers of citizen science this has crucial consequences in terms of developing more responsible forms of citizen science engagement, because insights about the exclusions we are part of designing and enacting as part of the technological apparatus both the insights produced by the communities of volunteers but also the insights produced within as part of the SDO developer team, can help us to create new knowledge about our designs and how they keep on designing unjust epistemic exclusions that restricts participants' epistemic practices and decrease their possibilities to use and share epistemic resources.

One way to move forward and start designing more responsibly and relationally is to understand that we are not the only active beings of the technoscientific apparatus. Or, as Irwin and Michael (2003) states: "we as analysts cannot maintain a separation form the ethno-epistemic assemblages we study, since we provide some of the discourses through which these assemblages articulate themselves (2003, 135). In sum, we are part of the agential reconfiguration of the technoscientific apparatus of bodily production. Therefore, we are accountable for our entangled knowledge practices and the exclusions we enact because knowledge creates reality.

In addition, these key findings emphasize the importance of establishing strong science-citizen relations that makes it possible to communicate with, listen to different citizen voices, and respond to their requirements and concerns. Citizens can contribute with other forms of knowledge that can help to take the project in a more sustainable and democratic direction in terms of developing responsible ways to participate that strengthen citizen agencies and minimises epistemic exclusions in the project.

05.02.10 Conclusion

In this section I attempted to make visible the technological entanglements of the CS project as techno-scientific apparatuses, to understand that both human and nonhumans are actively reconfiguring particular epistemic practices and agencies through their entanglements. This has obvious consequences for us as researchers and developers because we are part of the entanglements that designs and produced unhealthy and unjust exclusions, constraints, borders and power structures. Hence to design more responsible forms of citizen science communication, we need to rethink and understand the consequences of our designing and how they keep on designing epistemic agencies and exclusions. In the next section I elaborate on this chapter by investigating the distributed agencies and enactments of scientific citizenship to demonstrate how responsibility must be understood as a relational practice and enactment that has consequences for our ways of designing and reconfiguring unjust exclusions.

05.03 Enacting scientific citizenship: entangled responsibility and enactments of concern

05.03.11 Introduction

In this section I will demonstrate how scientific citizenship is enacted at different moments through citizens' intra-active engagement with SOD. I will argue that citizens are not merely contributing to scientific research; rather they enact themselves as citizens through their material engagements and matters of concern as an integral part of the project in its ongoing development. I emphasise that citizens' enactments of responsibility and concern for the project, implies an ongoing responsiveness to the project, its data quality, and the production of scientific knowledge. While, former studies of citizenship puts humans at the locus of agency, this section suggests that citizenship is better understood as the enactments and relational doings and distributed agencies of humans and nonhumans (see also, Irwin and Michael, 2003). I end this section by pointing out further perspectives for developing responsible citizen science engagement that strengthens civic capacities.

05.03.12 Enactments of citizenship through matters of concern

Responsibility, according to Barad, is enacted, it is relational and entails an ongoing responsiveness to the human and nonhuman entanglements of which we are part (2007, 394). This implies that we are accountable for how facts come to matter but also the epistemic exclusions, unjust constraints, and boundaries we participate in and enact (2007, 394). The work of Juelskjær et al. (2021) is consistent with this and suggests that we are accountable for the meaning-making practices that enact specific cuts in the technoscientific apparatus and defines what comes to matter, but also for explaining what is excluded from mattering (Juelskjær, Plauborg, and Adrian 2021, 145).

By tracing citizens' intra-active engagements and communication across SOD's digital platform my attempt is to make visible how and through which practices citizens enact themselves, or are prevented from acting as citizens, and how they express their concern about important matters in intra-action with the CS project, the communication officers and other community members. Following citizens' epistemic practices and communication with the project, I understand that citizen scientists are not merely contributing with data to scientific research, rather they are actively influencing technoscientific development and expressing their matters of concern through their active and diverse forms of material-discursive engagements with the project and the project team. While some of these enactments with the project include different forms of sonic engagements, concern about security issues, feedback about technical issues, others are concerned with questioning the scientific process and the project's data quality. Throughout the different cases I demonstrate that citizen scientists – when they follow their own agendas and interests that deviate from those of the project – can produce tensions in the CS project (Kasperowski and Hillman 2018). By doing this they question and challenge the protocols of the CS project.

In the preceding sections, I have already presented a few examples on how citizens enact citizenship, through their involvement in SOD, including how citizens' feedback in a participatory design context can contribute to the development of more responsible forms of engagement. The Following elaborates on these arguments through different examples with a focus on the enactments of citizenship.

Citizens make their voices heard through matters of concern

In an email to the project Louise (pensioner, self-proclaimed data collector) describes her sonic engagement and experiments with the project. She points out that there are technical issues such as in adequate sound quality and feedback from the AI system that affect her experience and engagement with the project.

> The mobile recorder is selective – it does not provide a 'true' sound image. I wrote to you last Saturday about my experiences on Thursday with recording the sound of Denmark. I only left audio file # 1530 of the fountain at Frederiksborg Castle. Then I went for a walk in Copenhagen to visit several fountains. In some places I gave up due to too much background noise, but I have kept 4 of the recordings.
>
> Your "sound robot" is apparently not capable of recognizing splashing or rippling water, it perceives it as a rumbling stomach or gasping for breath. I was able to download my sound files afterwards and have listened to them carefully (3 out of 4 were deleted because of poor sound quality). While I still have the recordings and the real sound image in fresh memory, I will provide the following information about the 4 audio recordings:
>
> In all my recordings, I placed myself close to the splashing water and sheltered from the wind, until the sound was potent. #2508 Gefion Fountain. In the first seconds, you hear the water clearly. Next, the sound is reduced to a vague ripple as if the sound of splashing water is reduced. Since there were many tourists at the Gefion Fountain my explanation is that my mobile tries to mute the footage of water splashing to catch the nearby voices. The outcome is a messy soundscape where neither the splashing water nor the speech is clear.
>
> #2518 Amaliehaven. The fountain in the middle is a powerful fountain with nozzles that practically splash like fire hoses. In the first half of the audio file, the loud splash of water is clear, but about midway through the audio file, the water recording is barely audible because the mobile captures the sound of talking tourists passing by. This substantiates my theory that the mobile is designed to suppress and filter out "background noise". Even though I was standing very close to the splashing water all the time, the 'sound image' is incorrect because human voices represented the background noise. The sound of splashing water was not abruptly

> muted. Based on this, I have substantiated my previous objections that cell phones may not provide one true sound image because they are designed to suppress background noise in favour of human voices. However, since the project interests me, I will continue my sound experiments on my hikes.

The examples demonstrate that Louise is a dedicated 'citizen listener' who during her hikes and sonic engagement with the SOD app discovers that the sound quality in her recordings is inadequate. What she heard as loud and clear in the situation was impossible to identify when she later relistened to the sounds, therefore she decided to delete most of her recordings from her trip. Furthermore, Louise discovers that her mobile phone is selective because the software in the phone is programmed to enhance human voices rather than nonhuman voices, this means that when she is recording sound when there are people nearby, the mobile will focus on the human voices rather than the sound of the fountain and creates a biased soundscape that did not represent her experience of the sound scape. She demonstrates that the AI system does not recognise the sound of splashing water even though she has positioned herself close to the sound source. Finally, she questions the use of mobile phones as an epistemic tool for data collection because of its selective behaviour during her recordings. In a following email she elaborates on this by suggesting other ways to participate in the project that holds potentials for enhancing the sound quality in the project:

> Collecting sound is a fascinating project, but don't you think mobile phones alone are unsuitable for these sound data collections? Could you consider the possibility that data collectors upload their sound recordings with better equipment, so I can use my little Olympus LS-P1, which is half the size of my mobile phone, and then upload the sound afterwards?

Louise's sonic engagement with the app brings attention to her concern about inadequate sound quality, incorrect feedback from the AI system, and interferences from the mobile phones software. Her ongoing experiments and documentation of the technical issues in the project is an example of enactments of citizenship that is motivated by her passion for doing listening through her ongoing engagement with the project. Her intra-actions with the project makes visible not only the shortcomings of the project but also the potential risks of producing sound images, data and research that are distorted and biased because the mobile phone is intervening in her sound recordings, and forces her to delete most of her sound recordings from her trip around in Copenhagen. Hence, having the possibilities to produce decent sound and data quality is clearly essential for people's ongoing engagement with the project. As Mads adds, in a mail to the project about sound recording and upload via PC:

> Dear CMEC and others. I record sound with an Olympus and would like to upload via PC. It is completely unacceptable and exclusive that you exclude users who do not use their mobile phone to record. But I suppose you are completely indifferent; at least that is how it appears in your FAQ. I therefore choose not to contribute.

The examples indicate that people have the willingness and capacities to produce sound of high quality, but the boundaries of the project protocols and the Mobile app design constraints and excludes them from participating and contributing to scientific knowledge production in their terms. From this perspective the entire technoscientific apparatus of entangled intra-actions therefore produces boundaries for people's involvement in the project which reconfigures how sound is recorded and produced. Moreover, it influences the sound quality and the bias encoded in the sound data, and therefore how people engage with the project or are excluded from engaging in citizen science.

In summary, the examples demonstrate the importance of establishing stronger science-citizen relations. I have demonstrated that citizens' sonic engagements with the project, their documentation of the sound recordings process, their different ways of making their voices heard and their enactments of concern holds essential potentials for making visible the epistemic exclusions that traverse a citizen science project and prevents citizens for enacting scientific citizenship. I have argued that citizens make their voices heard through their different experiments with the project, their critique of the project's shortcomings and

boundaries that constraints and excludes their capacities for engaging with the project on their terms. Furthermore, I have demonstrated that citizens bring attention to different matters of concern that both questions the scientific process but also holds potentials for informing the ongoing design of the project. Finally, the key findings in this section emphasise people's capacities as co-designers of technoscientific developments by pointing out the importance of designing for stronger science-citizen relations that includes the diverse knowledges and understandings of citizen voices and their matters of concern, and enactments of responsibility.

Citizens take ownership of the project and make it their own

In the preceding section I demonstrated how citizens enact citizenship by making their voices heard and by enacting their matters of concern. In the following I will build on this and show how citizens also enact citizenship by making the project their own. The following resume of a forum post from Hanne (kindergarten teacher) describes her experiences and participation in SOD with children 3-4 years of age, and demonstrates how volunteer contributors make the project their own and take ownership of the project:

> Over five weeks, SOD was incorporated into our projects to explore the sound of the water; we discovered that each city fountain has a unique sound. We threw stones in Limfjorden of varying sizes at the children's request to hear the different sounds. We repeated the session at Vilsted lake, and it sounded like music. In the daycare, we addressed different words for water, wrote them down, and painted our experiences with watercolours. We conducted water experiments based on our experiences with sound and discussed the importance of caring for water. The project's objective was to realize it from the children's perspective. We followed a playful and experimental approach to wonder, curiosity, and participation throughout the experiment. Throughout the experiment, we wanted to teach the children that water comes in different forms.

This example demonstrated how citizens can take ownership of CS project by integrating it into their everyday lives and practices, just as we heard earlier in the examples with Louise who mentions how she is recording sound on her daily walks with her partner in Copenhagen. As Hanne writes, the kindergarten's adaption of the project in their every data incited new and interesting directions that opened op for further ways of thinking with sound. Their investigations of sounds and places in the city, their sound-making and listening experiments, over scientific experiments, to playful experiments with words describing water demonstrate how the volunteer contributors create new layers of meaning, value, curiosity and imagination to further the develop the digital citizen science project. The volunteer contributors' relational ways of thinking and doing with other people, things and the environment demonstrate that their diverse forms of practices and abilities to restage things in new situations and contexts hold great potential for generating alternative forms of engaged listening, reasoning, and involvement beyond the focus of the CS project to strengthen civic capacities and cultivate new sites of communication and scientific citizenship.

Anti-programs as responsible enactments of citizenship

I have argued that citizens create tensions in the project when they begin to follow and invest time in their own agendas, interests and protocols that diverge from the protocols of the citizen science project. The following demonstrate that tensions can emerge because of the epistemic exclusions that emerge from the intra-active engagements of the volunteer contributors, the CS project and the communication officers in the SOD project team. An example of tensions between the CS project and the possible deviations and developments of anti-programmes (Kasperowski and Hillman 2018), can be found in the case with the kindergarten who create their own project or programme in the CS project, that build on their interests, agendas and knowledges.

In other cases, tensions can emerge from citizens' questioning of the scientific process, their challenging of the project's approaches for data collection and by criticising the project through their diverse forms of engagements with the project. As the example with Louise told us earlier: "collecting sound is a fascinating project, but don't you think mobile phones alone are unsuitable for these sound data collections?". As a result of her experiments, she concluded that her mobile phone affected the sound quality of

her recordings because it prioritizes human voices over nonhumans. She questions the project's use of mobile devices for data collection and confronts it with her findings. To solve the problem of poor audio quality, she proposes alternative ways to participate that interfere with the project's protocols.

As the results suggest, participants in SOD are concerned about the sound quality in their recordings or in the project; for some participants the implications of this are that they purchase microphones that works with their smartphones so they can contribute with better sound quality in their recordings, even though it deviates from the project protocols. However, for others the boundaries that hinders people from participating with other epistemic tools than their smart phones, can be directly exclusive for their engagement and possibilities for partaking in science-centered decision-making in the project.

Louise, a dedicated citizen listener follows her own programmes and agendas that often deviate from those of the project, for her sonic engagements with the project she uses a Boya microphone to improve the sound quality in her recordings. In her diary she writes:

> I have listened to the recorded sounds from the mobile app at home via a small external speaker. I think the Boya microphone creates some really great recordings, but I am not impressed with the other users' recordings.

Louise's use of an external microphone is an example of citizens who develop anti-programmes that deviates from SOD's project protocols that specifically states that the project is only interested in sound data produced with the mobile phone and the SOD mobile app. Hence, when people inquire if they can use their own sound recording equipment, they are rejected this opportunity by the communication officers. For some of the participants who are more experienced with field recordings and working with sounds, this is a direct exclusion of their epistemic practices and future agencies in the project, why they decide not to contribute to the project.

This example underpins that participants, also unintentionally create tensions in the CS project when they follow their own interests and experiment with alternative practices and programmes (see Kasperowski & Hillman, 2018), such as using personal microphones to improve the sound quality and AI feedback that does not comply with the project protocol. Moreover, their different ways of making requests and expressing concern about the project's sound quality and AI feedback, contest the CS project's constraint focus on mere data collection, following project protocol, and matters of fact. Even though their epistemic practices interfere with the project protocol and deliberately establish a sphere of conflict, negotiation and possibility. It becomes their way to express their concern for the project's research and data quality and be recognised as epistemic subjects.

That people want to be recognised/acknowledge for their engagement and contribution to the CS project is not directly visible in the citizen science communication in the community forum or in the email between citizens and communication officers. Nonetheless, an examination of Louise's diary notes show that she was disappointed with the project, because they did not accept her help and offer about helping with the testing of the mobile application:

> Later an application was developed, but I was not involved in testing before it was released. Because of this, I found a lot of errors - I always do; that is why I am good at testing - I, therefore, had to spend a lot of time pointing out these errors and ensuring they were corrected. So it was a bit disappointing to experience as a user.

The example demonstrates the need for establishing close ties with volunteer contributors, to meet their interests, needs and desires and critique. Furthermore, there is a need for listening to citizens diverse voices and their matters of concern, and a need for acknowledging that they can contribute to citizen science in a variety of ways that goes beyond the project's mere data collection and analysis. Their problems of concern and care for important matters and relational experiments in the project, is also an opportunity to invite participants into the project as codevelopers, as they have capacities to bring attention to matters that goes unnoticed by the scientists and projects members in SOD.

05.03.13 Scientific citizenship and relational responsibility

In the preceding chapters, I have demonstrated how citizens enact themselves as scientific citizens in SOD by tracing people's intra-active engagements and communication across SOD's digital platform. In the next I will argue that scientific citizenship is better understood as the relational enactments of humans and nonhumans (see, Irwin and Michal 2003), hence the scientific citizen and their capacities to act is not something fixed or predetermined but is coming into being through her/his intra-active engagement with the CS project, its ongoing development and epistemic boundaries. As I will demonstrate these changing possibilities have implications for rethinking how to design for responsible engagement in citizen science.

My previous key findings have shown that citizen scientists are not merely helping out the scientists and contributing to scientific knowledge production and technoscientific development but are intra-actively producing and reconfiguring these processes through their material engagements in the project, by raising their critical voices and concern about the CS project's unwarrantly epistemic exclusions, by criticising its constraints of citizens' actions and agencies, and by questioning the projects boundaries, its approaches to data collection and production of knowledge, and through their involvement in the design of the project. Hence, from this perspective enactments of scientific citizenship involves the intra-actions/ enactments of the entire technoscientific apparatus, that is the CS project, the citizen scientists, the project/research team, and external developers. Technoscientific apparatuses, as Barad (2007) reminds us, are open-ended practices that involves specific intra-actions of both humans and nonhumans (2007, 171). She writes: Apparatuses are material (re)configurings or discursive practices that produce (and are part of) material phenomena in their becoming. (2007, 184).

Hence SOD as technoscientific apparatus is not something fixed, neither is phenomena and scientific knowledge production, or the project's boundaries, but are iteratively constituted through particular human and nonhuman practices. In an agential realist account, the citizen scientist, the scientists, the project team, developers, and the SOD mobile app, including me as analyst, do not stand outside of the bodily production of The Sound of Denmark but are part of its ongoing reconfigurations. At the same time,

we are reworked and influenced through our entanglement with the project. As Juelskjær et al. writes: “the researcher is thus not a neutral knowledge-creating subject but works with and through the studied phenomenon in a situated and entangled manner, leaving no external position from which it is possible to produce knowledge” (2021, 152).

In so far apparatuses are constituted through particular practices open to reconfigurations (Barad 2007), citizen scientists have a crucial role to play in terms of the ongoing development of the project. As I have demonstrated citizens hold capacities for making their voices heard throughout the development of and participation in a citizen science project; their attention and awareness for technical issues and shortcomings in the project, their critique of epistemic boundaries and sound quality, they questions about AI system, and concern about security issues, and their responsible experiments and feedback to the project team, these enactments as I have argued, are part of the ongoing iterations of the SOD mobile app.

Here exemplified through Louise’s engagement with the project, where she tests the SOD app’s offline location by agreement with the project:

> With my mobile offline I went down to Trianglens Metro, went to Marmorkirken, checked my current position with the mobile's GPS on maps, yes I was at Marmorkirken, then online with the app so it could transfer the recording from Ryesgade. Yes indeed, the recording was properly placed. [..] Finished the recording and moving up and down the subway to record another 4 sounds. After this I was done, and all the offline footage was correctly placed, so I reported it to the project.

The examples demonstrates that feedback and collaborations with citizens hold potentials to inform the ongoing development of the project. A different example would be the project protocols and the communication and feedback from the communication officers who influence prospective participants who wants to participate in the project on their terms and use their own sound equipment but are constrained from participating because of the boundaries in the project that restrict people to participate with the SOD app and smart phone. In all this, as Barad points out, agency is not restricted to human actions alone:

> Agency is a matter of intra-acting; it is an enactment, not something that someone or something has. [..] Agency is about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices (2007, 214).

Agencies are reconfigured throughout the entire technoscientific apparatuses through the material-discursive practices of humans and nonhumans. This means that our intra-actions as participants and researchers in SO, are taking part in the production of phenomena, the production of knowledge, but also in the enactments that effect what matters and what is excluded from mattering. In other words, we are responsible for the entanglements of which we are part and the exclusions, boundaries and constraints we partake in enacting.

Following Barad's notion that objectivity and agency are bound up with issues of responsibility, it means that accountability as developers of citizen science, citizens and researchers must be thought of in terms of what matters and what is excluded from mattering (2007, 184). Hence, we are responsible for our designs and how they take make particular enactments of scientific citizenship possible, how they exclude others, and how the project's entanglements take part in the production of particular understandings of soundscapes while excluding others. Finally, it shows why some concepts and forms of knowledge are coming into being while excluding of forms of knowing.

To design for responsible engagements in a CS context will require thinking critically about the boundaries, cuts, constraints, and exclusions that operate through particular material-discursive practices, because they are constituted of "particular practices that we have a role in shaping and through which we are shaped" (Barad 2007, 390). This shift in theoretical perspective enables me in this project to bring into attention how particular facts come to matter while others are excluded from mattering, that might otherwise be missed. For me in the SOD project, Barad's notion of material-discursive practices offers a new

perspective on scientific citizenship and openings for the design of more responsible forms of science-citizen relations that can strengthen epistemic and democratic agencies.

05.03.14 Conclusion

In summary of this section, I have demonstrated how scientific citizenship in SOD is enacted through the material-discursive practices of both humans and nonhumans. Key findings demonstrate that citizens are valuable resources in a citizen science context because they enact themselves through different epistemic practices that challenge and contextualise the CS project's epistemic practices, protocols and scientific approach. Citizens can consider the technical issues and limitations of the project that hinder citizens' epistemic capacities to act and be engaged in scientific activities. Moreover, I suggest that an account of scientific citizenship must take into account the entangled human and nonhuman intra-actions to make visible how agencies are reconfigured and why some concepts are made to matter to the exclusion of others. Finally, I argue that to design more responsible forms of citizen engagement will require an account of the entanglements of which we are part to make visible the constraints, exclusions, and boundaries a research/protect team in intra-action with citizens have a role in shaping. In the next chapter I will elaborate on these key findings and point out new directions for designing more responsible forms of citizen science.

06 Discussion: relational designing and responsibility

06.01 Introduction

The previous chapter outlined my analysis and discussion of designing citizen science communication in the Sound of Denmark. I have accounted for my co-design workshops with prospective citizen scientists, the implications of nonhuman agencies, and the enactments of scientific citizenship. The analysis has demonstrated that to design more responsible forms of citizen science engagement that strengthen science-citizens relationships, we as developers and researchers must rethink our ways of designing citizen science projects. I argue that this can be done by considering our entanglements with other than human actors to reveal the exclusions, boundaries and unsustainable relations that "we" all take part in enacting. In this chapter, I elaborate on these findings, arguing that another citizen science is possible. A citizen science that considers a plurality of different voices and knowledge forms a citizen science that embraces citizens' diverse and situational practices, uncertainties, and relational enactments of responsibility and

concern. Such citizen science, I argue, can pave the way for designing more responsible forms of citizen-science relations.

06.02 Responsibility through relational designing

As I have argued our designs are not passive structures, rather they participate in enacting the boundaries that exclude certain epistemic practices and agencies from being realised. The design of citizen science partakes in the production of knowledge and the formation of epistemic subjects; in other words, they hinder/constrain enactments of scientific citizenship and the publics participation in scientific research. Because of this we need more knowledge about the agency of designs – that is our apparatuses – and how they keep on designing to make visible that which hinders epistemic agencies and different voices from unfolding. According to Fry (2020), we have little knowledge about the ongoing agencies of our designs and the values, knowledge worlds and things we create and how they keep on designing after we have designed and made them (2020, 147). Following Fry design and designing does not create a finalised solution: “rather all that design brings into being remains in process within a particular kind of ecology of things, organic or inorganic” (Fry, 2008: 30). Hence, as developers and researchers, we are responsible for their ongoing designing and their implications in the world. We are part of their designing and intra-actions and mutually reconfigured through these processes (Juelskjær et al., 2021: 154). This argument is consistent with Escobar (2020), who writes: “we are all designers, and we are all designed; hence we must take responsibility for the worlds we co-create” (2020: 40).

In my perspective this understanding of design relates to the notion of responsibility. Responsibility following Barad (2007), involves accountability of the entangled practices that we participate in enacting, and the cuts we make because, as we recall, they are productive and determine how a given phenomenon materialises and how knowledge is produced, but also what matters and what is excluded from mattering (Barad 2007). As Barad points out these entanglements partake in reconfiguring our bodies/beings, psyches and our imaginations and institutions (2007, 383). They have a role to play in the formation of epistemic subjects and influence the agencies of the scientific citizen. Hence, an account of how they keep on designing our bodies and beings demands an account of the technoscientific practices of bodily production and how it reconfigures bodies, power structures, and knowledge. To state this differently, we need

knowledge about the material practices that constitutes the processes of knowledge production. By studying citizens material engagement in citizen science and participatory design contexts, we open for new possibilities for relational designing that can influence how we understand our roles and actions as designers.

Recalling the research question of the Ph.D-project, here rephrased: How can we design citizen science engagement that can evoke a science that strengthens the needs and concern of citizens, and their capacities to enact scientific citizenship? In the following, I will argue that citizens' involvement in a design process is a crucial capacity and opportunity for designing things differently; they can bring attention to matters of concern that that goes beyond the focus of the project/research team to contribute with alternative forms of knowledge practices. Not only through their voluntarily participation in the project but also by potential user-involvement in the development of a citizen science project.

The scientific citizen is not without powers and capacities to act, but through her epistemic practices she enacts herself as citizen, expresses her problems of concern and makes her voice heard through her sonic engagement and anti-programmes with the project. By such epistemic practices she also contests and questions the protocols of the project, its data collection practices, and boundaries for participation. Through these epistemic practices, she opens new possibilities for making new discoveries that goes beyond the imaginations of the CS project. As demonstrated earlier we heard how the citizen listener, Louise created new possibilities for engaging with the project because of her counter practices and purchase of a microphone for her mobile that improved the sound quality in her recordings and satisfied her need for better sound quality. In other words, she used her capacities to act in the project and created new possibilities for participation, doing and being even though the project constrained her options for participation new possibilities for participation emerged. In all this, Barad reminds us that:

> Agency is about changing possibilities of change entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are

> marked by those practices in the enactment of causal structure. Particular possibilities for (intra-)acting exist at every moment, and these changing possibilities entail an ethical obligation to intra-act responsibly in the world's becoming, to contest and rework what matters and what is excluded from mattering (2007, 235).

Taking the point of departure in Barad's notion of responsibility in relation to the world's becoming, I argue that citizen scientists have capacities to contest and change the structures/boundaries of the CS project and how scientific knowledge is produced (e.g. their intra-actions influence the sound quality and therefore the ongoing training and development of the AI system). Through their material and discursive engagements, they partake in the production of new possibilities for intra-active engagement in SOD; however, the volunteers are not responsible for realising these possibilities alone. Instead, responsibility is enacted intra-actively with the CS project and the project/research team behind SOD; hence, citizens have a role to play in enacting and realising new possibilities, for instance, by reconfiguring/ redesigning the CS project's different possibilities for engagement. This example reveals that citizen scientists can be their own resources and hold important capacities for designing things otherwise and creating new possibilities for engagement in citizen science; their ongoing intra-actions and feedback and communication with the project confirm this.

Hence, from the perspective of the project team, to take responsibility would entail the establishment of stronger ties and collaborations with the community of volunteer contributors. This challenges a science-centered perspective and will also disturb the focus on technoscientific development that are so deeply inscribed in the aim of the SOD project. However, as we have seen listening to the feedback from the participants in their engagement with the SOD app, and involving citizens in participatory design workshops, has not prevented the constitution of epistemic exclusions and the creating of boundaries and constraints.

Designing with citizens holds possibilities at every moment for empowering scientific capacities, at the same time it can make audible and empower new citizen voices. Hence, design collaborations can open the project towards other forms of beings, doings and knowing that would have been missed if there were no design collaborations with citizens, if there were no voices in the SOD project team from Our

Museum, that could challenge the technoscientific perspective that is so strongly dominating the design process.

Escobar (Escobar, 2020b) argues that design is a conversation about possibilities of beings and doings and knowing that profoundly affects our "kinds of beings" and develops through our situatedness in the world (2020b, 140). To this, I will add that this process should go beyond the mere dualist thinking to include the agencies of nonhumans to reorient the designer and the designed and bring attention to new relational ways of enacting citizenship in a CS context. That builds on citizens' and communities' capacities and diverse forms of knowledge through long terms relationships to capture the ongoing designing and the performative effects of the exclusions and boundaries of the project, but also to understand what phenomena are coming into being.

Finally, this way of designing is obviously challenging present modes of technoscientific development in citizen science that are influenced by technocratic and capitalist interest strategies. From this perspective it also holds potentials as a countermovement and potentials for creating other sustainable life worlds that are worth living.

This brings me to my following key argument: the need for designing more responsible forms of engagement and communication with volunteer contributors and with the people who participate in CS that are most affected by the design. Throughout the analysis, I have demonstrated that science communication as a form of intra-active engagement is not only important for providing feedback and information exchange about technical issues and shortcomings of the project. Citizen science communication is also a way for enacting citizenship and for making one’s voice heard, enacting matters of concern, sharing personal sonic experiences and interests and discussing epistemic resources with other community members. From this perspective, citizen science communication becomes much more than getting insights about people’s data contributions to the project and the training of the AI system. Citizen science communication can not only reveal how scientific citizenship is enacted through instances of science communication (Davies and Horst, 2016), but also how science communication contributes to active forms of citizenship (or not).

Horst and Davies argue that science communication is better understood as a cultural phenomenon and a capacity building for scientific citizenship (2016, 198). They write:

> Understanding science communication as culture can help us to investigate its organisation, professionalisation, and democratic role, as well as the role it plays in generating resources and creating expectations, emotions, and affects (2016, 9).

Horst and Davies (2016) suggest that we should pay more attention to nondiscursive practices within instances of science communication (2016, 216). To do so, one must shift away from understandings and discourses about science communication based mainly on analysing texts and verbal utterances (see article 4 for an example of a performative approach to science communication). Instead, they advocate a scientific knowledge production that imagines science communication as a place for examining the meanings of science, technology, and citizenship (2016, 9). Through my analysis of citizen science communication, I have demonstrated how these practices and responsible enactments of citizenship are unfolding in different ways; both through the participatory design process but also through people's participation in SOD. I have argued how important citizens' intra-active engagement with the project is, in terms of negotiating meanings, questioning the scientific practices, enacting disagreement, and challenging the project's epistemic boundaries. Hence, citizen science communication from this perspective increases citizens capacities and possibilities to enact citizenship in a citizen science context. My key findings are in this regard consistent with the work of Davies and Horst (2016) who argue that science communication, "should aim to empower citizens. It can and should equip them to perform citizenship" (2016, 207). Hence science communication from this perspective can be understood as the means to increase one's capacity for enacting scientific citizenship.

Horst and Davies (2016), states that the ability to use technoscientific resources in modern knowledge societies is crucial for enacting citizenship:

> Science communication is thus a crucial tool for inclusion and for ensuring that the ability to understand, evaluate, control and use technoscientific knowledge is shared throughout society. Although scientific citizenship may be expressed in many different ways, it is important to

> view science communication as a part of this, and as something that can play a role in wider dynamics of public concern, resistance, and appropriations of scientific knowledge (2016, 217)

Science communication is key for increasing people's capacities to enact citizenship and for sharing and using epistemic resources in their everyday lives. When designed for and integrated with a CS context, science communication can serve as a "boundary space" that enacts specific relationships and advances collaboration between scientists and non-scientists (Horst, 2022, 478). It is therefore crucial that developers, project/research teams prioritise the design for communication in the development of a CS project (Sturm et al., 2018), and that the value of this communication is discussed and made visual in the project team so all members understand that communication to and with citizens are key to the successful development of citizen science and its scientific outcomes.

06.03 The entangled researcher is not without responsibilities

With regard to my role as an ethnographic researcher in SOD, and my entanglements with the development of the CS project, I will reflect upon my own entangled practices and how they have influenced the various apparatuses of bodily production that I have been connected to e.g. Our Museum and The Sound of Denmark and even my family and life situation in general. My own practices and agencies as a researcher and a person have been challenged, put into question, been reconfigured and transformed. At the same time, I have intra-actively engaged in the reconfigurations of these environments and I have been a part of the enactments that both enable and exclude particular forms of practices and knowledge. As we recall from Barad, intra-actions always involve particular exclusions that reconfigure possible or impossible futures. And it is from this perspective we must act or rather react as responsible researchers and developers. Writing the last paragraphs in this project, it stands clear that we need new knowledge about the entanglements of which we are just a part to understand the materialisations and sometimes destructive cuts that

we participate in enacting and, in most cases, unintentionally design and bring into the world. We know little about our designs and how they keep reconfiguring new possible or impossible futures.

In this project, I investigated the epistemic inclusions and exclusions of citizen voices within the framework of SOD. I realize that those exclusions can be deeper investigated by considering, for instance, the racial and gendered exclusions in technoscience projects like SOD. For instance, how would the participatory design process unfold differently if my recruitment process had focused on inviting more diverse members of society from underserved groups and people of colour rather than people who are primarily white and middle-class? Moreover, this raises the question, who was the Sound of Denmark designed for? And how can participatory design be reoriented beyond the rationalist understanding of technoscience? These questions suggest that we need to pay attention to the entangled practices we participate in enacting that shape the entire technoscientific development and our human actions. In his analysis of algorithmic systems Seaver (2019) suggests that:

> We need to examine the logic that guides the hands, picking certain algorithms rather than others, choosing particular representations of data, and translating ideas into code. Unlike the technical details of algorithmic configuration at a given moment, these logics are more readily accessible and persistent over time, giving the critical researcher a firmer grasp (Seaver 2019, 419).

The example tells me, that we need to pay close attention to the different logics, the culture, and the power dynamics of the project that shapes the entire technoscientific apparatus and its production of knowledge, because knowledge produces realities. The ethnographer's situated position in the SOD project team allowed me to follow the project's techno-scientific materialisation. It provided insight into power dynamics and tensions among different fields. These tensions were both productive and creative and created new possibilities for collaboration. However, the science-centred perspective in the project, and a need for producing "solid" knowledge, and the collection of data to train a machine learning program, dominated the development process. I believe, this underlying science-centered perspective had a significant influence on the production of the CS project and the entire developer apparatus. How could things have been

different with closer collaborations with the public, the project team, and the citizens? A redefined research question in the CS project could have been how to include communities, their concerns and needs?

Furthermore, my research could have addressed the peculiar division between natural and anthropogenic sounds in the CS project. What led to the fact that cultural and natural sounds were being separated and classified in two groups? What scientific assumptions and ontologies lie behind such division and does it account for the complex entanglements we experience in the Anthropocene? Could I have directed and prioritised my design workshops differently in light of this, bringing forth the complexities and entanglements of sound in landscapes?

Finally, my own positionality as a white middle-class Danish male and the scientific norms I carry with a background in game design, marine engineering and digital media is another aspect that I have not unfolded in this project, how did my background come to matter in the design and research process? A final remark considers my research practices and thinking, which have mainly been influenced by the agential realism of Barad; here, I believe that the responsibility for the material-discursive practices I have been enacting could have been enacted differently. For instance, how would my co-design workshops or analysis have evolved and materialised if I had started the Ph.D. project from the perspective of an agential realist ontology?

07 Conclusion and future research – is another citizen science possible?

Returning to the research question of the Ph.D.-project: How can we design citizen science communication that strengthens citizens' democratic capacities? In this regard, the Ph. D.-project's key findings demonstrated that the scientific citizens are their own epistemic resources and that collaborations with citizens hold crucial potential for activating different voices in a CS context that questions technoscientific development and contributes with alternative forms of knowledge that benefit the design of more democratic and responsible forms of citizen science. Moreover, I have demonstrated how we developers and researchers should consider the material-discursive apparatuses we engage with and the exclusions, constraints, and boundaries we participate in enacting to design more responsible citizen science communication. Therefore, to design responsibly and create relevant modes of togetherness between expert and lay knowledge, we need to account for our intra-actions and how they make some concepts come to matter to the exclusion of others. I will elaborate on my key findings in the following paragraphs.

In the case *designing with citizens*, I demonstrated how a participatory design approach and codesign activities with the prospective citizen scientists can help to nurture new forms of togetherness and relevant modes of thinking together. I argued that PD can help to empower civic capacities and hereby contribute to the design of more responsible forms of citizen science. Our collective sonic engagements during the workshops, demonstrated that citizens are important capacities for reframing the design context and for creating new modes of togetherness and collective thinking. Moreover, I demonstrated that our sonic engagement in the workshops with citizens can encourage people to express and discuss their concerns through which they bring local knowledge and interests into play. Hence, the citizens epistemic practices are potentials for moving beyond the perspectives of the scientists and the CS project that sometimes put into question the scientific approach. The case together with (article 1) stated that participatory design workshops are important approaches that makes possible a meeting points between community knowledge and expert knowledge and further the actualisation of new democratic possibilities.

The second case focused on: Machinic agencies and technoscientific apparatuses. I analysed the CS project as technoscientific apparatus of bodily production through which different agencies and knowledge practices are reconfigured through material-discursive practices. With this analysis I made visible the unjust constraints, exclusions and boundaries that operate through material-discursive practices in the structures of the CS project. I argued that these material-discursive constraints had a major impact on the epistemic agencies of the scientific citizens and their possibilities for sharing, using and producing epistemic resources, and therefore, their possibilities for participating in scientific research. Through their intra-active and communicative engagement with the project, and ongoing feedback to the SOD project team, citizens made visible the epistemic exclusions that operate through the project. I concluded that to design more responsible forms of citizen science communication we need to understand the performative effects of the designed, and how the material and discursive in the designed keeps designing and enacting unjust epistemic exclusions and unsustainable futures. Therefore, in our entanglements with and design

of human-machine collaborations, we must acknowledge that our materialisations and enactments always entail a matter of relational responsibility.

The third case covers my analysis of Enacting scientific citizenship: entangled responsibility and enactments of concern. In this analysis, I show how citizens enact (or are prevented from enacting) scientific citizenship through diverse intra-active and communicative engagements as part of the technoscientific apparatus. I demonstrate that citizens bring attention to different matters of concern that contest the scientific process and inform the ongoing design of the project. In a technoscientific context, citizens are valuable resources as they can offer insight into the project's shortcomings, reenact specific situations and practices, and provide new possibilities for joint ventures, reasoning, and involvement. Finally, I emphasise that citizens' intra-active engagements can point out new directions for the CS project that goes beyond the focus of the scientists to enhance civic agencies and nurture new sites of communication that strengthen scientific citizenship. Moreover, I show that citizens take ownership of the project by enacting and following their own agendas that not only contest and question the scientific practices of the project but also contribute to its further development. Finally, I emphasise that the scientific citizen and her possibilities for enacting citizenship and using epistemic resources are intertwined and reconfigured by the material-discursive practices of the citizen science project. On that basis, my key findings emphasise that scientific citizenship is better understood and accounted for by analysing the relational intra-active engagements of both humans and nonhumans.

Finally, based on the empirical and theoretical work of the Ph.D.-project, I propose that future studies and analyses of citizen science, citizen science communication and scientific citizenship, may benefit from considering the agential and relational ontology of Karen Barad. My key findings demonstrated that a genealogical mapping of the material-discursive practices of citizen science could help facilitate new knowledge and understandings about our entangled relationships with nonhuman others and how they partake in the bodily formations of knowledge and reconfigurations of the scientific citizen. On that basis, I propose that future research in the intersection of such diverse fields as citizen science, design, and scientific citizenship, reconsider the material-discursive entanglements of which we are all a part. In order to unfold novel questions and research directions concerning our relational responsibilities in a more-than-human world that both address the present destructive cuts, we are all a part of, including more affirmative and possible futures. The context of citizen science is a fruitful space for such an experiment because it

embraces an entangled diversity of lay and expert knowledges that could open up for other possible and perhaps more responsible futures.

08 Listed publications

This chapter provides a listed overview of the publications of the PhD Thesis:

- Article 1: Designing with citizens: Cultivating affirmative relations in citizen science (sent to *International Journal of Design*, in review)
- Article 2: Reconfiguring sonic engagement: Exploring epistemic agency and exclusion in citizen science (sent to *Nordic Journal of Science and Technology*, accepted)
- Article 3: Entangled responsibility: an analysis of citizen science communication and scientific citizenship (Sent to *Journal of Philosophy & Technology*, sent to journal)
- Article 4: Relational responsibility - science communication as intra-action in multispecies communities (Co-authored paper with Kristine Samson see appendix 4)

08.01 Designing with citizens: Cultivating affirmative relations in citizen science

Recent studies in citizen science demonstrate that public participation in science communication can enhance civic capacities. They point to potential transformations of the science–citizen relation by questioning who can create scientific knowledge and what parts of the world should be subject to scientific inquiry. Existing research highlights direct communication with and feedback to participants as central to successful citizen science and emphasises participants' motivation and engagement in citizen science. Despite the results, there is little knowledge about what these communication formats include and how to design dialogical engagement that advances civic capacities. This paper addresses how a participatory design approach can be applied to create new knowledge on how to design citizen science communication that strengthens citizens' democratic actions. It demonstrates a practical framework for co-designing with citizens and identifies possibilities for developing responsible citizen engagement. Its key findings indicate that design collaborations with citizens can activate a plurality of voices and raise questions about participation in and democratisation of science. These findings are discussed with reference to three co-design workshops and interviews with citizens in the citizen science project, The Sound of Denmark (*Lyden af Danmark*).

Keywords: participatory design, co-design, citizen science, citizen science communication, democratising citizen science, cultivating affirmative relations

Relevance to design practice: This study demonstrates how participatory design can advance new democratic possibilities and affirmative relations in citizen science by involving citizens in the creation of tools, processes and communication that are central to scientific knowledge production. The key findings highlight a promising research area, encompassing design, citizen science and cultural citizenship.

Introduction

Stengers insists that another science is possible (2018). She proposes a slow science that can make us think, feel, and imagine again. A cultivated science that abandons previous destructive collaborations with neoliberal capitalism and advances new relationships with an intelligent public, that actively participates in and contests the research that targets them. Stengers' work confirms Irwin's (1995) earlier writings about sustainable futures and the divide among science, technology and citizens, calling for a reassessment of the science–citizenship relation. He argues about governments' and scientific communities' scant attempts to build on the diverse bodies of knowledge and epistemologies produced by citizens. He emphasises the need to clarify the requirement for a "science–citizen dialogue", which was and still is implicit in the citizen science (CS) context, in order to benefit from "marginalized expertise" and provide an antidote to "prevailing notions of scientific and technological determinism" (1995, p. 136).

According to Irwin, "it may follow that the necessary level of social and cognitive change cannot be achieved by governmental and science-centered strategies. In such a situation, contextual understandings may be at the heart of a sustainable pattern of socio-economic development" (1995, p. 137). These contextual understandings point to closer collaboration between scientific communities and society, new venues for dialogue involving different bodies of knowledge and epistemologies. However, Irwin stresses that participation is insufficient, as it might be designed for governments to achieve legitimation rather than social dialogue. Irwin (1995) outlines different criteria for science–citizen dialogue in projects adopting a citizen-oriented perspective. He emphasises the importance of offering citizens the possibilities for expressing themselves and enhancing their knowledge and expertise so that they are recognised as knowledge generators and that "various forms of public participation and science–citizen interaction permit real policy change" (p. 140). Irwin points to several potentials underlying these initiatives, primarily that the needs of science and citizens can be compatible and mutually benefit from collaboration.

CS is often referred to as a way to democratise science and support citizenship through collaborations with the public. However, few studies have addressed how this aim is realised (e.g. Haklay, 2018) and how citizens' democratic actions are considered in this process. Even fewer studies have specifically focused on the participatory design (PD) of CS (Senabre et al., 2018) and the need for developing communication formats of CS (Irwin, 1995; Sturm et al., 2018).

Previous studies have highlighted communication with and feedback to participants as central to citizens' motivation and engagement in CS (Alender, 2016; Geoghegan et al., 2016; Hecker, S. et al., 2018). Communication creates new opportunities for expanding citizens' participation in science, supports alternative models of knowledge production and contributes to a project's scientific success (Hecker et al., 2018). Communication offers ways to develop practices of citizenship, inclusion and political involvement (Davies & Horst, 2016).

Despite these insights, there is a lack of knowledge and discussions concerning how to design communication that advances citizens' democratic actions and embraces diverse forms of knowledge. Thus, facilitating novel meeting points between scientific communities and citizens seems to have much to offer in bridging the gap between lay and expert knowledge by accepting citizens as unique knowledge producers and giving the public a voice in scientific research. Addressing the present democratic crisis requires public intelligence that provides friction in the new formations of instrumentarian power in society and social life.

In this paper, I address this gap by investigating how to design CS communication that advances citizens' democratic actions. Consequently, my paper contributes with new knowledge on how a PD approach and collaborations with citizens can open up new forms of democratic participation in scientific research.

Theoretical framework

In this section, I draw together theories and practices from PD and ethnographic design (Blomberg & Karasti, 2012) in a productive encounter with CS. I open this encounter by unfolding the concepts of PD, which will be central to my later analyses, to address its experimental, empowering and democratic possibilities in the CS context.

Central to PD, also known as co-design, is the collective creativity of designers and people who are not trained designers, working together in a design process (Sanders & Stappers, 2008). Design workshops have demonstrated strong results as venues for this joint collaboration by creating a shared

understanding of a situation and possibilities for participants to express themselves through their actions (Westerlund, 2007) and conflicting conversations (Buur & Larsen, 2010). Co-design makes people come together through their actions and use of language (Lindh Karlsson & Redström, 2015). The overall design process and dialogical culture in the design team are developed from people's actions (Binder et al., 2015) and explorations with materiality, as well as from talking and listening to one another (Wright & McCarthy, 2010), which make them more prone to expose themselves and their opinions (Lindh Karlsson & Redström, 2015, p. 9). Several authors suggest considering co-design experiments and practices as design laboratories (Binder, 2007; Binder et al., 2011) or a "set of labs where vision making and codesign meet, resulting in organized conversations for action" (Escobar, 2018, p. 195), and as valuable factors of "democratizing democracy" (Binder et al., 2015, p. 153).

By giving the end user more control, co-design and participatory thinking challenge the "expert mindset" and existing power structures that build on hierarchy and control (Sanders & Stappers, 2008, p. 9). Thus, "we may think of design collaborations as the making of things that explore forms of emerging publics, and thus enrich the current repertoire of democratic engagement and expression" (Binder et al., 2015, p. 153). Björgvinsson et al. (2010, p. 50) argue that a central challenge for PD is to explore alternative perspectives on participation and democratisation:

> This challenge means actively exploring alternative ways to organize milieus for innovation that are more democratically-oriented than traditional milieus that focus on expert groups and individuals. It also means moving from the dominating technocratic view of innovation; a move from things [object or service] to Things [socio-material assemblages] where differences and controversies are allowed to exist, dilemmas are raised and possibilities explored.

A potential context for democratic design experiments is CS, with its strong separation between the scientific community and the people participating in scientific research. The challenge is not only to move away from the dominating technocratic view but also to move toward more collective and relational ways of designing and being. To capture this heterogenous complexity, Björgvinsson et al. (2010) argue for a shift in perspective from "design projects" to "design things" (see Binder et al., 2011) because Things are not cut off from human relations but comprise socio-material "collectives of humans and non-humans" through which "matters of concern" (Andersen et al., 2015; Latour, 2004) or controversies are handled. Binder et al. (2015, p. 152) write:

> We argue that participatory design practices are particularly well suited for renouncing the obsession with 'objects', so dominant within design, and replacing it with things or thinging as socio-material assemblies that evolve over time. [...] we suggest a shift from a focus on users and representation towards citizens and publics, including not only human, but also non-human participants.

Socio-material assemblages are important catalysts of democratisation because they dissolve power structures and decentralise power. Thus, in the CS context, the democratic design experiments are particularly interesting because they "work by making issues experientially available to such an extent that 'the possible' becomes tangible, formable, and within reach of engaged yet diverse citizens" (Binder et al., 2015, p. 163). From this, the democratic design experiment can work as a platform for dialogue, disagreement, imagination and exploration of alternative futures and new forms of "emerging publics".

Methodology of study

Context and empirical data

The following case is part of the national research and development programme, Our Museum (OM), undertaken in 2016–2020. The programme involves 13 projects and research collaborations among five Danish universities and eight museums. It aims to strengthen cultural citizenship through research and development of innovative museum communication. It documents that a communication perspective furthers new understandings of the interactions among museums, their content and their users. Situated in this context is the empirical case study, The Sound of Denmark (SOD), a research project developed at the Center for Macro Ecology, Evolution and Climate (CMEC) at the University of Copenhagen. The CS project invites citizens to participate in mapping the Danish soundscape and contribute with sound data by recording, geolocating, processing and classifying sounds with their mobile phones. The collected data are used by the CMEC researchers to investigate the Danish soundscape by identifying sound sources, noise levels and the distribution of natural and human-made sounds. The sound data are processed by a machine-learning program that will eventually automate the sound analysis.

I spent 16 months as an ethnographic designer–researcher in SOD, co-developing a mobile app for data collection in collaboration with citizens, project members and external developers. In this paper, I draw

from a diverse subset of the data corpus from my research, comprising six transcribed semi-structured interviews. The design materials are from three PD workshops (three-hour duration per workshop) that involve 14 participant design journals, including sound maps, sketches, texts and observations. Finally, the ethnographic materials from the workshops are obtained from nine hours of sound recordings, photos, observations and notes. The materials generated from the workshops, interviews and sound recordings have been transcribed and prepared for initial open coding in NVivo.

Participants and data collection

The data collection involved a co-design process, initiated with a pilot study and 6 semi-structured interviews with 3 amateur scientists, 2 family members and 1 non-user (who had never participated in CS). The participant groups were selected and defined in a joint collaboration between OM and the CMEC, based on well-known participant groups in CS. The participants were mostly white, Danish, 16–68 years old, with an equal distribution of women and men. They were recruited via mail, CS communities, Facebook groups, such as Friends of Amager Fælled (AF; in Danish, Amager Fælleds Venner), or in CS projects, such as The Ant Hunt. Eleven participants were mixed during the workshops to make possible dynamic exchanges of ideas, knowledge, skills and perspectives (e.g. Bratteteig & Stolterman, 1997).

The sounds from the interviews and the co-design workshops were recorded with my multitrack field recorder (Zoom F4) and transcribed with audio-transcription software (F5). The interviews were coded, first through an open-coding process and then a closed one, hereafter reduced and categorised in NVivo 12. The insights from the interviews were embedded in the workshops as means to spark new discussions, focus on particular features, reflect on a given subject and create new interrelations that were not previously obvious. Finally, they served as inspirations for designing CS communication.

The interviews were conducted face-to-face at the CMEC and via Skype, each with a 45–60-minute duration. The interview guide was created with open-ended questions, prompts and follow-up questions to increase breadth and depth in the dialogues and the responses (Brinkmann, 2014, pp. 38–39). I asked the interviewees to answer the questions under four categories: the importance of communication for involvement, CS communication and citizenship, digital technology and democratising science. My aim was to establish a clearer understanding of their everyday actions, engagement and communication across social media, online communities and in CS.

The semi-structured interviews helped me unpack the descriptions and the knowledge gained from the interviewees, as well as increased the possibilities to follow up on “conflicting” opinions (Brinkmann,

2014, pp. 42–43) or specific aspects of the interview that were important to the interviewee (p. 38). Hence, they were used as the basis for an explorative approach to the concept of CS communication, helped me formulate an early hypothesis and the research question and served as an inspiration for the subsequent workshops.

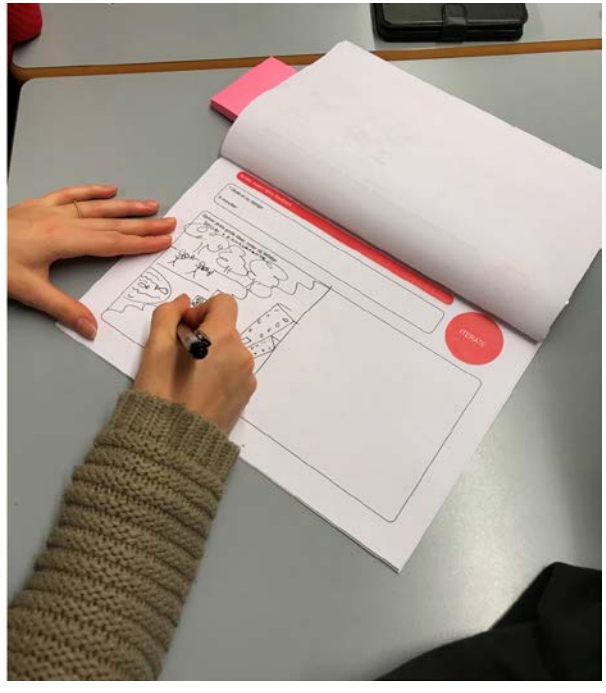

Figure 1. Ethnographic observations of socio-material interactions: dialogues, negotiations, sketching, design journals, scenarios and collective processing of ideas

Following people and materials through co-design

The PD process involved four phases: a pilot study that initiated the design programme (Redström, 2017), co-design workshops with three citizen groups, experimentation and implementation in collaboration with external developers and lastly, evaluation of the implemented design. In this paper, I focus on the data generated through the pilot study and the co-design process. I want to understand what constitutes citizens' engagement and communication in CS, specifically how new relations, exchanges and voices are constituted through design collaborations because in this way, researchers and practitioners can create new knowledge on how co-design can empower citizens and contribute to the development of CS communication.

The co-design workshops draw from design thinking (Dorst, 2011; Mitroff Silvers et al., 2013) and involve five phases where the participants perform the following tasks: 1) empathy – identify their needs and interests by means of a challenge that guides the process, 2) definition – define the challenge or the problem they want to solve, 3) ideation – sketch several creative solutions to the problem, 4) iteration – continue with one solution and develop a new design and 5) prototyping – make or draw and present their concept.

These phases are not separate entities but entangled processes where exchanges and intra-actions across the phases – among the experiments, the program and the questions and among the participants, their materials and ideas – unfold over time. As the participants move iteratively through the different phases, trying to frame the design challenge and the problem of interest, they deepen their understanding of the design space and reformulate new and more detailed hypotheses about their work. Thus, the design experiments function as frameworks for discovering paths into the problems (Redström, 2017, p. 94).

By following, observing and recording the participants' diverse actions and encounters (Figure 1), I gained enhanced insights into the complex affective relationships that are constantly co-created and transformed as a result of the participants' and the nonhumans' actions. My embodied experiences as an ethnographer and "engaged listener" (Gerard Forsey, 2010) allowed me to generate new knowledge about the participants' dialogical interactions, behaviours, experiences, practices and creations, as well as to follow different socio-material processes throughout the workshops and collaborations with citizens,

developers and researchers. Thus, I realised how new knowledge relations and civic capacities are cultivated or dissolved when co-designing with citizens.

The three design workshops aimed to investigate my research question, create tangible ideas with the users (Koskinen et al., 2011) and acquire new understandings of their needs, desires and modes of thinking. Involving citizens as co-designers enabled them to gain a critical voice in the design outcomes. Thus, a PD approach can itself be a way to strengthen civic capacities, create both project and process ownership, and establish long-term relationships with the participants from the beginning of the project.

Data analysis and thematic coding of themes

Because of the study's open-ended design approach, my analysis is not based on a quantification of the data. Instead, I organise the data into four main themes, following the recommendations (Braun & Clarke, 2006) for an inductive thematic analysis (TA) that emphasises an organic approach, which allows determining themes in a number of ways across the entire dataset, with the researcher playing an active role in developing the codes and the themes. It involves a coding process that does not attempt to fit the data into pre-existing coding frames; rather, the data suggest the name for each theme. The empirical analysis relies on coded sections of the data grouped under recurrent themes (Braun & Clarke, 2006).

My analysis uses direct quotes from my data corpus to illustrate how the data are qualified for each theme. The overall coding process can be summarised as follows: 1) transcribing and familiarising myself with the data; 2) creating and gathering the initial codes for each theme (through initial open coding in NVivo, I ended with 90 different codes); 3) searching for themes and writing memos around potential main themes and initial ideas, followed by closed/focused coding of observations (see Charmaz, 200609/07/2022 02:20:00; in this step, I categorised and reduced my codes to 20); 4) reviewing the themes, which included checking if they would work in relation to the coded extracts for each theme and across the entire data set; 5) clearly defining each theme; and 6) writing the analysis based on vivid examples of extracts. The four main themes are analysed in the next section.

Empirical analysis

My analysis has identified four major themes that reveal the potentials of designing with citizens, the importance of designing for dialogical interaction and how co-design strengthens citizens' democratic actions. The themes are as follows: 1) enabling cultivation of new relationships, 2) participatory thinking and emerging communities, 3) designing for communication and feedback, and 4) listening as political and ethical engagement.

Theme 1: Enabling cultivation of new relationships

The social and the scientific are negotiated and co-evolve with practice

In an interview, Ingemarie (aged 45, veterinarian, mother) describes her participation in the CS project, The Ant Hunt. She points out that doing CS is first of all a social and joint adventure with her son, stimulating their shared curiosity about ants and scientific research:

> I have an 11-year-old boy who thinks natural engineering is great fun, so that was actually the background. During our summer holidays, we found The Ant Hunt as something we could do together, and I think it was an interesting study to do and a good opportunity to teach him something about research.

For Ingemarie and her son, CS is a joint and social project that fuels their shared passion for studying ants and enables mutual learning "because we want to find out what kind of ant we have down there because then you can read more about it". For them, CS is a site where they can have fun and be curious together, learn about conducting research, care for nature and document their findings about the natural environment. Ingemarie says, "In general, it is this thing about teaching one's child to take interest in nature and observe and put into words what we see". Their mutual engagement, materialised through epistemic and non-epistemic practices, not only guides collective learning but also helps formulate new understandings and knowledge about their local environment. Ingemarie explains, "You know methods and how you register, all the things they are perhaps not learning in school – 'scientific methods' – and I think it is exciting to get more knowledge about where you are [our local environment]". Their mutual engagements in the project and their surroundings create a dialogical space that integrates both social and scientific processes: "when we have been out walking in the woods and things like that, we have talked about ants that live in different ways, look different, and things like that". Taken together, these examples

indicate that doing CS involves diverse forms of practices and ways to participate, through which participants interact and share findings, describe and discuss experiences, raise new questions and collectively process their uncertainties.

Connecting through differences: uncertain situations are reframed and negotiated collectively

The workshops and sound mappings at AF demonstrate the participants' difficulty in describing their findings and listening experiences, that is, putting sounds and the sound environment into words for one another. Christina (aged 42, Chief Consultant, activist) explains:

> There were sounds I found difficult to describe. I mean you [Niels] have written more rich words. I mean the feeling of going into a cave, from a more open sound [environment] to a more closed sound [environment]. I went that way, into this cave-like landscape, and I cannot put more words on it.

This 'uncertain' situation, as described by Christina, initiated a collective reframing of the situation, became part of the participants' sound explorations and negotiations and was integrated into our concepts as an 'unactualised' potential. I observed how central it was for the participants to share and communicate their ideas and experiences, as captured in my discussion with Christina and Joanne (aged 45, filmmaker, activist):

> Christina: I know the sound but lack the understanding of "well, it is this [specific] bird".
>
> Joanna: I can help you with that.
>
> Christina: Exactly! But I feel that there is something that I have not learned.
>
> Researcher: Do you mean describing the actual sounds, or...?
>
> Christina: Yes, I couldn't tell which bird it was.
>
> Researcher: I think this is interesting; you don't have the precise words or language to describe your surroundings.
>
> Christina: I can feel it myself; it is so physical, but I cannot describe what it is.

> Joanna: Why should we also have a name for everything? I would rather hear how you describe the sound than a name.
>
> Christina: Is that not what language can do – make it possible to share our experiences?
>
> Joanna: Yes, but what it [the great tit] says and does is not the only thing that designates, this is a great tit. I mean, if you describe the bird's sounds, you are saying more than "this is just a great tit"!
>
> Joanna: I would rather hear how you experience the sounds than a name.

During our explorations, I realised how challenging it was to describe AF's sounds and sound environment. People lacked a shared language for describing and expressing their sound mappings and listening experiences. For Joanna, a precise definition of a sound was not central; however, the possibilities for sharing and hearing about other participants' listening experiences were crucial: "But how does your nature sound? I mean, so I can relate to it". In contrast, for Christina, the uncertain situation caused frustration and made it challenging to share and connect with other people's experiences and make sense together. She explains, "What I mean is that language, as I see it, was it not Wittgenstein who said that the language is the reality we live in? However, I think that the richer a language we have, the better we can connect with each other's experiences".

This example demonstrates that it is crucial for participants to be capable of sharing, discussing, and articulating their findings, experiences and uncertainties with each other. Their active involvement and mutual exchanges make it possible to connect and relate to perspectives and understandings that differ from their own. This insight underpins a key finding – communication is central to participants' engagement in CS. Furthermore, I have heard that people's descriptions, discussions and disagreements constitute an important part of design collaborations that entail active involvement in a mutual process of negotiation. These distinctive forms of engagement support conditions for dialogue and deliberation.

In another interview, Tom (aged 68, pensioner, amateur scientist) states that doing CS with others, not only gives space to a different voice, but also helps advance collective productions of knowledge:

> Well, it's also something about getting more knowledge because you can't know everything, but when you go along with 5–10 others who also know something, you can get your knowledge tested, but you can also build on your knowledge, and I think that is an important thing, that you break out of your own little world.

This example emphasises that possibilities for sharing, exchanging and connecting with other participants' ideas and understandings, are important in order to move beyond one's ways of knowing and understanding. Anne (aged 65, pensioner, amateur scientist) confirms this, suggesting that the social and the scientific are co-produced: "You can take things with you [mushrooms] and show them to each other, and say, 'Do you have a sense of what this might be?', and further, "It is also interesting to see what the others find. It is not only myself; it is equally interesting to see what my friends find". Citizen scientists are curious. Their investigations and mutual sharing raise questions and start a dialogue, which moves them beyond their own experiences and understandings of a particular situation.

Taken together, this theme demonstrates that participants share experiences, interests and knowledge through a mutual process of dialogue and negotiation. Their collective sharing and exchanges connect them with perspectives that differ from their own, enable social encounters and cultural exchanges and contribute to the cultivation of new interrelations. The theme also shows the importance of designing new forms of engagement that allow participants to connect, share and discuss with one another; offer opportunities for socialising and encounters with otherness; and foster new ways of acting together. It calls for the creation of new venues for communication that promotes social and cultural exchanges, comprising a joint enterprise between scientists and citizens in SOD, from which new relations and collaborations can be nurtured and a dialogical culture can be developed.

Theme 2: Participatory thinking and emerging communities

Cultivating new structures of engagement

During a workshop, Mads (aged 45, nature and culture intermediary) has suggested that concepts solely focusing on individual sound collection might be too exclusionary:

> I think it becomes too much yourself and your surroundings; there is something exclusionary about this. I think, if you see it in a context where a lot of people are supposed to record soundscapes, then you have to create something community-like. I mean, how can we gather around this [SOD]?

Mads proposes that the participants and I consider how many participants can come together in SOD – around the practices of sound recording and as a community. Mads elaborates, “You know, when people have an affinity for places, ‘what is the sound of this place?’, then you can describe the sounds in your environment, and then you can somehow share it […]”. This example underlines that participants should have the means of exploring, questioning and sharing their local soundscapes with others. It calls for a multiplicity of ways to participate in SOD – that support mutual engagement and establish new socio-communicative relations.

The participants echo the workshop concepts, with statements such as, “We need a shared language, a sound community, to create a relationship with nature in order to be free” and (in a subsequent workshop) “We build teams and compete with one another”. Furthermore, participation is not necessarily active and productive all the time because the mere presence and agency of others are affective, arouse emotions and can be inspiring. Mads explains, “I think it is great that you can see there is some life, that others are out recording sounds, that you can almost livestream what is being recorded now, right? Wow! Something just came up from the southern part of Jutland, or a weird station – you just get tuned into it”. This suggests the participants’ desire to extend the possibilities of actively making sense together by engaging with others through their joint sonic practices in SOD.

Oliver (aged 27, MA in communication, field recordist) confirms the idea of a shared project yet questions Mads’ proposal: “I think this is a very good question. How can we come together around defining local sounds? [...] because personally, I think it is something you do alone, and it is difficult to do two and two, because you make noise, and you record each other”. Taken together, these examples make it evident that new ideas, concepts and practices and diverse forms of engagement are co-constituted through participants’ mutual negotiations, elaborations, creations and dialogues. Thus, co-design makes collective thinking and deliberation possible; it extends the possibility of actively making sense together.

Mutuality and shared actions involve the competence of others

Mutual engagement is made possible through dialogical exchanges and feedback, as Oliver states:

> I don’t know if you can call it a complete answer to ‘how we can gather around this’. But it is something with getting feedback, a response to what you are doing. It doesn’t necessarily involve [...] recording sounds together. But let’s say I made a recording and shared it in a forum, and then you say, ‘That is a great recording, and it’s an exciting sound; what is it?’. ‘Well, it’s from this place, and I recorded the sound myself’. So, feedback and response.

This example shows that communication and feedback are central to negotiating new meanings to obtain a different perspective of the situation at hand. It shows that people want to share their experiences, interests and curiosity. Cæcilie (aged 24, MSc student, intermediary) follows up on Oliver's argument, adding that collective sound production in a community might be enjoyable:

> In addition to what you said, I was thinking, maybe 'create new sounds together' [gives an example]. 'Well, that sounds great, that wind game you have; it's going to sound pretty nice with this cuckoo I've recorded'. Somehow, see if you can use the different inputs to create something within the community; I think it could be quite fun.

This suggests that a creative approach to sound recording could be an enjoyable way to establish new relations and form a community, that is, to connect people with perspectives that differ from their own. It indicates the participants' desire to do more than just contribute with data; they want to make the data their own through cultural production, which calls for sound data to be open for cultural and collective creation.

In an interview, Ingemarie tells me about her passion for knitting and engagement with the knitting community ravelry.com, as well as how this platform enables social and cultural exchanges:

> I got deeply interested in knitting a few years ago, and then I found this online community – and how wonderful it is to find someone who's just as crazy about knitting as yourself. If I'm thinking of making something, I can see other people's experiences; I can say, 'No, this will probably not work, or this pattern is hard to work with'. You also have really fun communication with other users, and there are events where you are knitting together.

Whether one's passion concerns studying ants, recording sounds or knitting, I have heard that it is interesting and enriching for people to share their experiences, passions and knowledge and to learn from one another about matters of common interest. People need to exchange ideas and connect with other participants' perspectives on a shared passion.

As Anne reminds the group, collective exchanges broaden their perspectives: "Alone, there you see for yourself, but when you are ten or twenty people [collecting mushrooms], you see what all the others

see because then we show it to each other and talk about it". Thus, collective action is made possible through active listening and speaking; it connects people through their differences in meanings, perspectives and understandings. Furthermore, building a community with others is a way to have fun and learn from one another. It offers a space where new ideas, questions and projects can be generated from the participants' mutual exchanges. A community and a dialogical culture expand from people's actions and exchanges with one another, broaden their perspectives and extend their possibilities for actively making sense together, strengthening citizens' capacities to act and express themselves.

This theme reveals the participants' desire for meaningful interactions and mutual exchanges around a joint enterprise. In the next section, I demonstrate the importance of designing for dialogical interaction that strengthens citizens' capacities to act.

Theme 3: Designing for communication and feedback

The CS participants connect in practice and through dialogue. They share and discuss their findings and experiences with other participants and the scientists, as Anne explains, "You can see what others find. This is great, and when you find something, you can see how common it is [at Svampeatlas.dk], where it grows and which months it is best to find such a thing." The participants share and discuss their findings to gain different perspectives and formulate new understandings about them.

Anne continues, "You can bring your findings and show them to each other and say, 'Do you know what this might be?', and further, it is also interesting to see what the others find. It is not only myself; it is just as interesting to see what my friends find". Thus, sharing becomes a way to relate to other people's interests and passions, a way to connect through differences, that potentially raises new questions: How common is this? Where can I find this? What participants say and do, their questioning of the situation at hand, creates new possibilities for reframing their uncertainties and negotiating new meanings and understandings about that situation.

Feedback is an important part of the participants' dialogical interactions and essential for continued and meaningful participation, here highlighted by Anne: "I mean you become happy if there is someone who takes the time to answer or comment on things [your findings]". [...] "If you don't get any feedback, it can be the same [...] if you just contribute [with data], and you do not understand how it might be useful to others, I think it would fade out". People want to understand how their work and findings become meaningful to other participants, including how they are used in scientific research. As Cæcilie says:

> Well, for me, it is interesting to know what insights it creates for the researcher and to hear about these things because the researcher often has a different perspective, different knowledge and another starting point for his research, so that is the realisation when we talk together. Well, what are the realisations that arise in the researcher?

Feedback not only serves to formulate citizens' new understandings about their findings, but more importantly, it feeds the dialogical interactions of the entire collective, where new meanings and knowledge are negotiated, elaborated and co-constituted among researchers, citizens and nonhuman agents. Feedback supports citizens' participation in CS; it makes their actions and contributions meaningful.

The results from the interviews and the workshops make it evident that people do not merely participate in CS to satisfy their interests, but their engagement is also motivated by selfless actions, as Tom says, "I can see that I have knowledge about this that I can contribute with". For Louise (aged 27, biologist), the shared cause is central: "For my part, knowing that what I have produced is part of something greater". For Thomas (aged 56, blue-collar worker, amateur scientist), it is also a matter of protecting the natural world: "Well, Svampeatlas is a database where you collect data that should benefit nature". Finally, Cæcilie suggests that actions and contributions are meaningful when they enrich the activity or the context that a person is part of: "It's always nice to be in a context where you can do something where what you do is valuable".

People participate because they possess knowledge that is valuable to others. Their contributions and engagement become part of something greater that makes collective action possible and potentially benefits the natural world. Knowing that their work has value to others is meaningful in itself, but how can people know the value of their engagement? How can they understand their work's impact and value?

Louise explains that feedback and appreciation from scientists are important for her participation: "I think it's important for people who want to use your data that they appreciate the extra data they [scientists] get. You feel that you have a dialogue and that your contribution is appreciated".

Dialogue with and feedback from scientists make citizens' actions and participation meaningful because these help them reframe their uncertainties, (re)formulate new understandings and uncover

unknown territories. As Tom explains, feedback helps in reformulating an unknown situation and creating new understandings and knowledge of the situation at hand:

> Questions were raised [by the researchers]: 'Well, what do you mean by that?' Then you had to, like, sharpen your attention: 'Well, I mean this because the spores look like this' or 'because the slats run down' or whatever it could be. But he asked me a question, so he actually helped me to become wiser.

This theme demonstrates that dialogical interaction and feedback make collective action and thinking possible, help raise new questions and collectively process and reframe the situation at hand, potentially strengthening citizens' capacities to act and participate in CS.

Theme 4: Listening as political and ethical engagement

Citizen science as collective and political action

My interviews and experiments demonstrate that co-design activates and makes audible a plurality of voices. It reveals citizens' needs to make their voices heard and enact themselves as citizens. As Louise states, "Clearly, I see it [CS] as a way of being politically involved, of being involved in the community life. I think it should be seen in line with these things because citizen science is very much about what we jointly develop". From this conception, CS is more than citizens collecting and contributing data to scientific research. It also involves collective and democratic practices through which citizens make their voices heard – the means for becoming politically active and involved in local issues, communities and the broader society.

As Ingemarie explains, she has recommended the CS project, *The Ant Hunt*, to her son's school because she has found that CS not only teaches children about caring for nature, but also about democratic engagement:

> I have also recommended The Ant Hunt to my son's school because I think it is a good way to - and that is also why I made it with my son - that children learn to contribute to society, and they understand that they are part of something larger than themselves, something that is larger than our small local community, both at a national level, but also a [global] society that you are a part of.

Citizens' doings are not isolated events in CS; rather, they are entangled with people's everyday lives, through which they shape social and cultural life, local communities, institutions and the broader

society. People enact themselves as citizens in engagement with other people and organisations by bringing attention to different matters of public concern, beyond personal intentions, that potentially benefit local communities.

Citizens bring attention to public matters and care and responsibility for these

Throughout the workshops and the experiments, I learned that citizens bring attention to different matters of public interest and care and concern for these, while collectively making sketches and listening. Their different actions result in new questions – here stated by Mads: "How can we be together around this?" – emerging from our concepts and sketches: "How can we develop a sound community that connects us with other people and nature so we can be free?" Finally, as stated by Joanna during our sound mappings at AF:

> It was great going out again [second round of sound mapping] because you get the opportunity to go one step further into the sounds again, and [asks herself] what do these sounds mean to me? In the end, I have experienced and accepted that I am not [walking in the forest] in Gribskov; I have to accept that I am in Copenhagen [Joanna uses the forest's soundscape as realisation]. That is also the reason why we must preserve AF because we need this place. How would it be to live in Copenhagen without AF, without this natural area? It is going to be hell if you don't preserve nature and these breathing holes because then, I will not be able to survive.

The participants' questions initiated new discussions and negotiations. They shared their thoughts, experiences, feelings and interests and expressed their concerns about public matters, such as preserving the natural areas in Copenhagen. As Joanna suggests, listening can open up new ways to connect with the natural world and participate in SOD: "If you establish a relationship with the nature around you, then maybe, the feelings [desire] to protect it are also awakened; it should be locally anchored so that people take more responsibility".

Design collaborations and practices of listening encourage citizens to express and discuss their concerns in order to bring their personal interests, perspectives and local knowledge into play. As listeners, engaged citizens bring attention to important and local matters of concern, as well as care and

responsibility for these, such as protecting the natural area AF, which is threatened by the municipality-led urban development and de-conservation. Their epistemic practices are opportunities to go beyond the focus of the scientists and the CS project. Materialised through practices of listening, citizen agencies hold the potential to be politically active in the world.

Activating new voices and ethical practices through co-design

From the experiments and the workshops at AF, we have learned that co-design can be an active and collective way to speculate on, negotiate and rearticulate ideas and develop responsible ways to protect and reconnect with nature through new forms of listening. Christina reflects:

> If more people become aware of the soundscapes out here [at AF], then it could be a legitimate input into the political debate, where right now it is money that is the input [shaping] factor, [...] but only if there's also a part of the political conversation that's about what kind of soundscapes we'd like to have in our city. I often think that within the next 10 years, we will become more aware of the energy landscapes we have. What kind of landscapes do we want? What kind of energy and soundscapes do we want in the city? It is not legitimate to talk about [it] in the political debate today.

This statement emerges from a passion for nature and community work with Friends of AF, through which she and others (e.g., Extinction Rebellion) fight for the protection and the conservation of the natural area AF. Christina proposes listening as a form of engagement that increases citizens' awareness by bringing attention to the natural areas at AF, serves as a critique of the municipality's plans to de-conserve parts of AF, activates a plurality of voices and asks new questions, such as "What kind of soundscapes do we want in the city?" The key findings underpin the fact that co-design activates new forms of engaged listening, new ways of reconnecting with and protecting the natural environment at AF, new ways of doing and bringing about new possible futures and ethical forms of engagement. Taken together, this theme reveals that design collaborations can open up new forms of ethical listening and engagement that strengthen citizens' democratic voices and cultivate new sites of communication. Thus, co-design might be recognised as offering the potential to create and imagine new ways of enacting citizenship.

Conclusion: Co-design as affirmative empowerment

Throughout this paper, I have demonstrated how a PD approach and design collaborations with diverse groups of citizens can create new productive relationships between science and citizens, diverse forms of knowledge, collective practices, and affirmative and empowering relations in a CS project. *The key findings*

document that PD methods, in combination with an ethnographic approach to sound and listening, can help develop new responsible forms of participation and communication in CS that strengthen civic capacities and scientific research. Thus, participatory research can benefit scientific communities and equally empower a plurality of critical voices among the public, hence contributing to the protection and the conservation of natural environments. This work may therefore serve as a design guideline for developing more responsible forms of engagement in CS. In this section, I discuss and elaborate on key findings through the PD lens.

Co-design experiments are spaces of democratic possibility and vision making that organise and move the conversation forward. A dialogical perspective on design collaborations with citizens holds significant potentials for advancing participatory, critical and collective thinking in CS, consequently challenging the expert mindset by giving participants more influence on early decisions in the design process (Bratteteig & Stolterman, 1997), the design outcomes (Sanders & Stappers, 2008), technoscientific development and ultimately, what is considered factual knowledge. Furthermore, co-designing with citizens can advance new forms of listening and ethical engagement and nurture affirmative relations with other participants, researchers and the natural world. Consequently, it can create new ways to reach out for "otherness" (Lacey, 2013; Wright & McCarthy, 2010), which activates a plurality of voices (Bickford, 1996), cultivates new spaces for communication, strengthens citizens' democratic actions and contributes to new areas of citizen-led research.

The key findings emphasise that citizens can bring attention to different matters of public concern and care and responsibility for these; accordingly, they shape social and cultural life, local communities, institutions and the broader society. Citizens bring different matters of concern and ways of knowing and doing into the design process, which include embracing the situational, uncertain and difficult aspects of co-design and participation (Andersen et al., 2015). As a result, design collaborations offer vital possibilities for exploring alternative perspectives on participation and democratisation (Björgvinsson et al., 2010) in the CS context. They are opportunities for exploring "conflicting intentions" (Buur & Larsen, 2010, p. 136) and developing a new "emergent public" (Binder et al., 2015, p. 153) of critical listeners who challenge and question dominating and repressive structures in society, which can help advance the shift from more

governing technocratic and scientific views to more collective and relational ways of designing and being – being communal (Escobar, 2018, pp. 225–226).

These insights are vital because they underpin the necessity of cultivating new cs engagements that counter scientisation of neoliberal governance and push for more just societies (Kimura, 2016), new democratic practices and closer relations between scientific communities and citizens, which means "finding [and creating] relevant ways of thinking together" (Stengers, 2018, p. 145). Stengers argues that citizens can contribute with an "imagination that research collectives have not cultivated" because they have downplayed everything that does not contribute to advancing specialised knowledge (p. 102). Therefore, if CS intends to give citizens a voice, enhance public knowledge and expertise and recognise citizens as generators and contesters of scientific knowledge (e.g. Strasser et al., 2019), all stakeholders have to build on and with non-scientists' diverse bodies of knowledge and epistemologies by designing new forms of engagement that connect citizens with science; allow them to speak and be heard in the production, negotiation, and communication of scientific knowledge; and enable different and conflicting voices to resound and new practices of citizenship to emerge.

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08.02 Reconfiguring sonic engagement: Exploring epistemic agency and exclusion in citizen science

Abstract

Citizen science projects are increasingly merging digital technology and artificial intelligence systems with data collection methods. In combination with the public's participation in scientific research activities, data is processed, qualified, and patterns identified at unprecedented scales and speeds. Hence, citizen science has created new opportunities for expanding the public's participation in and understanding of science that supports alternative models for knowledge production. *Despite this, few studies have addressed how digital technologies and AI systems may affect, constrain, and transform citizen agencies, knowledge relations, and public engagement in scientific research.* This paper will address this gap through netnographic studies of citizens' communicative actions in the citizen science project, The Sound of Denmark (Lyden af Danmark), to contribute new knowledge on designing responsible forms of engagement that strengthen citizens' capacities to act. Key findings call for a turn in designing more responsible forms of citizen engagement that consider how human-nonhuman material practices are shaping epistemic agency in citizen science. Finally, the paper contributes to a broader debate on the formation of epistemic subjects, inclusion and exclusion in citizen science.

Keywords: epistemic agency, epistemic exclusion, technological affordances, sonic engagement, antiprograms

Introduction

Digital technology and artificial intelligence (AI) systems have created unprecedented opportunities and capacities for collecting, classifying, identifying, and analysing large datasets in citizen science (CS) projects. In combination with volunteer contributors' epistemic work, computational technologies are increasingly transforming the very science-citizen relationships and scientific knowledge production. According to Mackenzie (2015), predictive machine learning models are performative and act as part of digital platforms that alter human actions (ibid, p. 442). Hence, consistent with Cox (2017), computational processes and algorithmic models increasingly reproduce what we see and know (ibid, p.2). They make decisions and judgements that exercise power, shape human actions (Azar et al., 2021), what constitutes knowledge and how epistemic subjects are (re)produced (Cox, 2017, p. 3). *Hence, new knowledge on how the technological environment influence and (re)configure the epistemic practices of volunteer contributors in CS, and their capacity to act on and contribute to scientific knowledge production, is critical to avoid "epistemic exclusions" of the "epistemic agency" of knowers* (Dotson, 2012, p. 24).

Previous studies found that emerging technologies can advance scientific research and public engagement in citizen science (Newman et al., 2012). CS technologies can enhance data collection and analysis and create new opportunities for participation and volunteer contributions to scientific research (Mazumdar et al., 2018, p. 303). In addition, they broaden participation and allow previously uninvolved communities to participate (Newman et al. 2012, p. 301). Newman et al. (2012) suggest that emerging technologies show great promise to create a community of "data-aware" and "always connected citizens" that support asynchronous data collection and contribution to science (ibid, p.302). Brenton et al. (2018) state that information technology is crucial for successful CS projects (Ibid p.63). They maintain that accessible and affordable technologies can empower and enable people to participate more actively in knowledge production and, as a result, democratise science (ibid, p. 74-75). Mazumdar et al. 2018

demonstrate that digital platforms support social and dialogic interactions between scientists and volunteer contributors and empower people to raise their voices and “drive change” (ibid, p.305). Technology can facilitate communication and keep people connected (Antoniou & Potsiou, 2021, p. 48). Ceccaroni, (et al., 2019) propose that applying AI systems in CS holds significant potential for connecting and engaging people with science and creating more inclusive and encouraging practices that benefit the volunteer contributors (ibid, p.4). Hence, innovative technologies have often been emphasised for their potential to empower volunteer contributors and enable new opportunities for CS engagement.

Despite these insights, there is a need for new knowledge regarding the opportunities and limitations of CS technology use (Skarlatidou & Haklay, 2021, p. 343). *However, few studies have addressed how digital technology and AI systems affect, constrain, and transform epistemic practices and knowledge relations, including the very processes of public engagement in scientific research.* This paper will address this gap by investigating the communicative processes in the citizen science project The Sound of Denmark to contribute new knowledge on how to design more responsible forms of engagement that advance *civic capacities.*

The empirical focus of this paper, The Sound of Denmark (SOD), is a digital CS project developed at the Center for Macro Ecology, Evolution and Climate (CMEC) at the University of Copenhagen. The project focuses on researching the Danish soundscape by identifying sounds sources, noise levels, and the distribution of natural and anthropogenic sounds based on large scale data collection. The project invites citizens to help scientists map the Danish soundscape and contribute with sound data by recording, geolocation, processing and classifying sounds using their mobile phones and the project's mobile application (see figure 1). The participants decide whether they want to create a profile and get full access to

the community forum or if they want to contribute with data anonymously. The sound data produced by the SOD community is used to train a machine-learning programme (AI system) that identifies sound sources and provides feedback on the recordings. The participants can suggest new sounds to the AI system and enrich the data set before finalising their contribution.

The community members are active contributors to scientific research and reconfiguring the epistemic tool for data collection (AI system), affecting the scientific process, including the final data set and results. At the same time, people are themselves reconfigured by the technological infrastructure's limitations and possibilities. From this perspective, the CS project, the community, and AI system constitute an entangled techno-scientific apparatus that reconfigures practices and agencies iteratively.

We need a better understanding of how a technological environment enables, constrains, and excludes the epistemic agencies of volunteer contributors and his/her abilities to participate in an epistemic community (Dotson 2012, 2014). Thus, rather than focusing on assessing technology itself and keeping humans and technology apart, this paper will address their entanglements and agencies to create new knowledge on the techno-scientific apparatus of bodily production in The Sound of Denmark.

Barad's agential realist ontology provides a useful framework for understanding the boundaries, constraints and exclusions that operate through material-discursive practices in techno-scientific apparatuses of bodily production (2007, p. 212). Barad demonstrates that apparatuses are phenomena constituted and reconfigured through specific human and nonhuman intra-actions (ibid, p.206). Apparatuses are boundary drawing practices (ibid, p.148), agential cuts that enable and constrain knowledge practices and give meaning to certain concepts but exclude others (ibid, p.147). She points out that phenomena are not the mere outcome of human agencies (ibid, p.206-207). Nonhumans actors are also engaged in scientific research with powers and effects that shape the experiment's course (Cetina, 2007, p. 365).

Barad (2007) argues that agency is a matter of intra-acting; it is an enactment, not an attribute of subjects or objects. Agencies are doings distributed across human and nonhuman forms (Barad 2007,

p.214; Bennett 2010, p. 21). Barad states: “Agency is about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices” (2007, p. 214). Hence, our intra-actions with the world matter because we are part of enacting the arrangements that reconfigure, constrain, and exclude certain knowledge practices over others. Suchman (2007) suggests that these entangled “accountabilities” are located neither in us nor in our digital artefacts but emerge from our intra-actions (ibid, p.285). Consequently, we are responsible for the knowledge we seek, what exists (Barad 2007, p. 207), and the exclusions we participate in enacting (ibid, p.394). We are responsible for our designs and how they go on designing (Fry, 2008, p.56) because reality is (re)produced through our intra-actions with the world, through specific material practices that we have a role in shaping and through which we are shaped.

Hence, the critical thing to understand is what practices matter and how they matter and reconfigure epistemic agencies. What kind of epistemic agencies and exclusions operate intra-actively through the technoscientific environment of SOD? How can we design and (re)configure technological environments in ways that allow more responsible forms of engagement?

In addition to this paper’s theoretical framework, the following introduces the concept of affordances and elaborates on the term agency as a capacity for action (Suchman 2007, p.2) to explain how SOD’s technological environment influences epistemic agency.

Theoretical Framework

Affordances, materiality, and agency

The capabilities afforded by the technological environment in a citizen science context may influence the volunteer contributors' capacities to act in particular ways, in terms of the communicative actions, epistemic practices and knowledge production it enables, constrains and reconfigures. This paper draws on the concept of affordances to explain how epistemic agency is conditioned and reconfigured through human-machine relationships.

Gibson (1986) proposed that when humans look at objects, surfaces, and substances in the environment, they perceive their affordances. He writes: "The affordance of an object is what the infant begins by noticing. The meaning is observed before the substance and surface" (ibid, p. 134). Hence, to see things is not to see what the objects are per se, but rather their potential uses, utility, and opportunities they offer a potential actor. For example, a door handle affords a potential user the possibility to open and close the door, the fire affords to burn and warm, and a chair affords sitting. An object's affordances tell us something about its potential uses, and possibilities for action (ibid, p.223), and constraints. Hjarvard (2008) emphasises that technological artefacts have affordances that facilitate, limit and structure communication and action (ibid, p.121). Hence communicative actions between potential actors in CS are not only enabled and limited by technological affordances but structured in specific ways.

To bring the materiality of technology artefacts and socio-materiality together, Faraj and Azad (2012) propose that: "Technology affordances are action possibilities and opportunities that emerge from actors engaging with a focal technology" (ibid, p.3). hence, technological affordances are relational structures that emerge from the user's enactments and the artefact's generative possibilities. Consequently, affordances cannot be limited to the functions and properties of the artefact or the potential observer (ibid, p.19). The environment's affordances exist in relation to an observer (Gibson 1986, p.143). Gibson emphasises that affordances are neither an objective nor subjective property. He writes: "It is equally a fact of the environment and a fact of behaviour. An affordance points both ways, to the environment and to the observer" (ibid, p.129).

These examples demonstrates that affordances are relational aspects of technology use (Gibbs et al., 2013; Hutchby, 2001); they belong neither to the environment nor the potential observer but emerge from the relationship between the observer and her/his perception of the environment (Parchoma, 2014, p. 361). Hutchby (2001) suggests that affordances are functional and relational aspects of technology use that frames "agentic action" (ibid, p.444). Functional because they enable and constrain human agency, and relational because they differ with the object, potential actors in different contexts (Hutchby 2014, p. 87). Consequently, the same technology may afford different possibilities for action to different participants in SOD.

Hutchby (2006) proposes that new communication technologies' opportunities and limits are realised in their practical use and application (2006, p. 166). The functionality of an affordance is the result of both the artefact's "configuration" and how the actor "reconfigure" it (Lievrouw, 2014, p. 49). Treem and Leonardi (2013) emphasise that affordances are constituted from the material relationships of the potential actors and the materiality of artefacts (ibid, p.146). These examples underline that the relational structures emerging between the technological environment and the volunteer contributors in a CS project give shape to, enable, and limit epistemic agencies, not the technology itself. The technological environment's materiality can affect, guide, and reconfigure the possible interactions with an artefact and thus people's epistemic practices. Technological affordances enable and constrain human agency; they define the limits for what is possible to do with a digital artefact, which calls for an increased focus on humans and nonhumans' material entanglements and their reconfiguration and distribution of epistemic agency.

The following section unfolds the concept of agency as a capacity for action. It demonstrates that bodies and actions are given shape through human-nonhuman entanglements.

Capacities for action

Butler (2015) holds that the human body cannot be understood without its environment, machines or social organisations, its bodily existence and actions depend upon its supportive systems (2015, p.65), which are constituted through human and nonhuman relations (ibid, p.208-209). Butler proposes that: “The body is not isolated from all those conditions, technologies, and life processes that make it possible” (2015, p. 129). The body does not act alone; its capacities to act and be political are defined through its supportive and collective relations. The human body cannot be dissociated from its infrastructural and environmental conditions, it is part of nature, and its different ways of acting are always conditioned (2015, p. 65). Consequently, the agencies of the engaged observer in a CS context are always conditioned and constrained both by the technology and the possibilities it offers.

McCullagh (2019) demonstrates that the capacity to act in a political space is not exclusively human; agency is always co-constituted within heterogeneous milieus of humans and nonhumans. She writes:

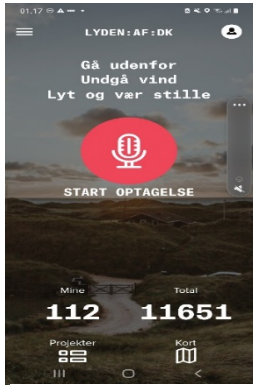
> Heterogeneous political space considers human-nonhuman assemblages as a genetic condition for the emergence of capacities to act. All action can thus be seen as emerging from constellations where humans are assembled with material and incorporeal elements (plant, animal, mineral, technological bodies and statements, utterances, expressions, affects, moods, gestures, etc.) (ibid 2019, p. 142).

Following McCullagh’s conception, human agencies cannot be separated from the production of their environment. The capacities to act and produce effects are always constituted from assemblages of humans and nonhumans (Suchman, 2007). Hence, nonhumans such as mobile apps, project protocols, sound data, algorithms, digital interfaces, mail, and Facebook groups, are always part of human actions, desires, and communicative actions; collectively, they coproduce new relational capacities for action and engagement.

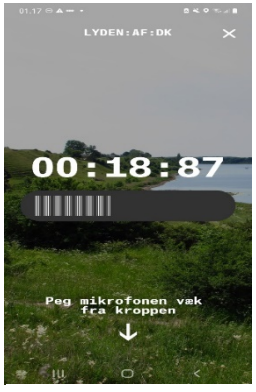
Irwin and Michael (2003), in their analysis of ethno-epistemic assemblages and scientific citizenship, underpin the importance of focusing on heterogeneous entanglements. They write: “the process of engagement with expert knowledge should also take into account the impact of various media [nonhumans] through which this, and related knowledge circulates” (2003, p. 133). From this perspective, action and knowledge are never exclusively constituted by humans, nonhumans are taking part in “shaping the ways knowledges – scientific, personal, experiential, ethical, economic, political - interact, come together, combine or polarise” (ibid, p. 133). Consequently, material agency is distributed (Bennett, 2010).

While this shift in perspective opens new ways of assembling and acting responsibly with nonhumans in CS, it demands consideration of the heterogeneous assemblages we are a part of and the processes enabling us otherwise depriving us the opportunity for acting. It raises the urgent question: how are epistemic capacities shaped within and through SOD’s technological milieu?

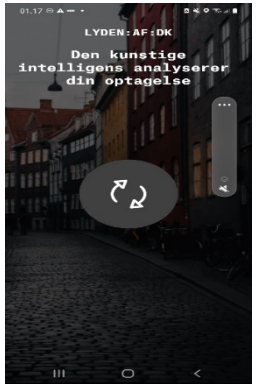
The Sound of Denmark mobile application and community platform



1) start sound recording

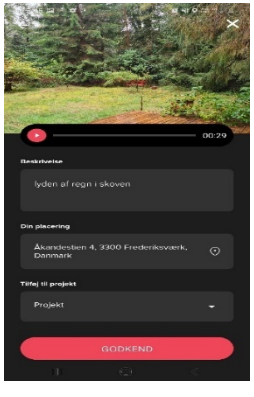


2) Machine listening (30 seconds)



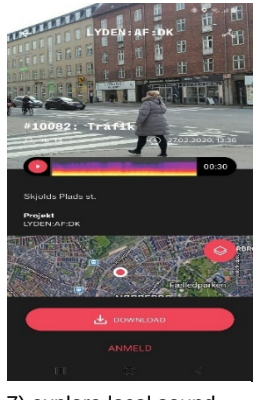
3) AI processing data

4) AI feedback. Did the AI determine the right sounds?

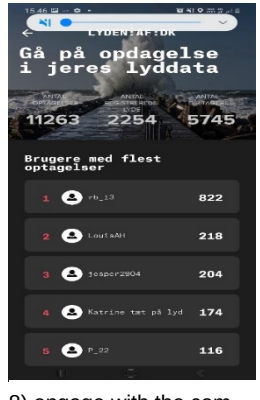


5) finish registration, upload, and share your findings

6) interactive sound map



7) explore local sound-



8) engage with the community

1) Start sound recording: go outdoors, avoid the wind, listen out and be as quiet as possible. Press the red button to start the recording (after 30 seconds, the recording automatically stops).
2) Machine-listening: point your smartphone in the direction of a sound source.
3) The AI system analyses the sound recording.
4) The AI system has identified a list of sound sources. The participants can now confirm (ja) or reject (nej) its suggestions, and it is possible to add new sounds.
5) People manipulate and enrich data with descriptions and photos of the soundscape before finalising their contribution (godkend).
6) People can interact with and explore sound data on an interactive map.
7) Through the map it is possible to explore locations, descriptions, sound spectrograms, distribution of human and natural sound sources, photos, listen to, download, share, search for sounds, and report harmful content.
8) People can also engage with community members and the project's communication officers in the mobile app's discussion forum. However, they cannot write to each other directly.

Figure.1. The Sound of Denmark mobile application

Methodology of study

Context and empirical data

In my research of designing citizen science communication, as part of the research programme, Our Museum, I conducted case studies in the digital CS project, The Sound of Denmark, a research project developed in collaboration with CMEC at the University of Copenhagen. I spent 16 months as an ethnographic designer-researcher in SOD, co-designing a mobile app and digital CS project in collaboration with prospective users and a developer team that brings people from diverse fields such as computer science, macroecology, science communication, design research, media science, including non-experts, and external developers together.

My analysis of citizens' intra-actions and engagement across SOD's communication platform: the community forum in the mobile app (see fig.1), email correspondences between communication officers and volunteer contributors, and the project's Facebook page, involves a data corpus that consist of (160) email correspondences, (40) Facebook posts, and (30) threads from the mobile app's community forum. The documentary materials include text, photos and video materials (e.g. Facebook posts), including photographic materials of my interactions with the mobile app.

To get an understanding of the size of the community, (5745) the volunteer contributors contributed with (11263+) sound recordings and discovered (2254) distinct sound sources in the Danish soundscape. The SOD community's demographics are considered diverse across age, gender, education and occupation, with participant groups such as families, daycare children, primary and high school children, pensioners, unemployed and academics. The demographics of these groups resonate with my earlier co-design workshops and interviews with amateur scientists and non-experts, where the community members are predominantly white and middle class. Mail correspondences between the participants and the

communication officers, including my ongoing correspondence with an Amateur scientist from the SOD community, have also helped map the community's demographics and investigate their experiences as volunteer contributors. However, the SOD community and profile database does not reveal if underserved groups are part of the community. Therefore, to protect people in the project, especially those who have not been informed and given consent to use their information, all names have been anonymised using pseudonyms.

My data collection covers the period from the project release: April 24. 2019 until September 2020. The community forum and Facebook page were not implemented at the project launch because of delays in the development process. Consequently, participants and communication officers communicated exclusively via email. Within this period, the forum and the mobile app had been in constant development because of technological issues and new implementations; feedback from the participants across SOD's communication channels has been an essential part of solving the project's shortcomings.

Data collection

I adapted a netnographic research approach (Kozinets, 2015; Kozinets, 2017) combined with virtual ethnography (Hine, 2000), as a general approach to study SOD's technological environment and the affordances and possibilities it offers. It involved participant observations through instances of dialogic interactions with participants, project members and developers across SOD's communication platform, with me as co-developer and active participant. The netnographic approach allowed me to explore and focus on the communicative interactions among the volunteer contributors and between the volunteers and communication officers and how communicative actions unfolded across SOD's communication channels: a

community forum, a Facebook group, and email correspondence with participants. The personal descriptions and experiences by the volunteer contributors revealed their agencies, epistemic practices, experiments, social relations, and different styles of reasoning (Mahr, 2021, p. 38). They allowed to explore, identify and make comprehensible the technological environment's affordances, the possibilities, and limitations it introduces in the cs-project, including its influence on the epistemic engagement.

Data analysis and thematic coding of themes

My data analysis focuses on significant events that capture the communicative actions and intra-actions among the participants and between the volunteers and communication officers across the project's communication channels. I have chosen these because they can reveal how volunteer contributors' communicative actions and epistemic agencies are constituted, shaped or excluded in intra-action with the mobile platform, project protocol, and AI system. My data analysis follows the process described by Braun & Clarke (2006) for inductive thematic analysis (TA), which emphasises an organic approach that allows theming across the entire dataset, with the researcher playing an active role in the creation of themes and codes, and where the data suggests each theme's names.

The empirical analysis relies on coded data sections grouped under recurrent themes. It uses direct quotes (translated from Danish) and resumes from the data corpus to illustrate how the data are qualified for each theme. The overall coding process involved the following phases: 1) familiarising with the data and initialising data categorisation; 2) creating and gathering codes for each theme through initial open coding in NVivo. 3) searching for themes and writing memos around potential main themes and initial ideas. Examples of my early ideas and codes include: anti-programs, technological constraints, exclusion, data quality, and uncertainties. This was followed by closed coding of observations (Charmaz, 2006), categorisation, and a reduction in the number of codes; 4) reviewing themes: comparing codes with the coded

extracts for each theme and across data set. 5) define each theme, and 6) write the analysis based on selected examples.

Empirical analysis

The following analysis identifies four themes demonstrating how digital technology and AI system affordances, including the project protocol, as an entangled apparatus affect and shape citizens' epistemic practices and engagement in cs. The themes are as follows:

1. Thinking with sonic engagement.
2. Performing citizenship through matters of concern.
3. Digital technology enables and constrains epistemic agency.
4. Technological issues and antiprograms.

Theme 1: thinking with sonic engagement

The citizen scientist inscribes new layers of meaning.

Participants in SOD contribute to the project by listening, recording, uploading, and mapping sounds, classifying, tagging, selecting, deleting, relocating sounds on an interactive map, and helping the AI system identify sounds, downloading, sharing, and discussing sounds and experiences across the project's discussion forum and social media platforms in communication with others. Key findings suggest that citizen scientists want to contribute with data and participate on their terms by following personal interests,

values, and passions. Furthermore, they want to share and communicate their experiences with other project participants.

The following resume of a mail from Hanne (kindergarten teacher) describes her experiences and participation in SOD with children 3-4 years of age:

> Over five weeks, we integrated SOD into our projects to focus on the sound of the water; we discovered that every city fountain made different sounds. At the children's requests, we threw stones of various sizes in Limfjorden and listened to the different sounds. At Vilsted lake, we repeated the session - it sounded like music. Back in the day-care, we addressed different words for water, wrote them down, and painted our experiences with watercolours. Based on our experiences with sound, we prepared small scientific experiments with water and talked about the importance of caring for the water.

Hanne explained that the project's learning goals: "was to realise it from the children's perspective. Our didactic considerations followed a playful and experimental approach to wonder, curiosity, and participation in the experiments. We wanted to teach the children that water exists in different forms".

This example demonstrates how the day-care took ownership of the CS project by integrating it into their everyday lives. Their adaption of the project incited a new and different direction that opened for further involvement and collective ways of thinking with sound. Their joint explorations of sounds and places in the city, experiments with listening and sound-making, over scientific experiments, to playful experiments with words describing water; demonstrate how the citizen scientists can contribute with new layers of meaning, value, curiosity, and imagination.

The volunteer contributors' relational ways of thinking and doing with other people, things and the environment demonstrate that their diverse forms of practices and abilities to restage things in new

situations and contexts hold great potential for generating alternative forms of engaged listening, reasoning, and involvement beyond the focus of the CS project, strengthen civic capacities, and cultivate new potential sites of communication.

Thinking with the critical work of citizen listeners.

The volunteer contributors contest the protocols of SOD and inscribe, share, and communicate their values and interests in the CS project. Hence, citizen listeners' actions are not limited to the critique of power but recreate their relationship and involvement with the project through that critique.

In a mail correspondence with SOD's communication officers, Louise (pensioner and dedicated citizen scientist) describes her experiences and sound experiments from the project, including the technological issues she had discovered during her data collection. Louise writes: "I have recorded several sounds but deleted some of them again because the sound was poor. There are inconsistencies between what the map shows (fig.1) to all participants and me alone. Why this discrepancy?".

Louise's feedback and questions suggest that people have struggled with inadequate sound quality during their sound recordings, and discrepancies in visualisations of data on the overall map have been confusing. Another participant Ole, confirms this, underpinning the importance of adequate sound quality: "the sound is excessively compressed. Very unfortunate for such a project - and in these times when decent sound is standard. May I recommend maximum sound quality!".

In SOD's discussion forum, Henry criticises the distorted sound quality, based on his listening to several recordings:

> I have recorded excellent sounds with my phone, but in SOD, they are barely recognisable. So far, I have listened to around 40 recordings; the best is one eating an apple, bird song sounds horrible, and my recording of a street orchestra at Nørrebro in Copenhagen is highly distorted. What is the point?

Participants' actions, feedback and critique point to crucial technological issues in the project that influence their willingness to engage themselves in the project - as Henry underpins, why should he participate when he can record better sounds with his phone? While engagement with the project has resulted in confusion, deletion of recordings and unsatisfactory audio recordings among the participants, it has further demonstrated participants' concern about the CS project's sound quality, which demands immediate attention and action.

To improve the sound quality, Louise experimented with different approaches to sound recording. While sheltering herself from the wind, her recordings of fountains in Copenhagen demonstrated that the AI system provided inaccurate feedback. Louise explains: "your 'sound robot' [AI system] is not able to recognise splashing and rippling water; it recognises it as a 'rumbling stomach' or 'heavy breathing'".

When Louise downloaded her recordings and listened to them carefully, she discovered that every time people approached the fountain, the mobile phone's software would reduce the splashing water's sound while amplifying the nearby human voices. The outcome was a distorted soundscape where neither fountain nor human voices were clear. Louise's detailed descriptions and dialogue with the communication officers contributed to significant changes to the AI system's sound data analysis and the mobile app's visual feedback; hence, it improved relevant issues concerning the mobile app's general use and understanding.

The examples demonstrate that communication between participants and project members is crucial for a cs project's continued development because citizen listeners' attention and actions can uncover

a project's shortcomings and create new knowledge on how technology and technological issues influence, constrain and shape participants' involvement in the project. Citizens' critical work not only intervenes in the CS project and involves them in the project's further development and becoming but points to how things could be designed differently.

Theme 2: performing citizenship through matters of concern

Citizen sensibilities: listening as care and critical intervention.

While the dialogic communication between SOD's communication officers and citizen scientists demonstrates that participants care about the project, they are concerned about the quality of their sound recordings and data contributions. The participants provide essential feedback to the project about their experiences, data quality, and technological issues and contest and question the project and its research methods.

Citizen listener Louise, who describes herself as: "sound-oriented, pensioner and data-collector", explained how her involvement in the project had become part of her everyday life: "I planned to record sounds in the same way as I collect other data from my walks (photos of animals and plants and others)". In her communication with the project, she described her practices and experiences with the app in detail, and the sounds she recorded: e.g., of the fountain near Frederiksborg castle, of the local train station, events that happen, weather conditions and people. In the example, Louise described the weather conditions for sound recording as ideal: "while the recording was going on the sound of the train on the rails, the braking, the sound of the engine and when the door went up, seemed very clear to me. There was no wind or traffic noise, and only one passenger next to me".

Louise relistened to her recordings and evaluated which ones to delete: “When I came home, I listened to the results and ended with deleting 3 out of 4 of the audio files I had recorded - the quality was simply inadequate. The recording of the train arrival was impossible to recognise”. Louise explained that the quality of her sound recordings was inadequate and significant events impossible to identify. Thus, she deleted most of her recordings and concluded that the smartphone might be the problem, as she followed the project protocol very carefully. Louise writes: “I believe that it is constructed solely to recognise human voices and filter out background noise and other disruptive frequencies”.

The inadequate quality remained unchanged when she listened to the recordings from other participants. It made her ask critical questions and contest using mobile phones for data collection. Louise writes: “Sound collection is a fascinating project; however, don’t you think that smartphones alone are unsuitable for these data gatherings? My experience from last Thursday seems to verify this”. Moreover, Louise points out that another CS project, Naturbasen, makes it possible to collect and contribute with data in ways other than using a smartphone.

Louise’s experiences demonstrate that the sound quality produced with the app is unsatisfactory and interferes with her expectations about appropriate sound quality. She expresses her concern about this matter to the project and proposes alternative ways to collect and participate in the project. Louise writes: “could you consider the possibility that data collectors upload sound recordings with better equipment, so I can use my little Olympus LS-P1, which is half the size of my mobile phone, and then upload the sound afterwards?”. Another citizen listener, Thorsten, is also attentive to the sound quality and adds: “is it possible to upload [sound] files of higher quality if I have a better recorder than my mobile phone?”.

These examples support my earlier argument that the participants are concerned about the sound quality in SOD, they want to record and contribute with better sound and data quality, thus they propose alternative ways for recording and uploading sounds that contest and put into question the CS projects research approach.

Another participant Lars equally reached out to the project because he had discovered some problems with the project's sound quality. Lars writes:

> I have examined your excellent idea about recording the sounds of Denmark. However, there are some problems with the sound quality. The recordings I played were in a much reduced and compressed format. Because of the low bandwidth, it was impossible to hear what was played. If you make additional compression of data, it will become unusable! I am a tone master; I have a recording studio and make atmosphere recordings and other sound productions. If you need assistance, let me know.

Lars' feedback shows that he cares about the project; by pointing out the compression of sounds as a significant cause to the scant sound quality, he expressed his concern about this matter and offered his expertise and knowledge from sound production to find a solution.

This theme demonstrated that citizens' experiments and critical interventions in SOD are crucial to exposing the project's tensions and shortcomings, such as inadequate sound quality and more diverse possibilities for participating in the project with personal recording devices to improve the project's data quality. It points out inconsistencies between what is possible to do in the project and participants' expectations. Furthermore, it shows that citizens' matters of concern and agencies of care are essential for a CS project's continued success as they can contribute with different perspectives, ideas, and knowledge that is likely to improve the project. Key findings show that dialogic communication between project and participants is essential to understanding the participants' matters of concern, how they diverge from the project

protocol and the scientists' interests, and more importantly, how citizens' actions are shaped, amplified and constrained by the project protocol, digital technology, and AI system.

I elaborate on this in the following and demonstrate how the technological environment of SOD is shaping, constraining, and cultivating citizens capacities to act.

Theme 3: digital technology enables and constrains epistemic agency

When technology becomes exclusionary for citizens' engagement.

The following mail correspondence between Morten (field recordist) and a communication officer demonstrates that the boundaries of the mobile app and the project protocols are not only constraining but also excluding certain forms of engagement:

> *Morten*: I have made some sound recordings in Bulbjerg (with a good ORTF stereo mic system not with a mobile phone). Would you be interested in such material for your project? You can listen here [link to soundcloud]
>
> *Communication officer:* Thank you for your contribution and interest. We would like to have your sound recordings, but you will need to use the website www.lyden-af.dk (SOD started as a web app). The website is in Danish and you need to record outside somewhere in Denmark. You need to stand still and "tag" the sounds you have heard.
>
> *Morten:* Thanks for your mail. I am not interested in using an app on a Smart Phone to record audio since the quality is very poor compared to the high-end mics I use.

While the example demonstrates that people with a passion for sound and field recording want to contribute to the project by using their sound archives and their high-end microphones for sound recording, the project does not allow other forms of participation than sound and data collection with the mobile app, since the AI system has been trained on sounds of lower quality. Thus, the participants' actions, practices and possibilities are constrained by the mobile app, the AI system, and the project protocol. For Morten and other field recordists, the constraint is not appealing, so they decided not to participate because they wanted to use personal equipment and contribute with high audio quality, which indicates that both the project's and participants' protocols are diverging from one another and prevent people from participating on their terms.

As demonstrated earlier, field recordists are not exclusive in their passion for experimenting with sound recording and contributing with high audio quality, other participants have equally expressed their concern about the project's audio quality, and the lack of options to contribute with sounds and participate with own sound equipment. Henning writes: "can I record in other ways? I want to participate in SOD, but I do not like using a mobile phone. I have a decent Zoom H4n with a wind cap and would like to participate with it - is that possible?".

The participants ask if they can use their own recordings devices to produce better sound quality and participate on their terms, although the project and app do not allow this form of participation. For some participants, this constraint is very limiting for their possible actions and engagement in the project, if they cannot participate with their own devices. Pete, another volunteer, writes: "I do not have a smartphone, but a Zoom H5 sound recorder and a PC. It will be an unnecessary limitation if only those with a smartphone can participate". These examples show that people want to participate. The project, however, has constrained their possibilities by rejecting the more diverse forms of sonic engagements and contributions of

high audio quality, which could potentially exclude participants who want to share their experiences, sound archives and knowledge about sounding practices.

I elaborate on this in the following and demonstrate the implications of technological constraints and exclusion of certain forms of sonic engagements.

Theme 4: technological issues and antiprograms

Technological issues and AI feedback system condition citizens' actions.

Key findings emphasise that technological issues shape and constrain the volunteer contributors' actions and specific forms of participation. As a result, participants abandon the project or start following alternative programs and practices that diverge from SOD's project protocol. In a mail Jens (volunteer contributor) explains some of the technical issues he experienced during his recordings:

> The sound recording is not working on my iPhone SE. I have tried several times and followed your instructions. When I press the red button, I see a small, round animation that pulses red. The counter remains at 00:00:00:00. I count thirty seconds to see if the screen changes - it does not. I leave your site with no response without knowing if anything has happened at your end of the interaction. I have repeated this exercise a few times, even today at project launch. But now I am about to quit.

This example demonstrates that Jens is not provided with the proper feedback to understand his interactions with the app and if his operations have been successful. The sound recording and counter never start, so he cannot figure out if the sound recording has started, finished or if data has uploaded. Another participant, Anne, criticises the feedback from the AI during her recordings, she writes: "the AI system's suggestions for sounds are inadequate, you need to get this right. Where can I change my profile? I want

to change my username. Overall, the page is not very functional - it seems like you are still a pilot project". Anne highlights issues with the mobile app such as inadequate feedback from the AI system, limited functionality, and a lack of profile settings.

Louise underpins the inadequate feedback from the AI system. In the project's dialogic forum, she writes: "Once the AI system has evaluated the recording, it comes up with suggestions for the sounds it has 'heard'. There are often sound descriptions that I do not recognise, so I use the no-button. I am missing a dictionary of sounds where I can listen to these strange sounds". Even though Louise experiences the AI system's feedback as unclear and ambiguous, and discards most of its suggestions, she wants a more solid understanding of the ambiguous sounds, hence she proposes the idea of a sound archive and further opportunities to explore them.

For Louise, the inadequate feedback advances new questions: "On August 4th I recorded sounds at Allerød station. The suggestions were useless, so I used the no button (nej) (see fig.1). Thus, how does the AI learn to recognise a train?". Incorrect feedback from the AI system makes Louise wonder and reflect on how it works, and she posts her experiences and questions in SOD's dialogic forum together with a screenshot of the situation. Thus, Louise is not alone providing constructive feedback to the project, and new ideas for participation, she is also highlighting a wish to make her voice heard and share and discuss her concern and uncertainty with other people.

Taken together, feedback from community members is valuable for the ongoing process of designing more responsible forms of engagement and digital technologies in CS to allow people to participate in their terms and influence the technology they are using. Key findings show that the issues people are

concerned about and give feedback on are relevant for their continued participation in the project. Louise writes:

> My email address is my username, freely visible to anyone who sees my audio files. If you cannot change my username to something more discrete, I would like to be deleted as user. It seems like I do not have that option myself. I hope you will solve these data security problems soon.

This example demonstrates that feedback is crucial to the continued involvement in the project. Louise wants the project to act and respond to her feedback because of a security problem that makes her email public. She points out the lack of possibilities to change it herself, and if that is not possible, she wants her profile deleted.

The examples in this section highlight a complex techno scientific apparatus at work that involves humans and nonhumans intra-actions: e.g. between the mobile app, volunteers, scientists, mobile phone, interface, AI system, instructions/protocols, mail correspondence, forum, and functionality. From this constellation, the capacities to act and produce effects emerge from their mutual enactments. Hence, citizens' epistemic agencies are distributed and reconfigured across human and nonhuman components.

The examples demonstrate that technological issues, security issues, and incorrect feedback from the AI system constrain or exclude the participants from contributing to scientific knowledge production. However, the technological constraints also lead people to explore different practices and modes of reasoning and share their uncertainties with other community members about the functioning of the AI system. Their diverse epistemic explorations and concern about data quality are crucial for improving the mobile app's functionality and data quality and for designing more responsible and sustainable technologies that can advance human knowledge. Hence, closer collaboration with diverse community groups is crucial for

making different voices and concerns heard. It can be an asset for integrating “epistemic diversity” in CS to make another science possible.

Antiprograms as agencies of care.

The volunteer contributors express concern about the project's inadequate sound quality and technological issues. Some participants experiment with different practices to improve the sound quality in their recordings, and amateur field recordists have offered the project their sound archives with high-quality audio and proposed alternative ways to improve the sound quality. Key findings show that dedicated community members prefer using recording devices with their mobile phones to improve the sound quality in their recordings, even though it conflicts with SOD's procedures for data collection and communication officers prompt them to follow the project's protocol.

A Communication officer writes:

> We can only use sounds recorded with your mobile phone (through the SOD mobile app), as part of the project is about training an artificial intelligence that responds to your recording. The sound of Denmark is designed exclusively for smartphones and tablets. The reason for this is that sound must be recorded under the same conditions to be comparable in a research context”.

This example demonstrates that data collection has a high priority in the project, where participants are prompted and cultivated to participate according to the programme and protocols of SOD. As a result, some participants are excluded because they are not allowed to contribute with high-quality sound

archives, record with personal sound equipment, or in any other way manipulate their sound recordings (e.g. record indoor sounds or create their sounds). Rather participants are expected to follow the guidelines prompted by the project, app and communication officers. From this perspective, the project excludes different voices and actions to be heard.

Key findings show that participants are following their own interests, practices and curiosities alongside the project programme, of which some are in direct conflict with the project's protocols. In a thread about poor sound quality in the project's dialogic forum, Louise posts a photo of the microphone she uses and writes: "small and nifty microphone for a smartphone. I had great joy with this microphone".

This example underpins that participants can create tensions in the CS project when they follow their own interests and experiment with alternative practices and programmes (see Kasperowski & Hillman, 2018), such as using personal microphones to improve the sound quality and AI feedback that does not comply with the project protocol. Their different ways of making requests and expressing concern about the project's sound quality and AI feedback contest the CS project's constraint focus on mere data collection, following project protocol, and matters of fact. Although their practices interfere with the project protocol and deliberately establish a sphere of conflict, negotiation and possibility, it becomes their way to express their concern for the project's research and data quality and be recognised as epistemic subjects.

Concluding discussion

This paper has demonstrated how technological affordances increase and decrease volunteer contributors' capacities to act and articulate their concern by analysing citizens' communicative actions, engagement and agencies in a CS project. Key findings demonstrate that an increased focus on designing *citizen science communication* is crucial for advancing civic capacities and developing more responsible technologies in a CS context. In the following, I discuss and elaborate on key findings through the concepts of affordances and capacities to act.

Key findings demonstrate that a CS project's digital environment can bring forward new possibilities for citizens' communicative actions and interactions (Hutchby, 2006, p. 166), including promising potentials for establishing new relationships between citizens and scientists. By bringing attention to different matters of concern, such as the project's sound and data quality and technological issues and care and responsibility to these, the citizen listeners contest and question project protocols and scientific methods by pointing out a different direction for the project, that includes more diverse participation forms. Hence, by inscribing new layers of meaning through epistemic practices, experiments and dialogic interactions with the project and other participants, the volunteer contributors are taking ownership of the project and cultivating new sites and platforms for science communication and participatory research.

What may be necessary to observe is that the digital environment's affordances constrain participants' capacities to act, eliminate certain forms of sonic practices diverging from the project protocol to potentially exclude critical public voices their matters of concern and participation in the production of scientific knowledge. Hence, the current app design and project protocol are nurturing and cultivating specific conditions for listening (Sterne, 2003), and knowing through the audible (Feld, 2015; Voegelin, 2018) that affects, transforms, and unjustly excludes the participants' sonic sensibilities, their "awareness for blindspots" (Voegelin, 2018), and engagement with the project; to produce a certain kind of epistemic subject (Kasperowski & Hillman, 2018, p. 569).

LaBelle (2018) suggests that engaged listening connects people and things and gives the opportunity and capacity to hear "something about the world differently through the sounding of another's perspective" (ibid, p. 145). Sounding practices and engaged forms of listening are potentials for nurturing new ways of doing and being, for political exploration (Kanngieser, 2015), and ethical forms of engagement

(Voegelin, 2018). The freedom to listen is essential for enabling an active and relational space where different voices can be heard and resound. Listening enables us to rearticulate the meanings of justice, freedom, and democratic engagement with others, and it is political and ethical, a democratic act that makes possible a plurality of voices in the world (Lacey, 2013). From this perspective, the technoscientific apparatus of bodily production, including the design and technological affordances of SOD, defines not only what we hear but also what and how we allow ourselves to hear, which potentially excludes a plurality of different voices.

Suppose CS is to evolve and become more than a tool for "governing the critique of science" (Strasser et al., 2019, p. 16) that empowers citizens' critical understanding of science and strengthens their possibilities for claiming their rights and nurturing new science-citizen relations. We must address the technological affordances in our digital environments and artefacts, the "ethics" and "governability" of algorithm systems (Seaver, 2019), including the powers, values and norms inscribed in them, to understand how different boundary drawing practices decrease and exclude citizens' capacities to communicate, act on and contribute to knowledge production. Hence, further research is needed to detail what constitutes the boundaries of the apparatus that actualise some concepts and exclude others (Barad, 2007).

Dotson (2014) underpins that unjustly epistemic exclusions are harmful to the knowers' epistemic agency. They limit the knower's capacity to share epistemic resources (ibid, p. 119-120), participation in epistemic practices and communities (Dotson, 2012, p. 24), and their contribution to knowledge production. Consequently, the community risks losing its "epistemic friction" constituted between heterogeneous perspectives (Medina, 2013), that is, its critical awareness "of multiple ways of perceiving" and capacity to "point in the direction of change" (ibid p.224). Medina proposes that the experience of oppression is also an opportunity to counter dominating stands and recognising their limitations to develop alternative viewpoints (ibid p.74).

Epistemic oppression might be impossible to avoid in CS. However, more open, and inclusive structures can reduce the retention of epistemic suppression (Dotson, 2012, p. 42). This paper's key findings suggest that we engage with and include the critical work of citizen communities when designing CS because of their heterogeneous capacities to generate different forms of engaged listening and sonic engagement that go beyond the viewpoints and imagination of the CS project and the scientists and afford the volunteer contributors new opportunities to contest, negotiate, and contribute to knowledge production.

Based on this discussion, I propose the following elements for thinking about ways to design more responsible and sustainable forms of engagement that address epistemic exclusions in citizen science and advance civic capacities.

One way to design citizen science communication that strengthens citizen communities' capacities to act is to involve people in the design of citizen science through a codesign process. Codesign brings people together through their actions, conversations and practices. Codesign makes it possible for volunteers to be part of the material-discursive practices that shape the CS project and the technoscientific apparatus, scientific knowledge production, and the very communication of science. To move away from a dominating technocratic view to more collective and relational ways of doing and designing citizen science, we must take responsibility for the entanglements of agencies of which we are intra-actively a part (Barad 2007).

Citizen communities bring attention to different matters of concern that can challenge and question the technoscientific approach to set a new direction for the project. Hence a bottom-up approach to codesign and collaboration with diverse local communities that builds on people's values, experience, ideas, and

experimental knowledge, holds promising potential for designing more ethical and responsible forms of digital citizen science engagement.

Design collaborations with citizens makes it possible to leverage diverse and collective capacities that contest the decisions of developers and scientists and hold them accountable for their designs and how these designs go on designing to reconfigure epistemic agencies and exclusions. Furthermore, it becomes possible for the community to take ownership of the project and contribute to new sites for science communication and participatory research.

In a design context, the critical work of volunteer contributors can help to challenge and counter dominating power structures, instrumentalisation, epistemic exclusions, and programmed bias in AI systems. Their concerns, values, sensibilities, and local knowledges can help raise new questions and explore an AI system's influence on human behaviour. Citizen communities can also help improve AI systems by collecting, analysing, and classifying large amounts of data, which was the initial idea in SOD, and in this relation contest data quality, access to data and help to improve technical shortcomings and ethical considerations (Ceccaroni et al., 2019, p. 7).

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08.03 Entangled responsibility: an analysis of citizen science communication and scientific citizenship

Abstract
The notion of citizen science is often referred to as the means of engaging public members in scientific research activities that can advance the reach and impact of technoscience. Despite this, few studies have addressed how human-machine collaborations in a citizen science context enable and constrain scientific citizenship and citizens' epistemic agencies and reconfigure science-citizen relations, including the process of citizens' engagement in scientific knowledge production. The following will address this gap by analysing the human and nonhuman material and discursive engagements in the citizen science project The Sound of Denmark. Doing so contributes to new knowledge on designing more responsible forms of citizen science engagement that advance civic agencies. Key findings emphasise that citizen science development can benefit from diverse fields such as participatory design research and feminist technoscience. Finally, the paper contributes to a broader debate on the formation of epistemic subjects, scientific citizenship, and responsible designing and evaluation of citizen science.

Keywords: scientific citizenship, citizen science communication, epistemic agency, co-design, material-discursive apparatus, response-ability.

Introduction

The active involvement of volunteer contributors is critical for a successful citizen science project and its scientific outcome (Robinson et al. 2018). Citizen science (CS) depends on the public's meaningful involvement with science (Shirk and Bonney 2018, 42). Therefore, CS projects are often developed in ways that make it possible for their community of volunteers to participate in and contribute to multiple aspects of the scientific process, from the collection, selection, processing, and submission of data, over influencing

research questions, codesigning research methods and tools (Novak et al. 2018), to communicating the project's research results and incorporating local knowledge. The benefits of a successful science-citizen collaboration can therefore be multiple and may contribute to new opportunities, such as addressing local and national issues, contributing to scientific output, dialogical interactions with scientists, and potentially influencing policy and everyday matters of concern (Robinson et al. 2018, p.29).

Citizen science connects scientific research with public engagement to potentially inform political decisions (Shirk & Bonney 2018, p.41), as citizens become involved in producing and communicating science, the entire research process and knowledge production are being mediated, distributed, and shaped by citizens engagements. Science communication is changing; it is no longer done by individual scientists but is increasingly produced in collaboration with volunteer contributors (Hecker et al. 2018, 448). Schäfer and Kieslinger suggest that citizen science is comparable to a form of science communication (Schäfer and Kieslinger 2016). Hence, the citizen scientists are never mere data contributors their multiple intra-actions with digital technologies and artificial intelligence (AI) systems, communication officers and scientists, including their local communities, make them deeply entangled with the CS project, scientific knowledge production including technological innovation (Shirk & Bonney, 2018). Irwin and Michael (2003), point out that because of humans' profound entanglement with technology, humans can be understood as hybrids that emerge from heterogenous relationships of humans and nonhumans (2003, 133). Thus, according to this understanding nonhumans are actively taking part in how scientific, political and ethical knowledge is produced (2003, 133), hence nonhumans have agency (Barad 2007; Suchman 2007) and take part in reconfiguring the scientific citizen (Irwin 2001). Irwin and Michal (2003) suggest that we consider how scientific citizenship is interwoven with technologies, environments, and animals (2003, 134). Hence, from this perspective agency and responsibility is extended and distributed throughout the techno-scientific apparatus (Dickel 2020, 261) and can better be understood as the relational enactments of humans and nonhumans, and in terms of "what comes to matter" or are "excluded from mattering" (Barad 2007).

Despite our knowledge about technoscience's implications in modern knowledge society (Maasen, Dickel, and Schneider 2020) and its reconfiguration of the scientific citizen (Dickel 2020, 262), few studies have addressed *how human-machine collaborations in a citizen science project and its technoscientific structures partake in reconfiguring the scientific citizen, science-citizen relations, including the very process of citizens' engagement in scientific knowledge production.* Stilgoe, Lock, and Wilsdon (2014) calls for new knowledge about these spaces for technoscientific engagement and their impact on scientific culture, politics and society (2014, p. 9-10). We need more knowledge about citizens engagement with new technologies and how their entangled practices shape, constrain and widens potentials for science and democracy (Nowotny 2014). In light of recent innovations of digital CS technologies that integrate AI systems in the analysis and processing of data at unprecedent scales and speeds. There is an increased need for understanding human-machine collaborations in CS (Ponti & Seredko 2022; Seredko, Gander, and Ponti 2021)

to understand how different human-machine entanglements and practices are reconfiguring and impacting citizen agencies and enactments of scientific citizenship. However, rather than assessing technology itself and keeping humans and technology apart, this paper will address the entanglements and agencies of humans and technology, drawing from Barad's agential realist theory (2007), to create new knowledge on the technological apparatus of bodily production in The Sound of Denmark.

This paper addresses this gap by analysing citizens material and discursive engagement in the citizen science project The Sound of Denmark (Lyden af Danmark), a CS project developed at the Center for Macro Ecology, Evolution and Climate (CMEC) at the University of Copenhagen. This project collects large-scale data to identify sound sources, noise levels, and the distribution of natural and anthropogenic sounds in Denmark. The CS project invites citizens to contribute to sound mapping by recording, geolocating, processing and categorizing sounds using their mobile phones and the mobile application (see figure 1). The recorded sound data trains a machine-learning programme (AI system) that identifies sound sources. Participants can suggest new sounds to the AI system before finalizing the contribution. Citizen involvement in the project contributes actively to scientific research and reshapes the epistemic tool for data collection (AI system), affecting the final data set and results. As a result, people become reshaped by the capabilities and limitations of technological infrastructure. Therefore, the CS project, the community, and the AI system comprise an interconnected techno-scientific apparatus that iteratively restructures practices and agencies.

By doing this it contributes to new knowledge on designing more responsible forms of citizen-science engagement that advance civic agencies. I will demonstrate how the citizen scientists are actively taking part in shaping the technoscientific processes in a citizen science context through their different intra-actions with the digital citizen science project The Sound of Denmark (SOD), and at the same time citizens are themselves shaped, constrained and empowered by the technoscientific structures.

In the following, I will outline the theoretical framework of this paper that builds on Karen Barad's Agential Realist ontology (2007). *I expected to contribute new knowledge on how technoscience takes part in the reconfiguration of epistemic subjects, the enactment of scientific citizenship, and the bodily production of knowledge.* Following this, I discuss the methods and materials of this study, followed by an analysis and discussion of the key findings.

Agential realist framework for understanding the entanglements of which we are part

According to Barad phenomena is co-constituted by material-discursive apparatuses of bodily production that are made of specific human and nonhuman intra-actions (2007, 206). Phenomena, she argues, are

the effect of boundary-drawing practices that make some concepts, identities or attributes come to matter to the exclusion of others (2007, 208). She writes:

> The identities or attributes that are *determinate do not represent inherent properties of subjects or objects*. Subjects and objects do not pre-exist as such but are constituted through, within, and as part of *particular practices*. The objective referents for identities or attributes are the *phenomena constituted* through the i*ntra-action of multiple apparatuses* (208).

Therefore, the phenomena including the inherent properties of objects and subjects do not pre-exist per se, but are constituted through specific material-discursive practices within and as part of apparatuses of bodily production. Following from this agential realist understanding materialisation is better understood as the intra-active engagements of humans and nonhumans. Barad (2007) that the notion of intra-actions is a key element in her agential realist framework and implies the mutual constitution of entangled agencies (2007, 33). This is in contrast to the concept of interaction that assumes individual agencies precede their interactions, in contrast Barad's use of intra-action recognises that distinct agencies do not pre-exist but rather emerge through intra-action (2007, 33). Hence from this conceptualisation agencies do not pre-exist as individual elements, it is not something that someone has (2007, 172), but exist only through their mutual entanglement in e.g. a technoscientific apparatus.

Agency, according to Barad, is a matter of intra-acting it is a doing, it is relational and an enactment:

> Agency is about changing possibilities of change entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices in the enactment of a causal structure. Particular possibilities for (intra-)acting exist at every moment, and these changing possibilities entail an ethical obligation to intra-act responsibly in the world's becoming, to contest and rework what matters and what is excluded from mattering (2007, 178).

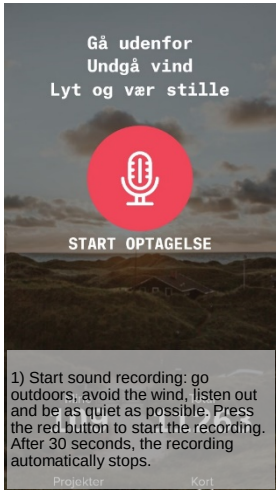
As Barad points out the researcher or developer, the project team, who takes part in the enactments that shapes and constitutes the citizen science project, that is the technoscientific apparatus, are not without responsibility, because she/he/they are implicated in the production of the phenomena, and the bodily production of scientific knowledge (see Juelskjær 2020, 143). This includes the enactments that enable some concepts and knowledge to matter, to the exclusion of others. Hence, as Barad points out in the example because of our entanglements with the world and the apparatus in questions we are responsible for the knowledge we seek and partake in producing and the "consequences of our research" (Juelskjær 2021, 143) because it is a result of the practises, we have a role in shaping (2007, 203).

Hence, from an agential realist understanding responsibility as researcher and codeveloper of citizen science entails an ongoing responsiveness, or response-ability to the entanglements of which they are

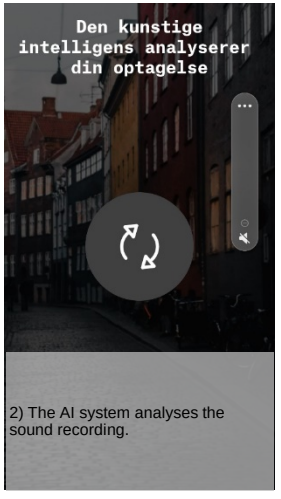
a part (Barad 2007, 394). In agential realism the researcher is an emergent part of the technoscientific apparatus and its human and nonhuman intra-actions. In so far as these research and participatory apparatus enact agential cuts that make some things come to matter to the exclusion of others. This implies that both the scientists, the citizen scientist the technoscientific apparatus and the phenomenon are mutually reconfigured through the research and development process (Juelskjær, Plauborg, and Adrian 2021).

This agential realist production of knowledge implies that to intra-act responsibly with and as part of the development of a CS project, will require a critical exploration of the boundaries, constraints, and exclusions that we partake in enacting, and which operate through the intra-actions of the technoscientific apparatus. Therefore, by acknowledging that 'we' are an entangled part of the worlds ongoing becoming together with human and nonhuman others, we realise that "the subject of knowing is not an individual but is linked to the research apparatus" (Juelskjær et. al 2021, 154).

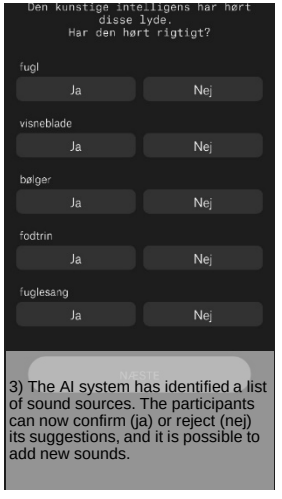
Knowing and responsibility emerges from the intra-active engagements of the scientists, project/research team and the citizen scientists, and the digital platform itself. Responsibility is relational and entails accountability for the material-discursive practices we partake in shaping because these entanglements reconfigure our very beings, our imaginations, and societies (2007, p.383). The agential shift in theoretical perspective is crucial because it creates new opportunities for redefining unjust epistemic exclusions and constraints of the scientific citizen, and for taking responsibility for the designs we create, as well as to create knowledge about how they shape our very beings, doings, and knowledge. The next chapter outlines the methodological approach of this study.



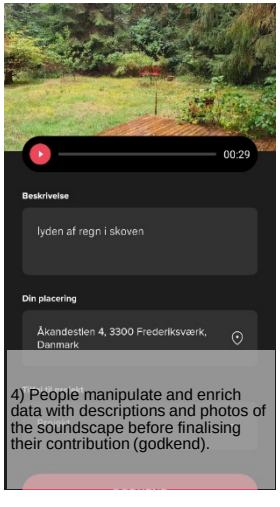
1) Start sound recording: go outdoors, avoid the wind, listen out and be as quiet as possible. Press the red button to start the recording. After 30 seconds, the recording automatically stops.



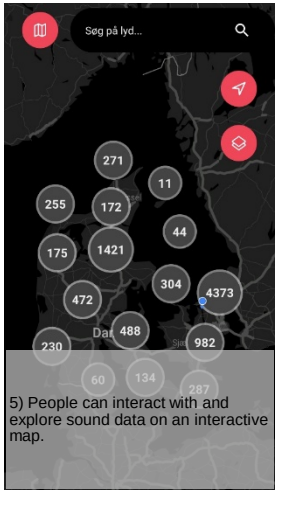
2) The AI system analyses the sound recording.



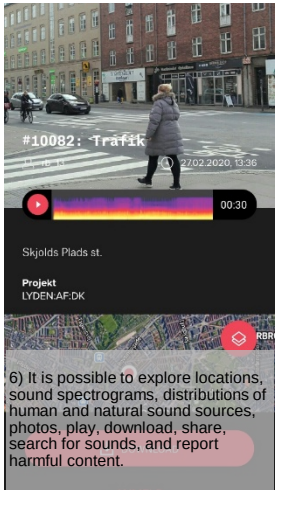
3) The AI system has identified a list of sound sources. The participants can now confirm (ja) or reject (nej) its suggestions, and it is possible to add new sounds.



4) People manipulate and enrich data with descriptions and photos of the soundscape before finalising their contribution (godkend).



5) People can interact with and explore sound data on an interactive map.



6) It is possible to explore locations, sound spectrograms, distributions of human and natural sound sources, photos, play, download, share, search for sounds, and report harmful content.

Figure 1. The digital citizen science project The Sound of Denmark (mobile interface).

Methods and materials

Empirical setting and role as codeveloper

My empirical focus in this paper involves my ethnographic research in the citizen science project the Sound of Denmark, a research project developed in collaboration with the Center for Macro Ecology Evolution and Climate and the University of Copenhagen. As a member of the project/developer team, I spent 16 months, from March 2018 until June 2020, as an ethnographic and participatory design researcher (Blomberg and Karasti 2012) focusing on how to design citizen science communication that strengthens citizens' democratic actions, through the co-development of a mobile app and digital citizen science project (figure 1) in Participatory design collaborations with prospective citizen scientists and with the SOD project team and external developers. In this role, I acted as a connection between the domain of the project/developer team and the workshop participants (Hughes, Randall, and Shapiro 1992). The participatory design approach in combination with ethnographic methods provided the opportunity to study the practices and contexts of prospective users/citizen scientists in a co-design context (Blomberg and Karasti 2012), and as codeveloper and member of the SOD project team, to explore and experiment as part of the material-discursive practises that give shape to the digital development process.

My analysis of peoples' engagement across the SOD communication platform involved a focus on the intra-active engagements of the community of volunteers, and their exchanges and involvement across SOD's communication platform, that is: the SOD mobile app forum (fig.1), email exchanges between communication officers and citizens, and the Facebook group of the project, and a data corpus that includes (160) emails, (40) Facebook posts, and (30) threads from the mobile app's community forum. The documentary materials include text, photos and video materials (e.g. Facebook posts), including photographic materials of my interactions with the mobile app, and excerpts from the diary notes of a dedicated citizen scientist.

To understand the size of the SOD community, there have been 5745 contributions made by the volunteer contributors comprising over 11263 unique sound recordings and 2254 distinct sound sources found in the Danish soundscape. Among SOD's demographics are diverse ages, genders, etiquette and occupations, with participant groups like families, daycare children, elementary and secondary school children, pensioners, unemployed and academics. These groups have similar demographics to those of my

earlier co-design workshops and interviews with amateur scientists and non-experts, where the community members are predominantly white and middle class.

Through the mail correspondences between the volunteer community and the communication officers, as well as my ongoing correspondence with a citizen scientist from the SOD community, I was able to map the group's demographics and examine their experiences as volunteers. However, it is not clear whether underserved groups are represented in the SOD profile database. Anonymized data has been used and pseudonyms have been employed to protect the identity of those involved in the project, especially those who were not informed or had not provided consent. Moreover, since the excerpts of the data I used do not reveal the identity of the participants, I did not obtain consent from each individual who participated in the discussion across mobile forums, Facebook groups, and emails.

Data collection

I adapted a netnographic research approach inspired by (Kozinets 2015; Kozinets 2017) combined with virtual ethnography (Hine 2000) as a general approach to studying the technoscientific apparatus of the SOD and the intra-active engagements and communication of the community of volunteers. My approach involved participant observations through instances of digital communication with participants, project members and developers across SOD's communication channels. I examined the intra-active and communicative engagements between the CS project team and the community of volunteer contributors, as well as how this communication developed across the project's communication channels: a community forum, a Facebook group, and correspondence with participants via email. Through their communication with the project, the volunteers provided information about their agencies, epistemic practices, experimental designs, social relationships, and reasoning styles (Mahr 2021, 38). Through my ethnographic research, I explored, identified, and made visible the material-discursive practices of the technoscientific apparatus, its bodily production of knowledge, and its reconfiguration of the scientific citizen (Irwin 2001). In addition, my analysis of the citizen scientist Louise's diary notes allowed me to detail my understanding of the participants' experiences as part of the SOD community.

Data analysis and thematic coding

The data analysis focused on significant events in intra-active engagements and communications across the SOD communication platform, including diary notes of one of the citizen scientists. This revealed to me how the technoscientific apparatus reconfigured epistemic agencies and enacted scientific citizenship. My data analysis followed the recommendations of Braun & Clarke (Braun and Clarke 2006) for inductive thematic analysis, which emphasise an organic approach that allows theming across the entire dataset. Here the researcher plays an active role in creating new themes and codes, and where the data suggests each theme’s name. Hence, the researcher in his work with empirical materials is actively taking part in

enacting new entanglements (Juelskjær, Plauborg, and Adrian 2021, 146). Furthermore, I use coded data grouped under recurrent themes in my empirical analysis. I use direct quotes from the data corpus for each theme. Coding involved: 1) familiarising myself with the data to establish classifications; 2) creating and collecting codes for each category through open coding in NVivo. 3) Identifying potential main themes and writing memos about them. This led to a more closed coding of observations and a reduction in the number of codes (Charmaz 2006); categorisation and reduction of codes, 4) comparing codes for each theme, 5) Forming a final definition of themes, and 6) developing a preliminary analysis based on examples.

Analysis and discussion

In the following, I present the empirical findings of my analysis of citizen science communication. I aim to analyse the material and discursive practices that operate through the SOD mobile platform and, by doing this, to create new knowledge and understandings of how they partake in reconfiguring citizens' capacities to enact citizenship and bodily production of knowledge. The themes in this chapter are analysed as follows:

- Theme 1: The citizen science project as a material-discursive apparatus of bodily production
- Theme 2: Enacting Scientific citizenship – entanglements as relations of obligation
- Theme 3: Entangled responsibility and enactments of concern
- Theme 4: Machinic agencies, boundaries and epistemic exclusions

Theme 1: The citizen science project as a material-discursive apparatus of bodily production

The Sound of Denmark as technoscientific apparatus of bodily production

This section analyses SOD as a technoscientific and material-discursive apparatus of bodily production by focusing on 1) the entanglements of the CS project's mobile platform, its AI system, and its community of volunteer contributors, 2) how they enact human-machine boundaries and relations, 3) to create new knowledge on how human-machine collaborations intra-actively reconfigure the scientific object (sound) in the study (Barad 2007, p.383), epistemic practices, subjects in the community, and the production of scientific knowledge. In addition, human-machine interactions enact "cuts," which determine which

concepts are realised and which ones are excluded; they evolve what is possible and impossible (2007, p.234).

Citizens' material and epistemic practices involve many intra-actions with the mobile platform. For example, they are enacting active listening by recording city sounds (see figure 1), adding datasets, receiving and replying to feedback from AI systems, suggesting new sounds, uploading sound data, sound mapping, classifying, tagging, selecting, downloading, deleting, relocating, and sharing sound on the project's interactive map. But also reflecting critically on sound quality, sharing and discussing sounds with the project community, scientists and communication officers.

These entangled and epistemic practices are exemplified in Louise's (Pensioner citizen scientist) diary on Christmas Eve 2019:

> As a tradition, my partner and I walk on Christmas Eve while everyone is having dinner. We usually spend Christmas Eve in a dark forest with few sounds to record. Our family decided this year to walk to the Frederiksberg Alle Metro Station after celebrating our Christmas with some friends who live next to the new metro line after observing (listening) how others celebrate Christmas. During this time, we also made sound recordings of fun sound effects, such as a voice shouting out through an open window: "How many want port wine?". We took the metro to Nørrebro, got off the train, recorded sounds and photos, and went down to the next metro station (Skjolds Plads) and then up to a new place. This led to 14 audio recordings of Christmas Eve with photographs described in the report I sent to the project.

This example demonstrates that participants' epistemic practices are a part of enacting and reconfiguring what concepts are given a definition, and which one become excluded through their data collection and contribution to SOD. When the participants are recording sounds with the mobile app, they decide what to observe (people celebrating Christmas Eve), they decide what sounds to record, the location of their recordings, they document their findings with sound and photos and share their results with the project or the community. Furthermore, the results demonstrate, that their active engagement with the project is a social endeavour that is closely connected to their everyday life, something Louise and her partner do together to explore the city soundscape. Finally, it demonstrates that volunteer contributors are not only entangled in the production of scientific knowledge and other practices of knowing through their human-machine embodiments in the project (Barad 2007, 379), by drawing attention to issues they care about that might be ignored by the scientist (Davies and Horst 2016, 192), they are actively performing scientific citizenship.

The participants in SOD, intra-act as part of a larger material configuration that enact boundaries and exclusions of epistemic practices. As demonstrated in a mail from Beth:

> Hi, I think it is a fantastic idea (project), and I would very much like to be part of it. I have already recorded some sounds. In most occasions, unfortunately, *it will not play the recorded sound, hence I have to write tags from memory*. This means that I might be emphasising something that does not sound well in the recording. However, I cannot continue without saving and I can no longer add new tags. I suggest you change the setup and make it possible to add tags for 10 minutes after a recording, so you can listen to the sound after it has been uploaded, and then add the extra sounds.

This example demonstrates that the mobile app's technological issues are delimiting the participants' epistemic practices and agencies. First, the participants cannot relisten to their sound recordings. Therefore, they cannot process and analyse their recordings accordingly. Finally, they cannot tag the sounds and enrich the data correctly, which means that the AI system is receiving flawed data from the users. The experience is unsatisfactory for the participants, and it affects the quality of the uploaded sound recording and, therefore, the training of the AI system.

The examples demonstrate the material-discursive practices of the apparatus and how the intra-actions of humans and non-humans define what concepts comes to matter and which ones are excluded (Barad, 2007, p.234) from the data collection process. The participants and the AI system are intra-acting with one another. On one side, participants reconfigure the technological environment of SOD; on the other, people are shaped and reconfigured by the system. Citizens re-configure the AI system through sound recordings, suggestions of new sounds, and corrections of the AI feedback when they are using microphone devices to enhance the sound quality of their recordings. Moreover, technological issues in the app restrict the participants' epistemic practices and reduce their opportunities to utilize and share epistemic resources in the community (Dotson 2012).

Issues with poor sound quality and inadequate sound recognition, is another example that demonstrate how epistemic constraints and exclusions operate through SOD. As Henry tells us in a thread in the community forum:

> Why is the sound (quality) so bad? I have recorded excellent sounds with my phone, but they are barely recognisable in SOD. So far, I have listened to around 40 recordings; the best is one eating an apple, bird song sounds horrible, and my recording of a street orchestra at Nørrebro in Copenhagen is highly distorted. What is the point?

Henry's sound explorations demonstrate that the SOD mobile app distorts the sound quality in his recordings. His comment suggests that participation is pointless because of the poor sound quality. This is consistent with other responses from the community. An anonymous participant writes: "bad sound! When I listen to my recordings it sounds like it is recorded through an old can", and Louise: "I have recorded quite a few audio files but also deleted some again because they were too bad". These examples suggest that people are thinking critically about the poor quality of sound in the project. The poor sound quality is frustrating to most participants and discourages them from continuing to participate. The examples demonstrate that the technological environment is enacting boundaries and constraints that makes it difficult to contribute with high quality sound recordings. In some circumstances this can lead to anti-programmatic behaviour in the community with people following alternative programs and practices that diverge from the project protocol and scientific focus.

Machinic reworkings, constraints and exclusions

A number of community members have pointed out issues about inadequate sound recognition from the AI system. Louise (pensioner, citizen scientist) describes how it affects her engagement with the project:

> Once the AI has analysed the recording, it makes different sound suggestions. However, there are regular descriptions of sounds that I do not recognise, so I have to use the no-button, even if this means that I do not recognise the sound. Many of these sounds are unknown to me and cartoonish sounds. I cannot recall them, but I miss an sound dictionary where I can listen to the ML system's unusual sound suggestions.

The community of volunteers experienced incorrect sound recognition feedback from the AI system based on their intra-actions with the app. Together with the poor sound quality, it caused confusion for several participants. It not only constrained the quality of their contribution but also limited their possibilities for being fully engaged with the project's epistemic resources (Dotson 2014).

Louise's description of her sonic explorations in the forest, demonstrate her critical thinking and concern about the limitations that operate through the project, and how epistemic practices are constantly reworked:

> I tried to record more sounds with the app. It works best when recording offline. It takes way too long with the artificial analysis. I am losing my patience. It is easier to add the description of the sound yourself. However, maybe that means the robot is not getting smarter? There is a conflict between user interests and project interests, and I do not like the long waiting time – after all, the AI cannot provide a reasonable description of the sounds.

The example demonstrates how her engagement with the mobile platform and AI system reconfigured her epistemic practices and capacities to act. Louise found the app works best offline because the AI algorithm spends a lot of time processing data. Since the system's data analysis is slow and its sound recognition is inadequate, she found it easier to add sound descriptions manually. The shift from automatic to manual sound description, a reconfiguration of practice, makes her think about how it will impact AI system training.

Theme 2: Enacting Scientific citizenship – entanglements as relations of obligation

This theme demonstrates that citizen scientists in SOD are more than volunteers collecting and contributing to scientific research. Through material-discursive entanglements with SOD's technological milieu, they bring attention to different matters of concern and interests that affect the continued development of the project, and how knowledge and epistemic subjects are intra-actively produced. The community of volunteer contributors enact themselves as citizens through their intra-active engagement with the SOD mobile platform and ML system including data contributions to the production and transformation of scientific knowledge production.

Citizen science as social and scientific practices

Key findings from my early interviews with citizen scientists reveal that epistemic practices are often performed differently through their active engagement with a project. Inge (age 45, veterinarian) describes her participation in the CS project, The Ant Hunt as a social and collective experience with her son:

> I have an 11-year-old boy who thinks natural engineering is great fun, so that was actually the background. During our summer holidays, we found The Ant Hunt as something we could do together, and I think it was an interesting study to do and a good opportunity to teach him something about research.

Their material agencies with this project express their mutual engagement, involving social and scientific practices, and a means by which they can both discuss and share something that interests them. Their material-discursive practice with the project enables them to explore their curiosities and gain new knowledge about ants. Inge explains: "We want to find out what kind of ant we have down there (in the ground) because then you can read more about it". Together, they create a dialogical space where they

can collectively exchange ideas and process their uncertainties. Inge explains: "when we have been walking in the woods, we have talked about ants that live in different ways, look different, and things like that". Hence, Inge and her son's active engagement with the project in their local environment is also a learning process about science, caring for the natural world, and the ant species they discover. Inge states: "in general, it is about teaching one's child to take an interest in nature and observe and put into words what we see". Their entangled practices with the CS project, local environment, and the ants enhance collective learning and help formulate new understandings and knowledge about the world.

Inge explains: "You learn about methods and how to register, all the things they are not learning in school – 'scientific methods' – I think it is exciting to get more knowledge about where you are [local environment]". Taken together their different intra-active engagements with the project materialised through epistemic practices and dialogic communication, become the means to enact scientific citizenship that enhances their epistemic and democratic capacities to act on their interests and contribute to the very shaping of scientific knowledge production in the project.

Citizen scientists take ownership of the project

Key findings suggest that citizens want to participate on their terms by pursuing their own interests, values, and passions. Moreover, they wish to interact with others in the community and share their experiences. In a mail to SOD, Hanne (kindergarten teacher) describes her experiences and participation in SOD with children 3-4 years of age:

> Over a five-week period, we integrated SOD into our projects to focus on the sound of the water; we discovered that every city fountain made different sounds. At the children's requests, we threw stones of various sizes in Limfjorden and listened to the different sounds. At Vilsted lake, we repeated the session - it sounded like music. Back in the day-care, we addressed different words for water, wrote them down, and painted our experiences with watercolours. Based on our experiences with sound, we prepared small scientific experiments with water and talked about the importance of caring for the water.

The example demonstrates how the day-care through diverse material-discursive practices took ownership of the CS project by drawing attention to issues they care about and by integrating them into their everyday lives. Their intra-actions with the project set a different direction that opened for further involvement and collective ways to think about and with sound. Their intra-actions with the project, explorations of soundscapes and places in the city, experiments with listening and sound-making, scientific experiments, and playful experiments with words and language describing water. Demonstrate how the citizens not only contribute with new layers of meaning, value, curiosity, and imagination to a CS project but also how

different material-discursive “practices of citizenship” can create and enhance civic capacities (see Horst 2016, p.195).

The citizen scientists’ relational ways of thinking and doing with the project, other people, things and natural environment demonstrate their diverse forms of epistemic practices and capacities to restage things in new situations and contexts, hold great potential for generating alternative forms of listening practices and engagement beyond the focus of the scientists, to strengthen civic capacities, and cultivate new potential sites of communication that enhance scientific citizenship.

When citizen scientists criticise and contest the scientific process

The mail exchanges between Louise (pensioner and dedicated citizen scientist) and the communication officers in SOD, together with descriptions from her diary about personal experience, thoughts, practices and sound experiments form the project, and her concern about the technological issues and shortcomings she discovered along her engagement with the project, reveal that citizens’ diverse epistemic practices are part of and contribute to the project’s data collection, it is not limited to the critique of power but recreate their relations intra-actively through that critique.

Louise writes: “I have recorded several sounds but deleted some of them again because the sound was poor. There are inconsistencies between what the map shows (figure 1) to all participants and me alone. Why this discrepancy?”. According to her diary, on January 23, 2020, she experienced poor sound quality:

> Recording offline is the only way that the application works, but that cannot be the point. This time I was on Strandvejen, where I tried to capture the sound of roadworks, machinery and piling with lots of noise. After all, this is precisely one of the goals of the project. The sounds I recorded offline were not transferred when I came online again. I lost four recordings. This problem has been reported to the project team

These examples demonstrate that Louise has struggled with poor sound quality from the very beginning of the project including inconsistencies in visualisations of data on the project’s interactive map. To improve the sound quality, she experimented with different sound recording practices. E.g. her recordings of fountains in Copenhagen demonstrated that the M system provided inaccurate feedback: “your ‘sound robot’ [AI system] is not able to recognise splashing and rippling water; it recognises it as a ‘rumbling stomach’ or ‘heavy breathing’”.

When Louise downloaded her recordings and listened to them carefully, she discovered that every time people approached the fountain, the mobile phone's software would reduce the splashing water's sound while amplifying the nearby human voices. The result was a distorted soundscape where neither fountain nor human voices were clear. Louise's detailed descriptions and dialogue with the communication officers contributed to significant changes to the AI systems data processing and the mobile app's visual feedback. Hence it improved relevant user experience issues concerning the mobile app's general use and understanding.

Communications between participants and project members are crucial to a cs project's continued development since citizens have the potential to uncover a project's shortcomings and create new knowledge about how technology and technological issues influence, constrain, and shape participants' involvement in the project. Citizens' critical work not only influences the CS project and develops it further, but also points out how things could be designed differently.

This section demonstrated how citizens' different ways of knowing, doing and being directly influence the materialization of the CS project. Their entangled material practices of knowing and being make visible particular kinds of agencies and possibilities for reconfiguring epistemic oppression (Dotson 2014), constraints, and injustices that would be missed if we assumed that agency is exclusively human and central to the production of knowledge. The scientific citizen's entanglements with the technoscientific apparatus are dynamic relations of responsibility where nothing is given in advance, apparatuses are not "social formations of power that foreclose agency and produce ideological subjects." (Barad 2007, 240). On the contrary, structures are material-discursive phenomena produced and reconfigured through humans and nonhumans intra-active engagements; consequently, apparatuses, including the bodily production of knowledge, are themselves produced and reworked in iterative ways.

Theme 3: Entangled responsibility and enactments of concern

Enactments of responsibility - potentials for designing otherwise

Citizens are intra-actively reconfiguring the project through different material engagements with the project. From the early development of the project throughout interviews and participatory design workshops, citizens enact themselves as citizens and raise their voices and their matters of concern and care in different situations and contexts.

One of my design workshops at Amager Commons, (Amager Fælled), a natural area and public commons in Copenhagen, advanced from the statement: "We need a shared language, a sound community, to create relationships with the nature in order to be free". The concept emerged from the workshop members' concern about the protection and extinction of living species at the Amager Commons (AC), that

are under thread because of the municipality's plans of building houses on the ground. The participants' concern for the nature became more explicit during the workshop and through our collective sound explorations, sound mappings, and discussions and concept development at the site; through our intra-active material engagements their passion for protecting the nature shaped the focus of the workshop and the outcome of the workshops

One of the participants reflect on the political and ethical possibilities of the SOD project. That could serve to strengthen civic capacities to act making the public more aware about the natural landscape in Copenhagen. Kristine (activist, member of AC) reflects:

> If more people become aware of the soundscapes out here [at AC], then it could be a legitimate input into the political debate, where right now it is money that is the input [shaping] factor, [...] but only if there's also a part of the political conversation that's about what kind of soundscapes we'd like to have in our city. I often think that within the next 10 years, we will become more aware of the energy landscapes we have. What kind of landscapes do we want? What kind of energy and soundscapes do we want in the city? This is not legitimate to talk about in the political debate today.

This example demonstrates how the public's material engagement and matters of concern can serve as potentials for designing science-citizens relations with the public around community matters of concern, protection of natural areas, and potentially design digital citizen science engagement that serves community needs and interests including those defined by the scientists. Hence, co-designing another form of science that serves and involves collaboration between public and scientific capacities to act, holds interesting potential for developing more responsible and accountable forms of digital citizen science that combine contributory and democratic citizen engagement (Hetland 2020). The public clearly has capacities to act and react to others through their material-discursive "acts of citizenship" (Isin and Nielsen 2008).

These acts are political, ethical and responsible. They are relational acts that consider not only humans but also the nonhumans that are among us. In this sense, they perform ways of becoming political that potentially strengthen and transform epistemic practices and scientific knowledge production and collectively raise a plurality of different voices to be heard by creating new sites and scales of struggles that could serve to protect AC against extractive industries' intrusive influence of the natural commons. On the other hand, science can empower the voices of

citizens and strengthen their capacities for making their rights claims that builds on strong scientific evidence. Together they can constitute at citizen science that considers issues of responsibility and accountability and enhance our knowledge of what designs the agency of the already designed and the consequences of designing (Fry 2020). Citizen's material engagements in citizen science are crucial here because according to Barad (2007), “knowing is a material practice of engagement as part of the world in its differential becoming”. This has obvious ethical consequences for the human-machine relations of which we are just a part and through which potentials and agencies are articulated, constrained or excluded. We are part of the world in its differential becoming.

This is particularly noteworthy because for the citizen scientists the natural environment, science, and sustainability are understood as inseparable aspects of material-discursive engagements. According to Barad, responsibility is doing, a relational enactment where nothing is given in advance. Consequently, relational responsibility offers an opportunity to develop new forms of collaborative and responsible thinking with and from within the unfolding world. This process starts by realising communal agencies (see Escobar 2020) for the continual creation of communities and their connections to their surroundings.

Sonic engagement and enactments of concern

The active engagements of the volunteer contributors and their intra-actions with the project’s digital platform demonstrate how people are taking responsibility for the relations of which they are a part. Through their ongoing struggles with inadequate sound quality, poor sound recognition and technological issues in their sound recordings, citizens are expressing and enacting their concern and critique of the project.

In a mail to the project, Louise argues that the soundscape produced with the SOD app might be biased because of interferences from the smart phone:

> The mobile recorder is selective – it does not provide a ‘true’ sound image. Your “sound robot” had difficulties recognising splashing or rippling water; it perceived it as a rolling stomach or panting. Later, I downloaded my audio files and listened to them carefully (she deleted 3 out of 4 because of poor sound quality). In all four cases, I placed myself close to the splashing water and sheltered from the wind, until the sound was potent.
>
> #2518 Amaliehaven. The fountain in the middle is a powerful fountain with nozzles that practically splash like fire hoses. In the first half of the audio file, the loud splash of water is clear, but about midway through the audio file, the water recording is barely audible because the mobile captures the sound of talking tourists passing by. This substantiates my theory that the mobile is designed to suppress and filter out "background noise". Even though I was standing very close to the splashing water all the time, the ‘sound image’ is incorrect because

> human voices represented the background noise. The sound of splashing water was not abruptly muted.

Using this example, Louise's concern can be seen regarding the quality of sound in the project. In addition, it demonstrates how it affects and constrains her engagement with the project and her ability to generate and share epistemic resources of sufficient quality. In her ongoing experiments, she has found that when she records sounds near human voices, the AI system cannot recognise the sound of splashing water. This is because the voice recognition software in her phone is developed to enhance human voices rather than nonhuman sounds like fountains. In consequence, it provides incorrect feedback, diminishing the quality of the recording.

The machinic entanglements of which Louise is part are reconfiguring her material practices and agencies. They enact cuts that limit her possibilities for recording sound of acceptable quality even when she is standing close to a sound source. Thus, she deletes all her recordings from that day, except one. Moreover, Louise's key findings demonstrate that there is a potential risk of generating sound images, data and research that are too biased. This is because the mobile phone is coded to enhance human voices rather than nonhuman sounds such as splashing water. From this perspective, the entire apparatus of entangled intra-actions, therefore, reconfigure how sound is recorded and produced, including the sound quality, the bias encoded in the recorded data, and how people engage with the project or are excluded from engaging. Barad describes the apparatus of production as being reworked through human-nonhuman intra-actions. It is not just about producing products, but also about making subjects and remaking structures (2007, 238).

Louise's experiments is an enactment of responsibility and concern, that questions and contests the projects use of smart phones for scientific data collection:

> Collecting sound is a fascinating project, but don't you think mobile phones alone are unsuitable for these sound data collections? Could you consider the possibility that data collectors upload sound recordings with better equipment, so I can use my little Olympus LS-P1, which is half the size of my mobile phone, and then upload the sound afterwards?

For Louise, the poor sound quality and sound recognition in the project are constraining her engagement with the project. For Louise solid sound quality is imperative, hence she deletes many of her recordings in situations where the smartphone interferes and distorts the quality of the recording. She acquired a small

microphone to use with her phone to produce better sound for the project, and here she asks for other ways to participate in accommodating the poor sound quality. With her experiments, and by questioning the scientific process, as well as by using microphones to improve the sound quality, she not only expresses her concerns regarding the deficiencies and epistemic exclusions of the project that should be addressed to ensure participation is worthwhile but also suggests other forms of sonic participation to the project.

Louise acquired a small microphone to use with her phone to produce better sound for the project, and here she asks for other ways to participate to accommodate the poor sound quality. With her experiments, and by questioning the scientific process, as well as by using microphones to improve the sound quality, she not only expresses her concerns regarding the deficiencies and epistemic exclusions of the project that should be addressed to ensure participation is worthwhile but also suggests other forms of sonic participation to the project. With her enactments of concern and contestation, as well as her anti-programmatic behaviour that diverges from protocol, she creates tensions within the project (Kasperowski and Hillman 2018), that contest the scientists' perspectives, opens up unjust constraints and exclusions, and enable alternative modes of sonic engagement.

Theme 4: Machinic agencies, boundaries and epistemic exclusions

The following demonstrates how SOD as a technoscientific apparatus of bodily production is constituted iteratively through human and nonhuman intra-actions. Its boundary drawing practices enacts cuts that both enables, constrains, and sometimes excludes specific human agencies, concepts and knowledge practices (see Barad 2007, p.147). In the following I will demonstrate how some of these boundary drawing practices can result in unwarrantedly epistemic exclusions of citizen scientists.

Human-machine intra-actions and epistemic exclusion

By following the active engagements of the volunteer contributors, the technological issues and shortcomings of the project and how they affect citizen agencies is made visible. One of the volunteer contributors, Jens, describes his experiences with the SOD app, and how a lack of feedback from the system affects his experience:

> The sound recording is not working on my iPhone SE. I have tried several times and followed your instructions. When I press the red button, I see a small, round animation that pulses red. The counter remains at 00:00:00:00. I count thirty seconds to see if the screen changes - it does not. I leave your site with no response without knowing if anything has happened at your end of the interaction. I have repeated this exercise a few times, even today at project

> launch. But now I am about to quit. Is there an opportunity to participate in the project and possibly also benefit from SOD's results in the future?

The example demonstrates that participants are not provided proper feedback from the interface to understand their interactions with the app nor if their contributions are uploaded. Jens started the recording, but the timer never started, and there is not feedback on his intra-actions with the app so he cannot comprehend if the sound recording has started, finished or if the project has received his contribution. The missing feedback constraints his epistemic practices and possibilities for contributing to scientific research and for being fully engaged with the projects epistemic ressources.

Louise's descriptions of her sonic explorations in the forest, demonstrate her critical thinking and concern about the AI system's limitations that operate through the project, and show how epistemic practices are constantly reworked:

> I tried to record more sounds with the app. It works best when recording offline. It simply takes way too long with the artificial analysis. I am losing my patience. It is easier to add the description of the sound yourself. However, maybe that means the robot is not getting smarter? There is a conflict between user interests and project interests, and I do not like the long waiting time – after all, the AI cannot provide a reasonable description of the sounds.

This example shows how Louis's engagement with the mobile platform and AI system intra-actively reconfigures her epistemic practices and capacities to act. Louise discovers the app works best offline because of the AI system's time-consuming data processing. She expresses her dissatisfaction and is about to lose her patience with the AI system's slow data analysis and inadequate sound recognition; hence she finds it easier to add sound descriptions manually. The shift from automatic to manual sound description, a reconfiguration of practice, makes her reflect on how it will affect the training of the ML system. The example, furthermore, suggests, that people are concerned about the data quality in the project, because how will her change in practice affect the system? Louise wants to contribute with sounds of good quality, and help to trin the AI system, but the entire apparatus constraints her epistemic possibilities for being fully engaged and to contribute with better data quality.

Intra-acting with project protocols

The following example and correspondence with Morten (field recordist) and a communication officer suggest that the project protocols as a structure in the project, not only constrains but unwarrantly excludes certain forms of epistemic agencies:

> **Morten:** I have made some sound recordings in Bulbjerg (with a good ORTF stereo mic system not with a mobile phone). Would you be interested in such material for your project? You can listen here [link to his Soundcloud]
>
> **Communication officer:** Thank you for your contribution and interest. We would like to have your sound recordings, but you will need to use the website www.lyden-af.dk (SOD started as a web app). The website is in Danish, and you need to record outside somewhere in Denmark. You need to stand still and “tag” the sounds you have heard.
>
> **Morten:** Thanks for your mail. I am not interested in using an app on a Smart Phone to record audio since the quality is very poor compared to the high-end mics I use.

As the examples illustrate, the project has an appeal to people who are passionate about sound and recording; therefore, they are willing to contribute using their sound archives and high-end microphones to the project. Since the AI system is trained on low-quality sounds, such as YouTube videos, the project protocols do not permit sound recordings and data collection with personal equipment or sound contributions of high quality, so participation in the project is constrained to sound recordings through the SOD mobile app.

Another volunteer Peter writes: "I do not have a smartphone, but I have a Zoom H5 sound recorder and a PC. It is an unnecessary restriction if only those with smartphones can participate". These examples indicate that people want to be involved. This project has, however, reduced its potential by rejecting more diverse modes of sonic engagement, as well as contributions of high audio quality. A consequence of this could be that participants who wish to share their experiences, sound archives, and knowledge about sounding practices would be excluded.

Several aspects of the project structure, the mobile app, and the artificial intelligence system limit and exclude citizens' opportunities for active engagement, epistemic practices, sharing epistemic resources, and participating in scientific research. Morten understands that smartphone microphones produce unsatisfactory sound quality compared to his high-end ones, which limits his active involvement in the project. Consequently, volunteers cannot contribute according to their interests and protocols. This type of entangled reconfigurations that restricts and excludes epistemic agencies results in anti-programmatic behaviours within a community because of responsible acts of citizenship. Nonetheless, citizens' participation in the project and their expression of concern

opens new possibilities for reconfiguring the project and enabling more diverse forms of engagement by allowing them to contribute with their mobile phones, laptops, and high-end microphones. Finally, the need for alternative forms of science-citizen relations to leverage these potentials and create new forms of responsible engagement is crucial, as they are mutually reinforcing.

Concluding discussion

This paper's key findings demonstrated how the technoscientific structures of a CS project participate in enacting, enabling and constraining the epistemic agencies of a community of volunteer contributors, the formation of the scientific citizen, and the production of scientific knowledge. Karen Barad's agential realist ontology demonstrated its usefulness as a framework for making distinct possibilities visible for reconfiguring unjust constraints, boundaries, and dynamic power structures that might be missed when agencies are assumed to be predominantly human. I elaborate on these key findings in the following.

Based on my analyses of the citizen science project as a technoscientific apparatus through which material-discursive practices are reconfigured and reconfiguring possibilities for agency through human and nonhuman intra-actions. I demonstrated that citizens are involved in and part of the overall digital development processes that constitute the production of knowledge and phenomena and reconfigure the interactive engagements of volunteer contributors. For the researcher, SOD project team, and the participants, description and observation always happens as an intra-active part of the apparatus; there is no inside nor outside (Barad 2007, 396). I argued that citizens enact citizenship by bringing their attention to issues they care about - that might be missed by the scientists - but also through their direct contributions and reconfigurations of the platform and AI system. I pointed out that the material-discursive enactments always entail human and nonhuman reconfigurations. Thus, agency is iteratively coming into being through the reconfiguration process and the human-nonhuman entanglements.

Through their material-discursive engagements with the project, the scientific citizens bring attention to different matters of concern but also of interest that affects the ongoing development of the CS project. Key findings show that the scientific citizen is interwoven in social and scientific practices that open new sites of negotiation and communication. Furthermore, the analysis points out that citizens take ownership of the CS project and make it their own by drawing attention to issues and agendas they care about and integrating new layers to their engagement with SOD. From this perspective, their intra-actions with the project set a different direction that opened for further collective ways of thinking about sound and sonic engagements that could potentially benefit the ongoing development of the CS project. In addition, I stated that citizens enact citizenship by criticising and contesting the scientific process and by pointing out and

making visible the shortcomings in the project, such as poor sound quality and technological and epistemic exclusions. Moreover, we heard that citizens' engagements with the project directly influence the ongoing materialisation of the project through their involvement in the project. While the engagements of citizens suggest how things could be made different, they also point out the importance of designing new sites of citizen science communication.

Through their entanglements with the project, citizens are intra-actively reconfiguring the project, but the project also reconfigures the very bodies and doings of the participants. Key findings suggest that by co-designing with citizens, there are possibilities for designing more responsible, political and ethical forms of citizen science that strengthen new science-citizen relations.

Finally, I demonstrated how the performative effects of the technoscientific apparatus affect the enactments of scientific citizenship and how the scientific citizen is constituted intra-actively through humans and nonhuman entanglements. The citizen scientist's enactments of concern show that people wish to contribute with high data quality and sound quality. However, the project protocols – understood as dynamic power structures – do not allow this. Therefore, the technoscientific apparatus enacts agential cuts and boundaries that both enable and exclude practices and agencies from being co-constituted. From this perspective, I concluded that to design more responsible forms of citizen science engagement; we need more knowledge on the performative effects of the design and how the material and discursive in the design keep designing and enacting unsustainable futures. The first step in this transformation is to acknowledge our relational responsibility for the materialisation process of which we are part because these processes have a role to play in the formation of the scientific citizen and the production of knowledge.

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08.04 Relational responsibility - science communication as intra-action in multispecies communities

Abstract
This paper points to how community-driven science is able to challenge and renegotiate the current planetary situation. A primary aim of the paper is to investigate citizen science as a responsible form of science communication that is capable of mapping and understanding human-nature relations by re-enchanting science and by creating awareness of environmental concerns. Departing from recent studies in citizen science, this paper develops a posthuman theoretical framework inspired by design thinker Arturo Escobar and feminist scholar Karen Barad. Two examples are presented in the following on how relational and pluriversal knowledge experiments between human citizens and more-than-human actors can activate critical voices and ethical relations in science communication. The paper concludes that another science communication is possible - a science communication taking environmental entanglements and more than human connectedness into consideration. While acknowledging citizens' affective and emotional entanglement with nature disturbs an anthropocentric understanding of science and agency, it also allows us to see science communication as a pluriversal and embodied knowledge that thrive in more-than-human communities.

Keywords: relational ontologies, responsibility, citizen science, science communication, embodied knowledge

Introduction
We are in times of a planetary crisis where species daily become extinct, and global and local ecologies are under threat. Planetary movements and environmentalists organize to find alternate ways of responding to environmental crises that do not only represent the crisis as alarming figures but also open up for environmental awareness and compassion rethinking the relationship between humans and the planet (Escobar 2018; Chakrabarty 2019; De la Cadena 2015; Tsing and Tsing 2015). This article points to how community-driven science is able to challenge and renegotiate the current situation. It looks into citizen science as a responsible form of science communication that both has the capacity to map and understand our human-nature relations and also the potential to re-enchant and create awareness of environmental concerns. By connecting citizens with the soil and planetary concerns, CS has the potential to improve awareness of environmental diversity and values (Bonney et al. 2016). However, to better shape a livable

future through science communication and CS, we need a more-than-human framework for understanding how citizens through technologies engage with the environment.

Two examples are presented in the following on how relational and pluralistic knowledge experiments between human citizens and more-than-human actors can be used to activate critical voices and ethical practices in science communication. The inclusion of relational ontologies in citizen science not only increases power inherent to communities to act in relation to planetary concerns; we also argue that citizens science practices may also be used to engage in a plurality of understandings of the environment and compose new fields for interspecies cohabitation. In spite of their differences in form and context, the two cases share the same understanding of how citizens can create engaging forms of knowledge through experimentation and co-creation with the environment. Through embodied experimentations, knowledge is enacted and shared in a more than human community. Consequently, we do not view citizen science and citizen communication solely as a means of gathering data *about* other species but as a matter of concern and a means of relating and acting responsibly with more than human communities.

The first case is the choreographer, Nana-Francisca's collective performance walk and science communication project NETLA, which was performed during the Science Festival Bloom in Copenhagen in May 2022. It is a speculative example of collective and experimental science communication as it cocreates interspecies connectedness through the body. As the performance shows, the human body is deeply entangled with the environment in our everyday ecosystems. The second case draws from co-design experiments from the development of the citizen science project, the Sound of Denmark, in which a sound and co-design workshop was conducted with community members from Friends of Amager Commons. In this case, we demonstrate how relations and responsibility between citizens and more-than-humans emerge from sound experiments and practices of listening. Both cases work with embodied, aesthetic, and collective forms of engaging with the environment. Both cases enable a sentient way of knowing and becoming with multispecies communities.

Drawing from the cases, the article suggests alternative and explorative directions for citizen science and science communication. Rather than being a tool for representing nature as an object outside ourselves, we suggest that citizen science can work with pluriversal relational epistemologies where citizens become-with-nature (Singh 2017; Haraway 2016). Citizen science communication has the potential to open up our life worlds, foster responsibilities among citizens, and enact relations of awareness and empathy in more-than-human communities. Rather than operating within a nature-culture divide, this article defines citizen science as an epistemic practice enacting multiple relational and responsible engagements as it considers both human citizens and their technologies (Irwin and Michael 2003) as already deeply entangled with nature. Horst and Davies have argued that we need to pay more attention to the non-discursive within science communication. They argue that

> Communication (...) is the constant, interpretative production of meaning. It is something that is embodied, and that is as reliant on material infrastructures and networks as it is on language. In the context of science communication this means that we need to think more about the role of images, spaces, objects, and emotions in structuring experiences of communication. By focusing on talk and text we run the risk of missing many of the meanings that develop within instances of science communication—including things such as boredom, misbehaviour and unauthorised uses of communication products (Horst and Davies 2016, 216).

A science communication focusing on images, spaces, objects, and emotions we see as a potential for opening up the situations of science communication and citizen science into a weaving together of a plethora of practices. In this article, we use the notion of citizen science as a form of scientific communication (Schäfer and Kieslinger 2016, 9). In line with Horst and Davies (2016), we consider citizen science as a tool for empowering citizen agencies and scientific citizenship. The concept of citizen science has often been described as the means and potential to enhance new forms of science-citizen relationships by enhancing both contributory and democratic possibilities, however, most citizen science projects are structured in ways that emphasize the contributory potentials of citizen science. Jennifer and Bonney (2020) suggest that:

> Citizen science, in all of its diverse forms, is a means of public engagement in scientific work that can expand the scope, reach, and impact of research. Citizen science can provide opportunities to collect data at scales otherwise not feasible for professional scientists alone and can engage members of the public in compiling and using issue-relevant evidence to effect change (Jennifer and Bonney 2020, 14).

From this example, we suggest that citizen science can be more, and is more, than the 'extended arm of the scientists' as it holds alternative possibilities for collaboration among members of society and science, between lay knowledge and expert knowledge, but also for establishing relationships with more-than-human species. as Irwin (1995) argues: "we need also to reconstruct our understanding of the science–citizen relationship in order to acknowledge the possibility of wider sources of knowledge and understanding" (1995, 79). From this understanding, we believe that citizen science holds important potential for establishing relations-to-come not only between science and citizens but also with the environment and more than human ecologies. However, there has been little focus on how more-than-human lives co-constitute citizens' practices, and how citizens' participation in knowledge production is often driven and shaped by emotions such as for instance environmental awareness and care.

In order to rethink how we can develop more responsible forms of engagement in citizen science and take emotions, affects and environmental awareness into consideration, we turn to relational ontologies and pluriversal design theory (Escobar 2018), and we bring in the notion of responsibility and intra-action from post-human feminist scholar Karen Barad (2007). With this theoretical framework, we seek to explore citizen science as an act of co-creation with more-than-human agencies. Our two cases contribute with knowledge on how experimenting with relational and pluriversal ontologies where humans and non-humans intra-act can help to open up and activate new critical voices and entangled ethical practices in a science communication context.

Two questions will be addressed in the following: *can scientific communication be understood as a way of enacting responsibility and environmental care within the context of the current biodiversity crisis?*

Responsibilities, intra-action and relational ontologies

Agencies are doings distributed across human and nonhuman lifeforms (Barad 2007, 214; Bennett 2010, 21). Barad states: “Agency is about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices' (2007, 214). Hence, our intra-actions with the world matter because we are part of and enacting the arrangements that reconfigure, constrain, and exclude certain knowledge practices over others. Agency can be designated as an attribute of neither subjects nor objects as they do not preexist as such but are actively enacted in knowledge situations. Furthermore, agency is a matter of intra-acting, and they unfold through material-discursive practices. Hence, agency can be understood as matters of making iterative changes to particular practices through the dynamics of intra-activity which includes material enfoldings and other topological reconfigurings. These reconfigurations open up media, sites, and landscapes, and as we shall see later in the cases, how citizens transform sound qualities and environments into possible futures. Agency is then about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices (Barad 2007, 214).

Broadly speaking, we can say that intra-action occurs as an interior relationality that is already and always occurring in knowledge situations, whereas interaction describes an exchange between separate entities. Consequently, as humans participating in the world in its multiple becomings we are entangled with, and become ethically responsible for how we relate to and respond in the situation. In other words, we are responsible for the knowledge we seek, what exists (Barad 2007, 207), and the exclusions we participate in enacting (ibid, 394). Furthermore, we are responsible for our designs and how they go on designing (Fry 2008) because reality is (re)produced through our intra-actions with the world, through the situated socio-material practices we co-create. Therefore, knowledge situation consists of intra-actions, and draws from the multiple entanglements we are part of; matter and meaning do not pre-exist as separate entities, but are enacted agentially in intra-actions. Barad also notes how “The entanglements we are part of reconfiguring our beings, imaginations intra-actions and societies (Barad 2007, 383). In this sense, we

- as humans, researchers and citizens - cannot stand outside of the multiple agencies of the world, rather we are part of its multiple becomings; Or in the words of Barad, “Our intra-activity is part of nature, human practices are agentive participants in the worlds intra-active becoming (Barad 2007, 207).

Barad reminds us that socio-material practices and intra-action also entail an ethics - a responsibility; As researchers and knowledge producers we have an ongoing responsiveness to the entanglements of which we are part, and an account of the exclusions and boundaries we participate in enacting (Barad 2007, 394).

We (as for instance researchers, citizens, communicators etc.) are responsible for the cuts that we participate in enacting because we are an agential part of the material becomings of the universe. “Cuts are agentially enacted not by willful individuals but by the larger material arrangement of which “we” are a “part” (Barad 2007, 178). Hence, Barad contends that ethics is not concerned with how we interact with others as separate beings outside of ourselves, rather “Ethics is about mattering, about taking account of the entangled materializations of which we are part, including new configurations, new subjectivities, new possibilities'' (Barad 2007, 384). To be accountable is then about making commitments and new connections while at the same time being responsible for how they come into being.

Horst and Davies (2016) regard science communication as a cultural phenomenon that is intertwined in culture, identity formation and citizenship, and they suggest that science communication is an integral part of people’s lives (Horst and Davies 2016, 10). Horst and Davies suggest that science communication holds potentials for enhancing science-citizen relations if it takes both outward-looking aspects and personal experiences into account, they write:

> Science communication offers many ways of establishing relationships between citizens and science that can form the basis of such inclusion and political involvement. We believe it offers opportunities to develop practices of citizenship that are active as well as passive, critical as

> well as appreciative, and outward looking as well as focused on personal experience (Horst & Davies 2016, 194).

Horst and Davies' conception of science communication can be seen within an agential realist framework, which reveals how citizenship is entangled with culture and community and is situated in both personal and societal concerns. If we furthermore relate their ideas to Barad's agential cuts and notions of responsibility, it allows us to see citizens' practices and engagements as enactments situated and driven by emotions. In this sense, citizens enact knowledges through their political and engaged entanglement with the world, and as such they are responsible and accountable.

Furthermore, (Davies and Horst) regard citizenship as "affective", "embodied" and "discursive" (2016, 193). They see such relationality as meaningful in so far as it can propel citizens to become included in political decision-making and further participatory and democratic decision-making between citizens and established institutions such as the State or science. Also, citizens are often motivated by an ethical contract with nature which may "democratize and 're-enchant' science, provided the scientist worldview of superior data is not allowed to conceal the diversity of amateur motivations (Minna Santaoja 2022).

We acknowledge that there are still deep epistemological and cultural divides in epistemic practices, as it is often not considered appropriate or relevant in natural science to discuss topics such as emotions or engagement in research, and a passionate relation to the objects studied might in many ways collide with the standards of much scientific research (Minna Santaoja 2022). Here, an affective, embodied or even political engagement with the world might in many ways trouble scientific objectivism, or what Haraway has famously called the God perspective in science (Haraway 1988). In citizen science, however, Wylie et al. call for a science that "empowers people to question the state of things" (Wylie, Shapiro, and Liboiron 2017, 403). In a similar vein, Isabelle Stengers calls for a slow science that can make us think, feel, and imagine again what is possible (Stengers 2018). She calls for a cultivated science that abandons its previous destructive collaborations with neoliberal capitalism and advances new relationships with an intelligent public that actively participates in and contests the research that targets them. In many ways we see this as a further elaboration of Irwins take on citizen science. Irwin calls for the need for reconfiguring the relationships between science, citizenship and society, because not only are matters of environmental

concern channeled through these relations, “those relations also shape and construct our environmental awareness” ((Irwin 1995, 182). As Irwin suggests, relationality and environmental concern can be productive in a citizen science context since relationality and matters of concern of the participating citizen can come to matter through engaged practices.

This may in many ways break with contributory framing of CS which to some extent is based on an instrumental and linear understanding of CS as a tool to obtain information and collect data. It also brings in the messy, the relational and emotional complexities into science. Whereas this might cause troubles in linear research projects, it may also open up for another responsibility in science that lives on the community-based interests and commitments of people to for instance care and connect to environmental concerns.

With such perspectives in mind, we suggest a shift towards relational ontologies and entanglement in citizen science, and see CS carrying a huge potential in so far as it takes relationality, emotions, empathy and political engagement to the core of scientific production. In the following, we will introduce another perspective, that of pluriversal design.

The pluriverse and the web of life

To relate the responsibility from posthumanism and Barad into co-design and design practices, we will juxtapose the accountability and relational ethics with the Colombian design thinker, Arturo Escobar who has coined the term pluriversal design (Escobar 2018). Pluriversal design gives us a theoretical framework that can help to advance new forms of responsible and critical engagement in the design of science communication. Elsewhere Escobar (2011) writes:

> The pluriverse can be described as ‘a world where many worlds fit’. At their best, it can be said that the rising concepts and struggles from and in defense of the pluriverse constitute a post-dualist theory and a practice of interbeing (Escobar 2011, 139).

Escobar's notion of the pluriverse stems from the Zapatista's understanding of the world as pluriversal - a world where many worlds fit. The pluriverse is for instance a world of more-than-human sentience constituted by the interconnectedness of all living beings. As Escobar notes above, the pluriverse constitute a post-dualist theory and a practice of interbeing. As such it opens up towards the lifeworlds of more-than human beings, animals, and natural phenomena such as forests, rivers, water sheds etc.

By frequently referring to the Zapatista community and indigenous knowledges, Escobar is furthermore interested in how communities engage and perform what he defines as ontological design. By ontological design we understand design practices that engage with being in the world and the mere art of living. As Escobar notes, "every community practices the design of itself: its organizations, its social relations, its daily practices, its ways of knowing and living, its relationships with the environment, and so on" (Escobar 2018, 37). This has been the case with most communities throughout history that they have practiced design independent of expert knowledge; rather they built their worlds autonomously, and in this sense they offer and alternative to the way design happens in liberal, secular modern worlds where design regulates social life and are carried out by experts (Ibid). This we find interesting in relation to citizen science as a knowledge practice often motivated by community engagement, and as we will see in the two cases, communities engage with other species and natural lifeworld's as a form of pluriversal practice driven by their environmental concern and awareness.

While Escobar, by bringing autonomy and design together, sees the potential for communities to change norms from within, his relational ontology also opens up towards environmental concerns and for enacting pluriversal knowledges. Communal knowledge allows redefining what we understand by knowledge and opens up to pluralistic ways of knowing the world and including thinking with the Earth (Escobar 2020; De la Cadena 2015); such ways of knowing to include indigenous knowledges and holistic understandings of the world. In particular, Escobar argues that knowledge produced from territorial struggles provides us with essential elements for thinking about the profound cultural and ecological transitions we are currently part of (Escobar 2016, 14). Territorial struggles in for instance indigenous cultures, grassroots organizations and environmental activism are examples of relational knowledges in which humans from a holistic worldview defend the rights of other species, rivers and forests (Escobar 2016; De la Cadena 2015; De la

Cadena and Blaser 2018). Such relational knowledges are needed to face the inter-related environmental crises of climate, food production, environmental injustice etc. as such knowledges are uniquely attuned to the needs of the Earth, Escobar argues (2018). Escobar goes as far as to claim that the failure to recognise relationality with the environment and the earth is one of the main causes for many of the crises and destructive forces we currently face, including climate collapse (Escobar 2018, 30). Therefore, to sustain the web of life, and to propel a future built on non-exploitative ways of living calls for the role of the designer to become a "transition activist" (Escobar 2018, 7). He calls for a change of how we relate to the environment and the earth. Here, communities and their ontological designs are a pathways for designers to become part of the transition; hence co-design in Escobar's thinking involves community collaborations and more-than human and environmental awareness through situated and communal practices.

Interestingly, Escobar argues that pluriversal knowledge as an earth thinking is expressed not primarily through theoretical notions, but "through art weavings, myth, place-centric economic and cultural practices and struggles for territory" (2020, 34). From this, we take that aesthetic and embodied forms of knowing such as sound, listening and performance hold a potential, not only for situating knowledges within local environmental struggles but also for weaving together another science and knowledge production that allows for a thinking-feeling with the earth (Escobar 2016). In short, another science and design practice that allows for passion and imagining the world otherwise.

Finally, we find similarities between the material epistemologies of Barad and her notion of intra-actions and the pluriversal design and politics of Escobar. Both work within a relational ontology, and while Escobar is more oriented towards autonomies of the community, the notion of the pluriverse opens up towards non-human lifeworlds in the sense that communities work with the web and materiality of life relating to nature and natural phenomena.

Relational ontologies in research methodologies

Following Barad, we as researchers are entangled, and our engagement with the world makes us accountable for the commitments and connections we make in the research process. Also participant observations and our engagement as researchers are agential cuts. Hence, we as humans, researchers and citizens are entangled and part of lively relations in more-than-human communities, and our actions and agency must be understood in relation to others. Donna Haraway famously argued for situated knowledges in the late 80ies; in situated knowledges practices, politics and epistemologies of location, positioning, and situating are stated as the condition for being heard (Haraway 1988). Like Barad's agential realism, "situated knowledges require that the object of knowledge be pictured as an actor and agent, not a screen or a ground or a resource" (Haraway 1988, 198).

In that regard, we argue that relational and materialist ontologies are situated knowledges that can help us question the predominant scientific epistemologies in citizen science and much science communication. In our methodological approach, we position ourselves as engaged, entangled and embodied researchers that actively partake in our knowledge production. As researchers we perform and enact agential cuts in how we put our methods together, how we relate to others and how we include and exclude information throughout the process of doing research. Therefore, we are accountable for the meaning and results we are producing.

In the two cases we have been engaged as co-creators of knowledge. In the first case, "becoming with the nettle", one of the authors participated as a co-creative audience in the performance walk. The methods were sensory ethnography (Pink 2009) and walking methodologies (Springgay and Truman 2018) which both unfold sensory and affective forms of inquiry where the researcher observes and maps the felt experiences and matterings that emerge in the encounter with a more than human world. Bodily sensations and affects between for instance the participating bodies and the environment of the nettles were mapped and explored as sensory ethnographies and matterings in the more-than-human environment of the nettles. For instance, walking with other participants in the nature produced embodied knowledges where the researcher's participation in the performance became an engaged way to practice feminist positionality and situated knowldeges while at the same time being accountable and committed to the connections and sensemaking (Springgay and Truman 2018; Barad 2007). Hence, participating from a partial and embodied position enabled the researcher to enact and perform knowledges to create an embodied and situated

archive (gurudev 2021; D. Haraway 1988)of her own entanglements with the environment and its multiple actors and agencies.

In the second case, “Sonic engagements with a multispecies community”, one of the authors participated as the organizer and co-designer of the workshop with the Friends of Amager Commons. By being a part of the SOD project, the task was also to develop ideas and a prototype for the citizens science project. Furthermore, by being himself committed to sound and its potential for environmental awareness, the researcher was partially engaged both in developing the SOD project, however also in the practices of listening and soundscape recording. As Juelskjær et al. (2021) write: “the researcher is thus not a neutral knowledge-creating subject but works with and through the studied phenomenon in a situated and entangled manner, leaving no external position from which it is possible to produce knowledge” (2020, 152). Both cases work in different ways from a situated and entangled perspective and are in this sense agential cuts that propose engaged and responsible propositions with more-than human communities. To sum up, this means that we are responsible for the knowledge situation of which we are part, and also the exclusions, inclusions and boundaries we partake in enacting throughout the research process.

Netla - Becoming with the nettle

Netla was a collaborative walk and a performance created by choreographer Nana Francisca and performed at the Science Festival Bloom in Copenhagen 2022. It becomes a case of science communication as a genre label from the context of being part of a science festival, experimenting with forms of knowing. We introduce this collective performance as a speculative case of science communication in which relational ontologies and becoming between human and non-humans is explored and qualified. The case helps us concretize Barad’s agential realism and what we may understand as agential cuts, and also allows us to unfold the notion of the pluriverse and how pluriversal knowledges are produced in more-than-human communities.

The performance consisted of three main stages. Being guided by a performer the participants were dressed in nettle-dyed cotton jumpsuits and walked in silence to three different stages where we interacted and related to the nettles in different ways.

In the first stage, we gathered in a beautiful bubble tent in which participants could see and sense the surrounding trees through the light membrane of the tent textile. Here, we watched a film about the life and the many nutritious and soil qualities of nettles, combining both scientific knowledge and a more tentative and poetic musings around the nettles. While watching and listening, a nettle tea and nettle chips were served. In the next stage, participants were led into a small meadow surrounded by trees. Here nettles in various sizes were growing, and we were asking by our guide to relate to the nettles by observing their structures, leaves and movements, and by gently touching them. From these interactions, we learned that by relating in a careful manner, we could avoid the stinging from the leaves.As such, the nettle, the human body and the environment interact in mutually constitutive processes. Before entering the final stage, we were asked by the guide whether we would like to contribute to the nettles by urinating in a small glass. The final stage was in a tent were participants in words and drawing could reflect upon relationality and connectedness. Also directly by contributing with our urine which were then later distributed to the nettles in the area.

The performance was in this regard and embodied ways of knowing about the nettle that engaged the body and the senses of the participants. The embodiments and enactments that took place during the performance walks, we see as entangled processes of “becoming-with” or “co-becoming” in which humans, nettles and the ecologies, we are all part of, all become co-creative partners. Intra-action is here a useful term as it exactly points to relationality from an entangled situated and embodied perspective, and point to a knowledge situation without an outside perspective.

In that sense, we see *Netla - the ambassador of the Nettle* as an example of science communication working from an embodied perspective engaging citizens and participants from their situated and partial perspective. Learnings from participation in the performance walk was also to be able to account for the a pluriversal world in which scientific objectivism co-existed along with a sensory and embodied forms of knowing about nettle.

What the case illustrates is an example of relational knowledge production in which environmental knowledge is enacted as a material-discursive cuts in which human embodied perception, the nettles and the environment co-produce the situation.

What inspires us in the nettle performance is an understanding of a science communication that takes its point of departure in more-than human environmental intra-actions, in which the encounter with non-human stakeholders such as the nettle or the tea has direct agency into how knowledges are produced, and where a situated and entangled human body serves as the relational tool for the enactment of knowledges. Also the example shows how sensory and embodied forms of knowing and engaging with the environment can unfold, and how science communication can take place as a collaborative and distributed agency in a more than human community.

Sonic engagements with a multispecies community

The second case draws from a participatory design workshop that is part of the research and co-development of the digital citizen science project, the Sound of Denmark, developed at the Center for Macro Ecology, Evolution and Climate (CMEC) at the University of Copenhagen. The citizen science project focuses on researching the Danish soundscape by engaging volunteer contributors in the sound mapping of the Danish landscape, and the following identification, documentation and analysis of sound objects and distribution of natural and anthropogenic sounds.

The participatory design workshop was held in the development process of the Sound of Denmark to explore how citizens engage with sound, what motivates them, and find potentials for how sound and environmental concerns can be related. The workshop was organized with 4 participants from the citizen community, Friends of Amager Commons: a community organized around the protection and conservation of the urban nature resort Amager Commons. FOAC is a civic group that works for the preservation of Amager Commons as an irreplaceable urban nature and a valuable green recreational breathing space for people and animal life in the city. Friends of Amager Commons' most important mission is currently to

prevent the private-public urban developers, By & Havn, from building in the area. In particular the habitats for the skylark and the ambassador species, great newt is currently under threat by the construction of the future Fælledby, the Commons City.

The history of the commons is diverse. The common has formerly been used as a common for pasture, and later in the 20th century as a garbage dump for an increasingly expanding city, and also as a training ground for the military. With this history, the commons can be understood as a hybrid urban nature that has developed over time; a unique territory in which human culture and urbanization, nature and multiple species have co-created a thriving and diverse ecosystem over time.

Activating new voices and ethical practices through sonic engagement

The intention of the workshop was not directly to engage with the environmental concerns of relating to the commons but to explore how a citizen group like FOAC engages with the environment through sound. The workshop consisted among others of a sound mapping exercise where people went out individually or two and two, listened and recorded sounds. This was followed by a collective discussion in the group about their findings and collective listening to some of their recordings. The workshop enabled the participants to concretise their ideas about sound, sound mapping and also to put words on sound, discuss sounds, and soundscapes, and let them explore the environment by their immediate attunements to the landscape. Through experimentation, the intention was to open-up for a broader discussion about sound, soundscapes and environmental justice that went beyond the interests of the CS project. Also, it was the interest to challenge the quantitative scientific understandings of sound within the SOD project. The interest was to explore forms of engagement and epistemic practices that could potentially enhance people's capacities to act, contribute to the scientific process and serve as a political and affirmative act in environmental justice claims. The participatory design workshop and the sonic engagements between citizens and the commons unfolded how citizens engaged through listening and attunement to the environment. Through the workshop, the political and democratic interests of the citizens were also brought to the for as it became clear how the community engages with environmental justice not only for their own rights to Amager Commons but also fighting for environmental justice on behalf of the many species living and breeding on the commons.

Sound and sonic practices became a medium for discussing people's justice claims and their ways of commoning with other species and nature at the commons (Singh 2017). Listening and recording sound enacted a more-than human soundscape and environmental qualities of the commons. Sound studies scholar, Salomé Voegelin (2021) argues that listening can propose alternative views on how we live in the world and suggest possibilities for inhabiting the world differently. She writes: "sound slices through the visual frame and organization to propose others: temporary, invisible, and ephemeral re-framings that demand our participation and re-frame the listener also" (2021, 22). Sound holds capacities for engaging the perspective of the listener. On listening and recording with the FOAC we saw that sound became an aesthetic practice that enacted environmental awareness and matters of concern for other species' lives, -enactments that also raised questions regarding the future of multispecies commons. In the following, Christina (activist from FOAC) reflects on the political and ethical possibilities of sound for environmental justice:

> If more people become aware of the soundscapes out here [at Amager Common], then it could be a legitimate input into the political debate, where right now it is money that is the input [shaping] factor, [...] but only if there's also a part of the political conversation that's about what kind of soundscapes we'd like to have in our city. I often think that within the next 10 years, we will become more aware of the energy landscapes we have. What kind of landscapes do we want? What kind of energy and soundscapes do we want in the city? It is not legitimate to talk about [it] in the political debate today.

This statement emerges from a passion for nature and the community work in FOAC, through which she and others (e.g. Extinction Rebellion, Embassy of the Species) fight for the protection and the conservation of the commons. Christina suggested listening as a form of engagement that increases citizens' awareness of the commons, and also questions what makes a livable future city. By asking, "what kind of soundscapes

do we want in the city?", she proposes a counter narrative to the predominant discourse in urban development. In this sense, the workshop activated forms of engaged listening and soundscaping, which reconnected citizens with the environment and its multiple species at the commons. Furthermore, we regard listening practices as a pluriversal knowledge production in the sense that it enacts human and non-human lifeworlds. The citizens from FOAC defend and argue for the rights of other species to live in the commons and explore the soundscape of such voices. Sonic engagement here becomes a way of intra-acting with ways of doing and bringing about possible multispecies futures to the attention. In this sense, citizens in FOAC enact ethical forms of engagements with the more-than human community at Amager Commons.

Sound becomes a way to enact agential cuts and is a potential for enacting other worlds, and what Escobar (2020) calls the pluriverse. The agency of sound relates the worlds of the citizens in FOAC with the multispecies worlds of the animals, insects and birds living in the commons; What motivates the enactments are the political and passionate engagement of the citizens who are driven by their community passion for preserving the environmental qualities of the commons.

Hence, sound becomes a mode of engagement that relates species in a more-than human community. A community that is pluriversal in the sense that listening and soundscaping allows many worlds to coexist. Finally, such pluriversal knowledge production raises questions to science communication and to how citizens science can be designed and practiced with care and awareness for more-than-human communities. We will return to that in the discussion.

The workshops at Amager Fælled demonstrated that listening is an active and collective way to speculate on, negotiate and rearticulate environmental concerns. What was practiced in the workshop was a careful listening to the voices of a multispecies commons (Singh 2017; Voegelin 2021; Haldrup et al. forthcoming 2022), and can be regarded as a responsible and pluriversal way to reconnect with other species and the environment.

The examples demonstrate that sonic engagement and experimental co-creation can serve as spaces for actualising new democratic possibilities that intra-actively influence and move the conversation and new ethical and environmental issues forward. Also it raises questions about what is considered knowledge, and to whom? By tapping into the pluriversal politics of the commons, in which multiple species and stakeholders intra-act, the workshop advanced listening as an ethical and pluriversal engagement that

neither saw the commons as a recreational area for citizens nor a construction sites for urban development, but importantly also as the living habitat and breeding ground for other species. During the workshop, such affirmative relations were established with citizens, researchers and more-than-human stakeholders living in the environment. Consequently, collaborative and experiential workshops like this can help to inform alternate ways to activate not only citizens' voices but a plurality of voices, human and more-than-human alike. As such they cultivate spaces of relational responsibility among species. Whereas the sonic engagements performed by the citizens in FOAC strengthens citizens' democratic actions and constitute them as epistemic subjects (Kasperowski and Hillman 2018; Gommesen forthcoming 2022), they also tap into the pluriversal politics relating to how to preserve and sustain the web of life.

Hence, citizens' collective and relational ways of listening, recording, valuing and negotiating the environmental qualities and the voices of silenced multispecies citizens such as the skylark and the great newt is a way of being communal (Escobar 2018, 225–26) that open up a pluriversal world of many worlds.

The sound recordings are environmental justice claims unfolded during the workshop enacting both citizens and other species' rights to the commons. They are art weavings working as cultural practices struggling for the territory and environmental rights (Escobar 2020). The matter of concern for species' rights that the activists in FOAC perform and weave in the sound workshop with their acts of listening, can furthermore be understood as agential cuts into the biodiverse environment of Amager Commons. The sound recordings were cuts in the sense that they did not represent other species; rather they were enactments of other species voices by bringing forth the sound matters of bird songs, insects and other environmental sounds. As voices they are both voices from the more-than human communities (animals and insects) on Amager commons, and enact the pluriversal political interests of FOAC asking what "kind of energy and soundscapes do we want in the city"?

Discussion

The two cases have demonstrated how knowledge does not emerge from linear processes but emerge from open ended situations in which citizens engage with, intra-act and ultimately learn from more-than human agencies. Decentering human agency in relational design ontologies raises the question of how we can start to imagine participatory design and science communication beyond human exceptionalism and scientific extractivism. Furthermore, what implications does relational ontologies have for citizen science and communication?

The cases have shown how agency is distributed, and we have in particular focused on the knowledge production taking place in more-than human communities when it is enacted from a situated and engaged position. From merely defining the role of media technologies as material-discursive apparatuses with agency (See also Gommesen, forthcoming 2022), this article expands the technoscientific non-human agency to encompass the agency of the environment, and to more-than human stakeholders such as animals, plants and the living landscapes of biodiverse commons.

Relational ontologies and the implications for science communication

Barad describes knowledge situations as having a material effect because we are entangled and inseparable from a world in constant becoming. Hence, life and in this also more-than-human life does not happen outside of us, rather we are intra-actively connected. Agential realism is enacted through response-ability with and in the environment and all of its living forms.

From a conventional science communication perspective, the world is made of interacting but still separate parts, which also constitute the split between subject and object, human and non-humans. However, relational ontologies, agential realism and the pluriverse give us a framework for understanding the entangled matter-movements of the web of life, we are all part of. In our two cases, we have shown how entangled life emerges from explorative and collaborative situations.

One major takeaway from the two cases is that our entanglement with the world cannot be separated from our responsibility to the world in its intra-active becoming; as Barad reminds us that responsibility entails ongoing responsiveness to the entanglements of which we are part, and an account of the exclusions and boundaries we participate in enacting (Barad 2007, 394). Hence, we must develop a scientific

communication that does not stand outside of its phenomena but actively engages with the world through a becoming with (Haraway 2016; Singh 2017). The gesture of bringing urine back to the environment in the Netla performance underlined such embodied and situated position; the fact that we are already responsible participants in the world.

Conclusion

Key findings demonstrate the potential of fostering another possible science that is constituted in relationality and responsibility with more-than-human communities.

While much CS is predominantly human-centred and ascribes agency to human stakeholders alone, our cases have shown how diverse forms of knowledges are enacted and coming into being. In our two examples we have shown how more-than human communities relate, and how interconnectedness emerge through embodied forms of knowing. We have brought into our analysis Barads notion of intra-action to show how citizens and participants enact embodied and sensory engagement with more-than human others. Movement, touching-feeling and sound were some of the embodied forms of knowing that enacted responsibility and relations in the more-than human communities

In this perspective we suggest another framing of citizen science; CS is no longer a means to represent or contribute to science on biodiversity, rather CS is deeply entangled with the agency of technologies, the multiple environmental agencies of other species and the political interests of citizens making environmental justice claims. Entanglement as the foundation for citizen science proposes another possible science that makes us feel, act and imagine again (Stengers 2018) and breaks with the extractivist nature of much scientific research. An entangled, situated and embodied foundation of CS and science communication holds great potential for another possible science that sees entangled nature-cultures in more-than human communities as the point of departure for knowledge production.

In this paper, we suggested a shift towards relational ontologies and to take more-than human entanglement in science communication into consideration when developing citizen science communication.

We also point to the necessity of taking embodied forms of knowing such as emotions, empathy and care into science communication.

Hence, we propose that future research and application in citizen science and other science communication contexts take environmental entanglements and more than human connectedness into consideration. Not only does entanglements break with a human-centered and anthropocentric understanding of agency, it also allows us to see science communication as a science emerging from feelings of connectedness in human more-than human communities.

As we have demonstrated throughout this paper, relational ontologies are not only a theoretical framework for understanding design and knowledge production. It is also a potential for refiguring whom and what partakes in knowledge situations, and how we can gain knowledge from the web of life of which we are part.

Acknowledgements

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10 Appendices

10.01 Appendix 1: Interview guide

Interviewguide: semi-struktureret deltagerinterview
Deltagere: Brugerinterviews

Varighed: 45-60 minutter. Jeg optager interviewet af hensyn til at kunne dokumentere vores samtale og bruge det i min forskning.

Sted: Center for Makroøkologi, Evolution og Klima alternativt hos de enkelte brugere.

Indledning/briefing:

- Mit navn er Niels Jørgen Gommesen, jeg er ph.d.-studerende i medievidenskab på Institut for kulturvidenskaber på Syddansk universitet.
- Mit forskningsprojekt er en del af forskningsprogrammet Vores Museum i samarbejde med Center for Makroøkologi, Evolution og Klima på Statens Naturhistoriske Museum.
- Et samarbejde der tager afsæt i udviklingen af et citizen science projektet Lyden af Danmark, der gør det muligt for almindelige borgere at deltage i kortlægningen af det danske lydlandskab.
- Projektet bidrager direkte til museets naturvidenskabelige forskning, der søger at forstå hvordan lyde påvirker vores oplevelse af omverdenen og vores velbefindende.

Ph.d-projekt har til formål at bidrage til at **styrke medborgerskab gennem brugerinddragende kommunikation på SNM,** samt undersøge **kommunikationens betydning for vellykket borgervidenskab.** Formålet opfyldes gennem en teoretisk udvikling og et empirisk meddesign og evaluering af borgervidenskabelig kommunikation.

(Hvordan designes, implementeres og evalueres nye former for citizen science-kommunikation med henblik på at styrke medborgerskab?)

I den sammenhæng er jeg meget interesseret i at høre om dine interesser for projektet LAD, erfaringer med citizen science og italesætte dine erfaringer med kommunikation og deltagelse på sociale medier eller online fælleskaber du måtte deltage i.

Har du nogen spørgsmål inden vi starter?
Ellers vil jeg bede dig om kort at fortælle **lidt om dig selv, navn, alder, beskæftigelse og dine interesser i relation til emnet**

Forskningsspørgsmål	Interviewspørgsmål
Kommunikationens betydning for involvering: Hvilken betydning har kommunikationen (el. citizen science-kommunikationen) i et vellykket citizen science projekt?	Kan du sige noget om dine erfaringer med deltagelse i citizen science? • Eller deltagelse i projekter der vedrører dine interesser? • Hvad fik dig til at deltage? • Deltager du både (offline og online)? • Hvorfor vil du gerne deltage i LAD? • Hvad fastholder din interesse? Hvad betyder deltagelse for dig? • Er det nok at du som deltager har mulighed for at bidrage til forskningen? I hvilke sammenhænge deltager du? • Hvilke forventninger har du som CS-deltager? forventer du at der kommer noget igen fra projektet? • Er CS noget du gør alene eller sammen med andre? Kan du beskrive den kommunikation du forbinder med din deltagelse på (ex. svampeatlas, myrejagten, eller andre sociale medier og fora)?

	• Kommunikerer du med andre deltagere/brugere (online og offline)? • Hvilken betydning har kommunikationen for din deltagelse? (brugere-brugere, brugere-forsker) Hvad betyder lyd for dig (ex. hvordan påvirkes du af KBHs urbane lydlandskab)? Hvilke lyde synes du er behagelige/ubehagelige? • Kan du sige noget mere om dine interesser i den sammenhæng? • Hvad kan projektet LAD bidrage med i forhold til dine interesser? Vi antager at du har været ude og optage lyd med din telefon hvad gør du med lyddata? Deler du? Arbejder du med lyddata? Er det noget du gerne vil have mulighed for? Kunne analysere lyddata? #feedback Flere artikler nævner kommunikation og tilbagemeldinger som afgørende for cs-brugeres deltagelse, hvad tænker du om dette? Hvilken form for feedback er du som deltager interesseret i at få fra ex. forskerne? (offline/online)

	hvilke elementer mener du at der indgår i et vellykket citizen science projekt? (vellykket forstået som et projekt der styrker både deltagernes og forskernes interesser og behov) #Dialog Synes du, at det er vigtigt som deltager at kunne tale med andre deltagere? Og med forskerne i projektet? Kan du give eksempler på medier og platforme hvor dialogen med andre fungere godt? Hvordan vil du definere en god og gensidig dialog og videnudveksling mellem deltagerne og forskerne i LAD? Kan du sige noget om sammenhængen mellem din motivation for at deltage, og dine muligheder for at tale med andre deltagere eller forskere?
Citizen science-kommunikation og medborgerskab: Hvilken betydning har citizen science-kommunikation for styrkelsen af medborgerskab?	Hvad kan får dig til at deltage og bidrage til videnskaben? Hvad får dig til at deltage i online aktiviteter (er du politisk, kulturelt, social, videnskabelig aktiv)?

	Kan du beskrive dine erfaringer med at deltage online (ex. myrejagten, sociale medier, aktivisme)? • Hvad får dig til at gå i dialog med andre brugere? Hvordan ser du udviklingen af denne kollektive videnudveksling mellem deltagerne? • Hvordan kan forskningen/forskerne bidrage til at styrke dine behov og interesser? Nyeste forskning taler om scientific citizenship som et personligt tilvalg, der handler om hvordan vi handler sammen i en moderne verden? Hvad tænker du om dette? Oplever du citizen science som en vejen til øget samhørighed og styrkelse af medborgerskab? Forståelse af klimaforandringer? Er det vigtigt for dig at kunne handle sammen med andre?
***Digitale teknologier**:* hvordan designes citizen science-kommunikation med henblik på at styrke medborgerskab?	Kan du sige noget om hvad der er vigtigt for dig som deltager? Hvad kan motivere dig til at deltage? Og hvilke muligheder skal bør være (online/offline)? Hvad tænker du om mulighederne for at præge den måde du indsamler/optager lyd er det en begrænsning at man kun kan benytte sin mobiltelefon? At

	man ikke kan uploade online? Og downloade indhold, hvad tænker du om det? Hvilken rolle spiller teknologi og digitale medier i din hverdag? Kommunikere du meget i forskellige fora? Hvilke? Deler du? Hvad får dig til at dele indhold på SoMe? LAD kommer til at foregå via en webapplikation hvor alle borgere i DK kan indsamle og registrere lyddata, og bidrage til forskningen på CMEC udelukkende via deres mobiltelefon. • Hvad betyder det for dig at man kun kan deltage med sin smartphone (og online)? • Hvilke styrker og svagheder ser du i denne form for deltagelse (erfaringer)? LAD kommer potentielt til at skabe store mængder data som er anvendelige for projektets deltagere. Kan du i den sammenhæng sige noget om et cs-projekts åbenhed, her tænker jeg på deling af resultater, data og open-source – bør data være tilgængelige for alle? Er det vigtigt med et åbent fora hvor man som deltager kan stille spørgsmål og diskutere med andre

	brugere og forskere? Hvad er dine erfaringer online/offline? er det vigtigt for dig med frihed til at vælge hvordan du vil deltage i LAD, eller er det ok at deltagelsen er meget struktureret i sin form? Hvad motiverer dig til at deltage i et citizen science projekt som LAD?
***Demokratisering af videnskaben**:* hvilke potentialer ligger der i borgervidenskaben for at demokratisere videnskaben? Hvilken rolle spiller kommunikationen i denne sammenhæng?	Flere studier forbinder citizen science med en bevægelse der søger at demokratisere videnskaben, ved at bringe offentligheden og videnskaben tættere sammen, facilitere en aktiv dialog og inddrage borgerne i beslutningsprocessen. Hvad tænker du om dette? Hvor ser du et potentiale for citizen science i forhold til at demokratisere videnskaben? Hvilken rolle spiller kommunikationen i denne sammenhæng? I hvor høj grad mener du at deltagerne bør inddrages i forskningsaktiviteter gennem et CS projekt? Er det tilstrækkeligt at borgerne inddrages i selve dataindsamlingen men ikke analysedelen?

	Hvilke potentialer/begrænsninger/udfordringer ser du i citizen science med henblik på udvikling af et aktivt medborgerskab?
Online/offline Fælleskab: sammenhænge mellem citizen science-kommunikation, online fælleskab, og styrkelse af medborgerskab.	Ser du det som en vigtig del af et CS-projekt at deltagerne har en fælles platform hvor de kan mødes, og gå i dialog og dele med hinanden? I hvor høj grad vil du gerne inddrages i udviklingen af dette fælleskab? (co-design) er det noget du har erfaring med gennem dine nuværende interesser? Har du behov for et fælleskab (online/offline) hvor du kan dele dine interesser med andre deltagere med samme interesser? Kan du give et eksempel? Hvad tænker du om et online fælleskab der udfolder sig dels via din smartphone og dels via facebook? Hvilke udfordringer vil det betyde i den måde du bruger digitale medier?

Debriefing: har du spørgsmål til interviewet eller lyst til at knytte yderligere kommentarer til interviewemnet?

Eventuelt **fremhæve hovedpunkter** fra interviewet (måske har informanten lyst til at kommentere yderligere på denne feedback).

Afslutning: Jeg har ikke flere spørgsmål. Er der andet du har lyst til at sige eller spørge om før vi afslutter interviewet?

Tak for din deltagelse det sætter vi stor pris på. Håber jeg må kontakte dig hvis der opstår nye spørgsmål på baggrund af vores samtale?

10.02 Appendix 2: Design journal

Udfordring: Hvordan vil du gerne deltage, kommunikere og involveres i projektet LAD?

Mission: Hvilke lyde optager dig?

Gå på opdagelse sammen, 2 og 2 eller alene, diskuter dine optagelser med en fra gruppen

EMPATHY

1 OPTAGELSE

8 minutter (3 x 2 min efterfulgt at noter og diskussion)

2 OPTAGELSE - DIG DEEPER

8 minutter (3 x 2 min efterfulgt at noter og 2-3 spg.)

Noter til lydkortlægning 1

Lokation:
dato:
tid:
vejrforhold:

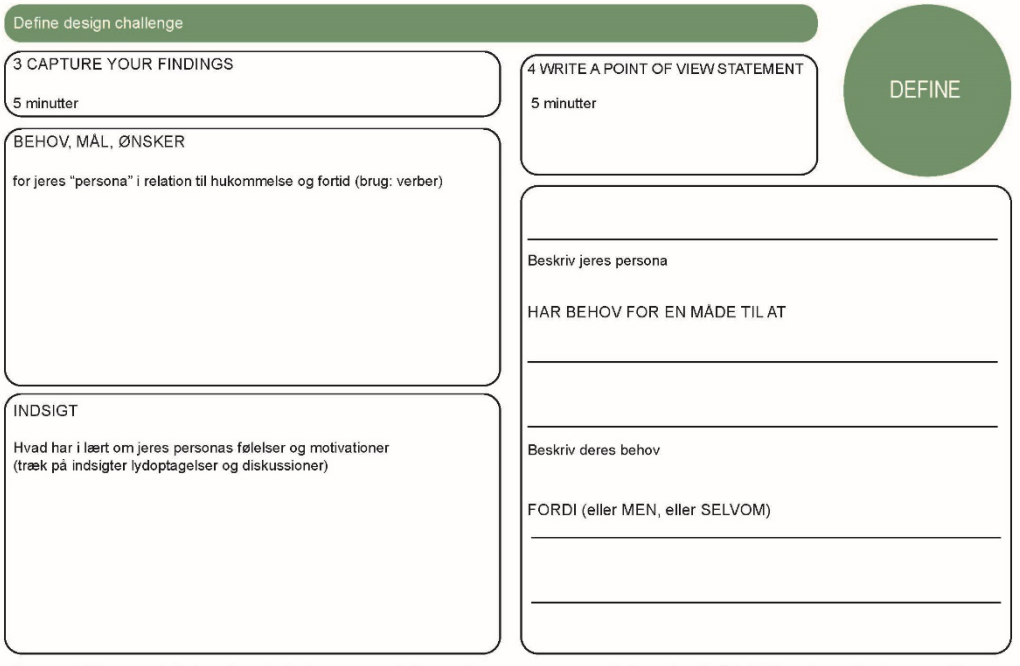
1. luk øjnene og hold dig for ørerne (1 min) inden du påbegynder dit lydkort.
2. beskriv de lyde du hører (detaljeret)
3. nedfæld 5 lyde du godt kan lide - hvad gør dem behagelige?
4. nedfæld 5 lyde du ikke bryder dig om - hvad gør dem ubehagelig?
5. hvordan påvirker de dig?

Noter til lydkortlægning 2

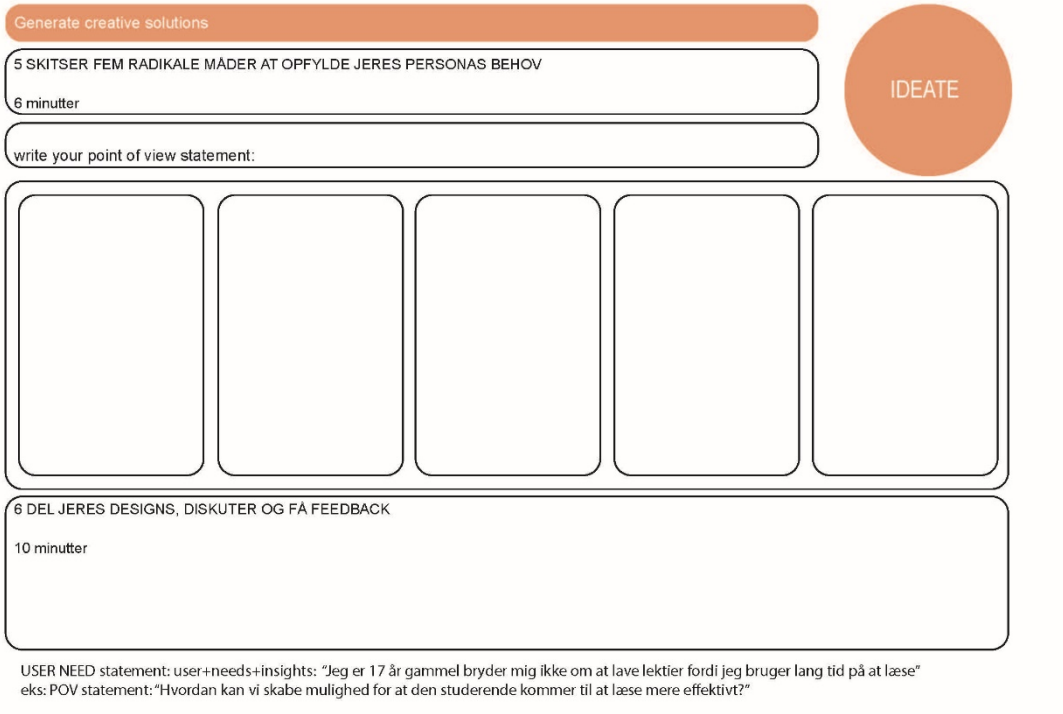
Lokation:
dato:
tid:
vejrforhold:

1. luk øjnene og hold dig for ørerne (1 min) inden du påbegynder dit lydkort.
2. beskriv de lyde du hører (detaljeret)
3. nedfæld 5 lyde du godt kan lide - hvad gør dem behagelige?
4. nedfæld 5 lyde du ikke bryder dig om - hvad gør dem ubehagelig?
5. hvordan påvirker de dig?
6. stil 2-3 spørgsmål til en fra gruppen.

Skift lokation efter første lydkortlægning og tilføj detaljer til kortet



Persona: 38 år gammel ph.d-studerende der interesserer sig for at opleve naturen gennem lyd, men har for lidt tid i hverdagen til at komme ud i naturen.



USER NEED statement: user+needs+insights: "Jeg er 17 år gammel bryder mig ikke om at lave lektier fordi jeg bruger lang tid på at læse"
eks: POV statement: "Hvordan kan vi skabe mulighed for at den studerende kommer til at læse mere effektivt?"

Iterate, based upon feedback

7 Skab et ny design

6 minutter

Skitser jeres gode ideer, noter og detaljer

Protype and TEST your design

PROTOTYPE

8 BYG JERES DESIGN (Byg eller tegn noget som andre kan interagere med)

10 minutter

9 DEL JERES DESIGN OG FA FEEDBACK

8 minutter

+ Hvad fungerer?	- Hvad kan forbedres	? Spørgsmål?	! Nye ideer?

Noter

10.03 Appendix 3: Example of ongoing feedback to external developers

Hej M,

Har leget lidt med nuværende udkast, og her min tilbamelding:

- Tilmeldte deltagere skal selv kunne oprette en ny tråd, pt. kan de blot kommentere
- Jeg kan heller ikke selv oprette tråde – adgang nægtet https://lydenafdk
- Man skal kunne redigere link-teksten (kendt!) - gerne alle steder i forum modul
- Der mangler visuel feedback på forum-forside:

her foreslår jeg tre:

1) tråde med flest views/mest kommentere tråde,
2) seneste aktive tråde/ eller nyeste tråde og
3) mest aktive deltagere (kommentarer)

Ex: som blok efter header på forumforsiden/forumkategorier

-- Unpublished node --

Forum kategorier_Giv Lyd

Velkommen til vores nye forum! Her finder du de seneste og mest populære emner. Her kan du stille spørgsmål til forskerne bag projektet og gå i dialog med andre deltagere.

Borgerchatten

Gå i dialog og del dine erfaringer og viden med andre deltagere

Desuden bør der være mulighed for:

- at tilføje billeder til en kommentar/tråd
- Mulighed for at redigere/slette oprettede kommentarer og tråde, gerne deltagere og som minimum administratorer.
- Tydeliggøre links/genveje mellem Forumforside>kategorier>tråde:
  Ex. Billede: fra thread 3 > ”Dagens lydoplevelse” og derfra > forumforside
  Altså så det bliver let for deltagerne at se at man kan navigere mellem de forskellige lag i forummet.

10.04 Appendix 4: Co-author statement

Faculty of Humanities
University of Southern Denmark

SDU

Co-author statement in relation to the position as:

Niels Gommesen PhD candidate

Title of publication:

Relational responsibility - science communication as intra-action in multispecies communities

The undersigned is co-author on the publication mentioned above and hereby confirms that _____ has contributed to the work as stated below:

Name of applicant

1. **Idea development**

   ☐ Less than 25% ☐ 25 – 50% ☑ 50 – 75% ☐ 75 – 100%

2. **Collection of data and research design**

   ☐ Less than 25% ☑ 25 – 50% ☐ 50 – 75% ☐ 75 – 100%

3. **Analysis**

   ☐ Less than 25% ☑ 25 – 50% ☐ 50 – 75% ☐ 75 – 100%

4. **Presentation**

   ☐ Less than 25% ☐ 25 – 50% ☑ 50 – 75% ☐ 75 – 100%

Other remarks:

Co-author signature		
Date 1st of July 2022	Name Kristine Samson	Title Associate Professor