Disassembling repairability

Breakdown-oriented thinking: On accommodating for repair, attachment and longevity through design

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August 1st, 2019

Abstract

In this thesis, concepts of repairability, longevity and relations are explored in the context of smartphone repair. An account and analysis of my visit to a repair shop in northern Norway is presented and related to a theoretical framework founded on broken world thinking and a postphenomenological perspective. In this framework, as related to the field of Sustainable Interaction Design, emphasis is placed on understanding things and treatment of them through their physical and digital materiality.

From the theoretical and empirical work, a thing-lifetime model is created and applied to reveal the breakdown relativity of things, where a material can have different effects on a thing's longevity, depending on factors such as a person's ability to repair or material relations. Through the model, smartphones are presented as devices that hinder their own longevity, through making repair practices an engagement with a high threshold for entry. However, the analysis and discussion in this thesis on observations and interviews performed in the repair shop shows that materiality of smartphones does not have a deterministic effect on longevity, as it is possible for a material to also be a support for longevity, although not necessarily at the same point in time.

The thesis offers insight on topics such as repair practices of digital artefacts and a critical analysis of major concepts present in contemporary literature concerning sustainability and interaction design. Additionally, the thing-lifetime model within has instrumental and conceptual value for investigations into the longevity of things and how their material constitution influence their reaction to breakdown.

Acknowledgements

A great number of people have helped me reach the conclusion of this journey. To actually have reached the point where I can say the thesis is complete is almost unbelievable, especially when I think back on the many moments of doubt and struggle I have had during the past two years. I am certain I wouldn't have gotten this far without the support of those near and dear to me.

A very special thank you to Rebekka and Svein, my supervisors, who have helped me throughout this thesis with interesting discussions, guidance, different perspectives and insight on the topics of this thesis. I am deeply grateful for their interest in and help with the creation of this thesis.

Thank you to the people at the repair shop who so kindly gave me an opportunity to visit them for my empirical work.

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1 Introduction

Issues of sustainability have become more and more apparent in recent years and HCI researchers and practitioners have been called to join the fray and contribute with moves which drives us closer to sustainable ways of living (Fry, 2017; Silberman et al., 2014; Tomlinson, Silberman, Patterson, Pan, & Blevis, 2012). This can be in the shape of a critical look at how software can contribute to premature disposal of artefacts (Blevis, 2007) or investigating how we treat our different household items similarly or separately and what that might mean for research of keeping and disposal of such items (Odom, Pierce, Stolterman, & Blevis, 2009). It can also be how a focus on repair can enrich the field of technology studies (Jackson, 2014), or an ontological questioning of how an object can be broken for some, but not for others (Kalantidou, 2015). Examining topics such as these might help us better understand how design relates to sustainability, considering an artefact as having a lifecycle which not only consists of use, but also wear-and-tear, disposal, reuse, and so on. Of the many methodologies related to HCI, SID is perhaps the one that I find most common ground with. Attention to sustainability has nurtured much interesting research, and while it is important for this thesis, sustainability is not the core theme of it. Rather, a concern and care for longevity here stems *from* sustainability and it can instead be understood as part of its foundation.

To start off, I will present a few stories that might give some perspective on matters of repair in relation to smartphones.

1.1 An image of repair

Cathrine is in a cheerful mood, as she has just bought the latest phone made by Samsung, a gorgeous thing that contains the best that Samsung has to offer in functionality and aesthetics. A year and some months later, while Cathrine is enjoying her morning coffee, she somehow manages to knock the phone off the table and onto the floor. The glass screen shatters into a crisscross pattern of fractures, even though she bought a leather

wallet cover for the phone to protect it. With the shattered screen rendering anything on it into a mosaic of nonsense, she heads out and towards the closest repair shop in town to figure out what this mess is going to cost her. After all, she has everything on her phone, from public transport tickets to apps for keeping in touch with her family on the other side of the world, not to mention the two-step authentication apps she needs for work and personal finances.

At the repair shop, she is met by a pleasant fellow who tells her that he'll look into what can be done for the phone, but she has to come by again in a few hours for the answer. Cathrine agrees to a small fee for the repairer's preliminary effort and heads off to work, walking, of course, because buying a bus ticket is too much of a hassle. Returning later that day, she gets the prognosis: It's going cost her nearly half of what she paid for the phone, just to replace the screen. She finds the price ridiculous, but doesn't have much choice. She can't afford a brand new phone and really needs access to the apps she has on the phone. The repairer does his thing, swaps out the screen with a new one, and Cathrine gets her phone back, almost as good as new.

In an alternate timeline, Cathrine visits the repair shop, but the price stated by the repairer makes her decide that she is going to fix the phone herself. She first thought about gluing the glass back together, but there are pieces of it forever lost somewhere on the kitchen floor. Whatever, she thinks, the glue probably would have messed with the tech. Moving on, she goes online to find parts and guides for replacing the screen. A new screen—glass, digitizer (whatever that is) and all—clocks in at one quarter of what the phone cost originally. She tries to find only the glass component, but that doesn't seem to be an option. Some people online say it's because the glass is notoriously difficult to remove without breaking all the other parts of the screen. Dejected, she orders a new screen and looks over the repair guide again. She realizes quickly that repairing the phone isn't going to be a quick and easy process, as the old screen has to be unglued and cut away. In this she also finds the reason why just removing the glass is nigh-impossible: the glue used in her phone is extremely strong. According to the guide she found, several

tools are necessary to deal with this, and the replacement of the screen: A Phillips screwdriver, a spudger, tweezers, cleaning alcohol, suction cups, and a guitar pick. The guide itself consisted of close to 20 different steps, for disassembly of the phone and proper replacement of the screen. Reading further into it, the process seems more and more complex to her, with tricky maneuvers that demand tools she doesn't have, even if some of the tools can be improvised. At this point, she cancels the order for the screen, returns to the repair shop and agrees to the repair cost. In her mind, she has saved both time and money doing it this way.

In a third possible reality, Cathrine's situation is a bit different. She can easily afford a new phone, and compared to the previous realities presented her concern for the phone is drastically reduced. To this Cathrine, the phone is only a thing, a simple means to an end. Having the money for it, and only being concerned with gaining access to her apps again, she goes out to the closest electronics store, buys a new phone, runs the setup process, downloads her apps again and logs into her accounts. All is good and back to normal, same as it was before the phone fell to the floor.

1.2 Repairability, replaceability and transparency of phones

While the stories above are entirely fictitious, the premises of Cathrine's dealing with a broken phone is based on real issues one might face in such a situation, drawn from personal experience and observations from a phone repair shop. Phone repair can be perplexing: Costs seem to exceed reasonable amounts in regard to how much of the phone is repaired. Figuring out how to fix things on one's own requires navigating a jungle of sites and resources. The actual doing of phone repair is a dive into the unknown, picking apart a collection of shapes and materials that communicate little of their *how* and *why*, information that is necessary to perform a successful repair.

These effects of design seem to be a common denominator amongst mass-produced objects, for instance consumer-grade electronics and kitchen appliances, things which work wonderfully, as long as they work. Once they break down—and they will break

down at some point, in some way—we're left clueless to how they can be repaired, due to their highly closed-off design, increasing the likeliness that the product becomes waste instead of returning to functionality. This thesis could have been a closer look at these types of objects, but few things are as present in our lives as the smartphone. Thinking about longevity as the *prevention of unnecessary waste*, combined with looking into the smartphone as a thing, materially, is an attempt to find clues that can help make sense of how one can work towards preventing smartphones ending up prematurely disposed. Premature disposal, for instance, could be a matter of *unwillingness*, but it might just as well be a case of *inability,* or something else entirely.

I want to bring to the table of HCI and SID a way of thinking about and realizing a fourth alternative to the story presented above, one where ideally, Cathrine would not only be able to repair her phone herself, but that the act of repairing it would be both natural and accommodated. The reality where Cathrine simply disposes of the phone and buys a new one instead of repairing it should, in my opinion, be the least viable option, for reasons to be disclosed later. First and foremost, repair should be the primary activity sought after when things break down. Whether this is realistic, particularly in the case of smartphones, is a major topic of discussion in this thesis. The triangle of replaceability, repairability and transparency shape different forms of *relations between people and things*, steering us into different sorts of *treatments of the things*. How can we make sense of this in relation to sustainability? How and why does repair matter in relation to use, and vice versa? Questions such as these led me to my research questions.

1.3 Research questions

This thesis is an investigative effort into the implications of phone repair, what kind of repair emerges in that context, and in turn, what these implications and practices might mean for how we relate to the things-to-be-repaired. The stories of Cathrine describe, amongst other things, how smartphones in themselves affect what we are able to do with them once they break down. As such, the first research question is as follows:

[RQ1] *How can the materiality of smartphones affect our ability to repair them?*

To explore RQ1, I was guided by several underlying questions:

- *What is repair?*
- *What is the practice of repairing smartphones?*
- *How can design of smartphones influence their repairability?*

The questions above are then to be put in the context of relations, attachment and longevity:

[RQ2] *How can smartphones be designed to accommodate longer ownership?*

Subordinate to the second question, I formulated a set of questions that directed the search for possible answers to RQ2 as well, namely

- *What sort of relations can emerge in relation to repair?*
- *How might longer relations emerge differently?*

What follows from this point is an exploration of the above questions, as pertinent to design, sustainability and ontology of the things we design *for* sustainability. It is a focus on the smartphone as both a *shape* and a *shaper* of the world we relate to, making "realities" more or less possible, but not in a deterministic manner. It is how a smartphone, through its design, can lend itself to being less repaired, as not directing us towards or directly hindering repair. And yet, repair still occurs, which leads to the important point that this is far removed from a deterministic view of smartphones as these dystopian devices that drive us off a cliff. Rather, it is a view of activities and possibilities that largely happen in spite *of* all the signs that point in the cliff's direction. Naturally, there are many possible explanations of why we "mistreat" smartphones, and different treatments that might be seen as appropriate. Some might say that we need more awareness campaigns, that it is a matter of changing the attitudes people have about disposal, particularly the premature variant. These approaches might all be valid, and possibly necessary, in preventing premature disposal of smartphones. My approach,

however, is to examine the smartphone itself and see how its design might support or hinder repair of it in its state of breakdown.

Smartphones are these ubiquitous, fantastic technological devices that allow us to be within reach of information, goods, services and other people just by a touch or two on the screen. At the same time, we've come to depend on these things for many of our everyday doings, requiring what they afford us, but not so much the thing in itself. We need them, but are pushed away from them when they break down, while what they offer us in functionality can be attained just as easily from other instances of the same type of device. The potential of troubles in smartphones, prior to their breakdown, are invisible to us until the actual point of breakdown, leaving us highly unprepared. Out of this view of the smartphone emerges a few descriptors that will be delved into in this thesis, namely *replaceability, repairability* and *transparency*, as properties of artefacts which matter in relation to repair and disposal.

1.4 Thesis structure

This thesis is structured in a somewhat unorthodox way, and so I have dedicated this subchapter to give a short presentation of what each chapter contains.

Chapter 2

Past this introductory chapter, I will first delve into theoretical and empirical work of others that can lead to insights on how smartphone design affects our ability to repair them. This section closely resembles a chapter for *theory* and *background*. Work from the texts described in chapter 2 is brought into later parts of the thesis, most explicitly in chapter 4 and 5. The texts in chapter 2 have influenced and inspired my understanding of the problem space, selection of phenomena and means to garner knowledge.

Chapter 3

This section of the thesis is more or less equivalent to a *methods* chapter, where I present the methods used during my own empirical work, the goals I set and experiences gained from the execution of those methods. It also contains a fair amount of reflections on

methods, and the nature of doing research from an interpretive standpoint, into a context of relational and processual phenomena.

Chapter 4

In "Case: The Repair Shop", I present the *empirical work* and perform an *ad-hoc analysis* of it, based on a four-day visit to a repair shop in northern Norway. This is a chapter that focuses on the physical materiality of smartphones and the practice of repairers, as a reflection of that materiality.

Chapter 5

Considerations of the material effects caused by smartphone design are related to matters of relations and longevity in the fifth chapter, which acts as a chapter for both *findings* and *analysis*. It is also where I introduce my *thing-lifetime* model, a synthesis of my theoretical framework from chapter 2 and my empirical work from this fifth chapter and chapter 4.

Chapter 6

In the sixth chapter, I discuss the topic of longevity as something that can be attained in different ways, such as through attachment based on the physical or digital dimensions of digital artefacts.

Chapter 7

The seventh and final chapter follows conventions typical of *conclusions*, where a summary of insights and implications of the thesis is given.

1.5 Aspirations and inspirations

Steven Jackson's work inspired me greatly in the construction of my thesis, theoretically and practically. While he presents breakdown and repair as having many possible forms, I am particularly interested in the material troubles involved when breakdown and repair occurs in relation to smartphones. Where a neglect of repair and breakdown can be seen as a precursor to things poorly suited to a world where decay is unavoidable, I wonder

how the design of smartphones might exhibit a lack of suitability in regard to repair. As breakdown and repair are on-going, I went looking for it in the context of smartphones, asking *what smartphones are when broken down*: When no longer offering a "seamless" experience of itself, what kind of experience does it then offer? It became a process of reading repair guides, scrolling through online forums and attending repair events such as those hosted by Restarters Oslo.

To lay the foundation for such an understanding of phones, the upcoming chapter—"Dealing with and learning from breakage"—will be a presentation of work from areas such as Sustainable Interaction Design, contemporary technological philosophy and postphenomenology, by authors like Steven Jackson, Peter-Paul Verbeek and Eli Blevis.

2 Dealing with and learning from breakage

"Men make their own history, but they do not make it as they please; they do not make it under self-selected circumstances, but under circumstances existing already, given and transmitted from the past."

Karl Marx, The Eighteenth Brumaire of Louis Bonaparte

I subscribe to a worldview in which matters are liable to change at any given moment, where any attempts to make an exhaustive account of potential outcomes are at the very least incredibly difficult, if not impossible. As time has passed, the interconnectedness and –dependency amongst the inhabitants of this world has increased at a tremendous rate, due to the effects of globalization and technological leaps, particularly with means of mass-production and information technology, and leaps in matters of economy and spending power. The lines are blurred, whether for good or bad, in matters of being. I find it difficult to draw distinct and rigid lines to separate things, when scrutiny more often than not reveals that they are not as "simple" as previously decided to be. Similarly, it does not seem sensible to draw such lines when the being of a thing not only has the capability to change from moment to moment, but also from person to person.

Given the world as described above, it seems appropriate to enter a stance which affords tools, so to speak, for being more able to handle the aforementioned properties of the world. Perfection in any shape or form is fruitless and unattainable in such a world, rendering any "solutions" a moot goal to strive for, as needs change, constraints shift and things deteriorate over time. A solution implies that by the point of implementation, its designated troubles-to-be-eliminated are resolved. As the saying goes, "time waits for no man", the world does not stand still for any solution. With a "solution" in place, a problem might have been solved, but a new one might have emerged as an effect of the fix.

In a moving world, including movement as part of the process can be seen as a concept which might make us more able to make considerations of the futures of artefacts. It is on the topic of futures I will now introduce Sustainable Interaction Design.

2.1 Sustainable Interaction Design

In 2007, Eli Blevis presented a paper where a new path was suggested for interaction design, one where sustainability is set as the central focus of it (2007). Here, I will present Blevis' perspective of Sustainable Interaction Design (SID) and key aspects which relate to this thesis. Sustainability in SID is "a notion of viable futures", whereas design is conceptualized as "*an act of choosing among or informing choices of future ways of being"*, a collaborative definition of sorts built upon the work of Tony Fry, Willis, Winograd and Flores, and Heidegger. It is a normative effort that tries to do away with the previous anthropocentric focus of interaction design, a condition described by Blevis as being "of ontological blindness", where human-centered conceptualizations of what we design for bears with it potential of neglect for what else might be necessary for viable futures (2007, p. 504). Through the work of Tony Fry, Blevis points out that interaction designers are not expected to commit "economic suicide", but that sustainability has to be *worked into* interaction design so as to create an "economically-viable *viable* future" (cited in Blevis, 2007, p. 504). Sustainability in a capitalistic economy seems a daunting challenge, and quickly spirals into terms that sound nice, such as "green capitalism", in addition to the emergence of questions of whether sustainability is compatible at all with capitalism. Interaction designers also have to align themselves with not only the needs of users, but also that of the organization they work for, the market forces which are at play, design trends and more.

Instead, a somewhere-in-between approach is espoused, where sustainability acts as a foundation for thinking of *why*, *what* and *how* we contribute through our skills as interaction design researchers and practitioners, as best as possible alongside economic concerns. A framework for SID is suggested, that contains a number of values, principles, methods and a rubric for how one might start to integrate sustainability into interaction

design, as being a part of a conscientious practice. Matters of laws, regulation, behavior and values, as well as the digital and physical materiality of embedded information technology, are pointed out as relatively concrete starting points.

Methods-wise, Blevis suggests that SID be concerned with the integration of sustainability into what already exists, or create something new that "yields sustainable interaction design as a practice" (2007, p. 506). As HCI has been known to do, Blevis also suggests further "borrowing" of methods from other design disciplines, such as design critiques, design case studies and reflective practices, methods which afford exploration of the complex interaction between nature, humans and artefacts.

As another springboard into SID, Blevis creates a rubric for the critique of concrete interaction design cases (see fig. 1). Here, we find topics that relate to material effects of design, relations between thing and person, as well as variations of how a thing can be used, which are sorted roughly by their differences in environmental impact (top to bottom, most to least in fig. 1). The rubric is a way of making present *how interaction design cases can be thought of as contributing to matters of sustainability,* how design can cause an unsustainable treatment of artefacts, and ways to work towards a different treatment. For instance, Blevis points towards the "re-invention by Apple of its own product from time to time" being a "deliberately unsustainable act intent on driving consumption and with the clear side effect of premature disposal" (2007, p. 509). Another good example, also related to Apple, is how they began designing their Macbook Pros to have Solid State Drives soldered to its logic board (its main circuit board), which severely hampers opportunities to replace the storage component (Evangelho, July 25th, 2018).

Most relevant to this thesis are the topics of *disposal*, *salvage, achieving longevity of use,* and *achieving heirloom status*. Through looking at the design of artefacts, we might find ways to understand how design can contribute to ways of treating artefacts in their broken state as waste or as more opportunities to interact with it. Furthermore, a questioning of the interaction which takes place in relation to broken things can be a step towards finding opportunities to extend the lives of things, and expand the relationship between person and thing.

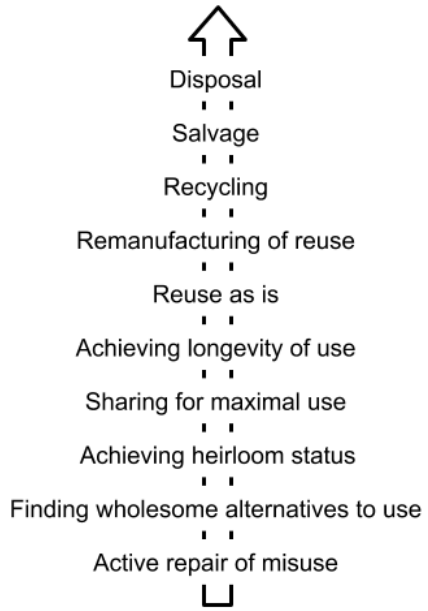

Figure 1 - Sustainability rubric for interaction design

From here follows a set of principles which are concise statements for more *sustainably favorable kinds of interaction* between people and things of digital and physical materials. The primary principles, *linking invention & disposal and promoting renewal & reuse*, are complemented by principles of *promoting quality & equality, de-coupling ownership & identity,* and *using natural models & reflection*. Together, they set a trajectory *towards* renewal and reuse, *away* from invention and disposal, and they to a varying degree contain the different categories from the rubric. Blevis goes on to perform a critique of different objects that are made of both digital and physical materials, based on the principle of *linking invention & disposal* to show what the principles might bring to the table in terms of insight and value. In a sense, Blevis suggests that interaction designers should be concerned with creating designs that strive to provide a combination of usefulness for as many as possible, across ownerships and purposes, and "wastelessness".

Blevis also emphasizes that "[n]othing is ever simple" (2007, p. 510), where a critique of a GPS devices becomes a showcase of its ability to contribute with effects in both *sustainability and un-sustainability*. As a device, it can create safety risks in navigation, but also improve navigation. It is able to become obsolete through the introduction of

newer GPS models, but also able to improve the longevity of older vehicles it is used in, by providing features typically found in newer vehicles. If one is to understand an SID-like manner of thinking to be along the lines of how Blevis presents his thinking, it is a complex manner. The GPS has both detriments and benefits in regard to sustainability, and such devices relate to how older cars might kept relevant, and be the more sustainable answer, compared to buying newer ones with cleaner technology, due to the troubles of disposal and manufacturing.

SID is a way of thinking and acting based on sustainability in a complex manner, a questioning of existing knowledge or lack of it and a coupling of both the material and digital as tightly interwoven; It is a way of aiming for *collective viable futures* through design (Blevis, 2007, p. 503). In light of sustainability, the space opens up for the research of interaction as a phenomena, as well as the designing situated around it. With different ways of designing sustainability *into* artefacts digital and material in nature, what sort of different *treatments* can emerge? From and with SID, I hope to contribute with a focus on the physical materiality of smartphones, what these dimensions might mean for artefacts of such a category, and the types of treatments that emerge in relation to smartphones. In turning the phrase of "designing viable futures", this thesis is concerned with how the futures of things, people and the relationships in between are influenced through design. When a thing ceases to provide a function, how can its functionality—and its future—be sustained, and what sort of knowledge can one find in the world through exploring this question?

2.2 Broken World Thinking

The world, as presented by Steven Jackson in *Rethinking Repair*, is in a constant flux between breakdown and repair (Jackson, 2014). Driven by decay, breakdown is the inevitable state which all things move towards, exemplified by devices which have to be fixed to allow "seamless" use again, or restoring systems back to functioning. In other words, objects are rendered unable to function at the point of breakdown, and repair is the activity which returns functionality to them. At the same time, breakdown is what

renders things visible to us, suddenly imposing themselves upon us as troubles to be dealt with. It is the difference between a smooth, beautiful phone that "just works" and that same phone, but with a shattered screen, with edges that nip at fingers, images that aren't whole anymore or previously simple interactions turned into inconveniences. Both breakdown and repair have always occurred in the world, the phenomena have just been neglected. This neglect stems from an "imaginary nineteenth-century world of progress and advance, novelty and invention, open frontiers and endless development" (Jackson, 2014, p. 221). The result is apparent in hardly repairable devices such as the MacBook Pro's retina display and the dumping of ships on Bangladeshi beaches. This *broken world thinking* is an approach that brings repair front and centre, as a crucial activity in the world and a natural effect of the fact that the world moves towards breakdown.

The investigation of who, how, why and where of repair and breakdown are opportunities to know more about the world, an effort that expands our knowing, rather than reducing it via the previously dominant views, as an activity that pulls us "downstream" of following breakdown. It is also a line of thinking that runs contrary to the simplified view of the world as just being about making new things and throwing them away: It shows how there is an after to these points in the life of things, an *aftermath* to use Jackson's term, where creation and disposal are acts which have consequences, and that those consequences have to be taken into account and handled, unless we want to perpetuate the disregard for a critical part of how the world naturally works. Without broken world thinking we *might* stumble into a concern for how things break down and are repaired, but with it, we are *guided* towards the cracks and seams of the world, those who live there and what their world is like. To borrow a stanza from Donna Haraway, "It matters what matters we use to think other matters with" (2016, p. 12). Breakdown has "world-disclosing properties" that bears with it opportunities to gain knowledge of how the world pivots between broken and repaired (Jackson, 2014, p. 230).

At this point, asking "when does repair happen?", we might say "after breakdown". However, the answer is only a halfway measure to understand when repair might emerge.

Reshaping the question into "when *can* repair happen?" invites us deeper into breakdown. If the well-being of infrastructures, systems and artefacts, and the people who rely on them, hinges on repair as a possible activity, it is essential to explore *repairability*. *When repair can happen* is a topic that embodies who, how and what: Who are *able* to repair? How can a thing be repaired? What is necessary for repair? When certain things aren't repairable, or only repairable for some, it seems prudent to ask why that is, which is a path that can quickly leads towards the subject of power.

While repairability isn't necessarily an intentional effect of design, it is an effect nevertheless. We decide or decide not to use particular materials, composed and structured in certain ways. Where a thing possesses repairability, one might say that users have *repair-ability* in the face of breakdown. If a user, as a result of these doings or avoidances, becomes unable to repair after breakdown, we as designers are implicated in their repair-ability (or the lack thereof) and the effects that follow. Some emergences of breakage might require special tools or competencies, prior experiences are related to that which is on-going. We extend ourselves, grasping back in time for experiences and stories, or more literally, towards the tools and parts we need. Thus, repair can be seen as a *gathering*—a semiotic turn inspired by Latour (2005)—or an attempt to gather what we need to remedy breakdown. As designers, we have the power to influence how the world breaks and is rebuilt, and who has the power to put things back together again, and furthermore, we have the means to accommodate or inhibit how a gathering can happen. If the design of an artefacts makes a *user* powerless to repair, then who has the power? Tracing power in this example leads us to locations such as phone repair shops, customer service offices, and to those who are equipped with the necessary tools and competencies to repair.

In between, before and after breakdown, there are many other activities going on in addition to repair, such as maintenance, diagnostics, bug fixing, updating, and more. However, the when I am concerned with is the *aftermath*, when wear-and-tear, damage, abuse, accidents and use has happened. It is not only interesting as both a time and place

of improvisation, evaluation and reflection, but also is an opportunity to better understand use, a concern of interaction design, as breakdown and repair so naturally follows from the field's primary focus on the use of things. Without a care for breakdown, repair disappears, and opportunities for rich learning about interaction floats back into obscurity. Why doesn't usability embody repairability, for instance? With breakdown as an intentional backdrop, we might start to understand use differently as not separate from repair, but connected to it. However, there is a need to look closely at what repair *is*, as a matter of analytical clarity, before we can move deeper into the topic of use and function.

2.3 Repair as a concept

Repair is one of those woolly, fluid, situated practices which shifts its shape rapidly from one context to the next, highly resistant to simplifying methods such as generalization. Any attempt to set strong boundaries on the concept quickly turns the phenomena into something too constrained or diffuse, solidifying or evaporating beyond any usefulness or as a topic for discussion based on the same wavelength. If repair is the act of remediating soil to allow sustainment of vegetables, it has nothing to do with cars, watches or clothes. If we define repair as the restoration of functionality, trouble immediately appears when art becomes a part of the discussion. To say with confidence what repair is and is not on a general level will not do, as it kills the concepts ability to emerge differently across contexts. Similar conceptual difficulties can also be found with 'work', as analysed by Kjeld Schmidt in relation to Computer-Supported Cooperative Work (CSCW) (Schmidt, 2011), and I will lean on this conceptual analysis in order to make my own analysis of repair as a concept, with examples from contexts of repair.

First off, there is the matter of ordinary language. According to Schmidt, "Like concepts such 'power' and 'thinking', work is not a technical term; it belongs to ordinary language. That is, as far as CSCW should be concerned, there is no escaping the everyday use of the term 'work': we somehow have to relate to how 'work' is ordinarily used" (Schmidt, 2011, p. 360). This means that there is already an established understanding of what 'work' is,

and the same can be said for 'repair'. One can ask any person and they will give you an answer that will most likely not be wrong, even though it might not be a pinpoint definition. Of importance is also the fact that if one aims to research work or repair, there is no escaping the common household definition of the concept. Potentially, attempting to redefine either concept can be directly detrimental to the research. With work defined as something constrained, what might we miss? Could it be that the participants of a research project think "Ah, he doesn't mean work, he means x", where x is either separate from or a lesser part of what the project's goal is to research. In other words, it allows for misunderstandings to occur. A better approach would then be to ask someone you consider to be a repairman "What is it you do?", perhaps followed by "What does that work consist of?", so as to not only gain a better understanding for yourself, but also to present this to the readers.

Following that, Schmidt presents Wittgenstein's notion of *family resemblance*, in accordance with how "concepts are enormously variegated not only in *what* they are used for but also in *how* they are bounded and interrelated" (Schmidt, 2011, p. 363). This notion, he says, is not sufficient to leave the matter at this point, and that one must *look and see* what the concept is in the many situations and relations where it appears, i.e. what is 'work' *used for* and *how* is it used in a given context. Can we say that something is work here? Is it similar to work elsewhere? How is it similar? Do others agree? Can this instance of work be considered different from *other* activities? These are some of the questions that can provide insight into whether the observed phenomena matches the concept or not.

My point here is not to place repair in relation to work, but rather make visible the conceptual difficulties that these two concepts have in common. Whether the concepts themselves have similarities or differences—"Is repair work?"—is beside the point I am trying to make, even if such an analysis could prove interesting if one were to investigate notions of repair in relation to CSCW, to better support activities of repair through computers, for instance.

Given the above, it can be reasoned that repair cannot be precisely defined without causing confusion, potentially harming the research or design process, or make impossible any fruitful discussion or analysis. Work is presented as a *polymorphous concept* by Schmidt; "There is nothing which must be going on in one piece of work which need to be going on in another. Nothing answers to the general description 'what work consists of'. None the less, each specific job is describable" (2011, p. 372).

As repair is something relational, we can find it as something entirely different from one situation to the next, contingent on rules, needs, availability of tools and materials, and much more. Work "[…] is polymorphous in the sense that the application of the term 'working' does not imply the performance of any *specific* activity" (Schmidt, 2011, p. 372). So it is with *repairing*, and the *object of repair* as well in how it is *broken*. For instance: Two cars might be broken in equal ways, but availability of tools and spare parts, as two simple examples, can result in two entirely different emerging acts of repair. Now, if an elevator were to break down and refuse operation, could we call it repair when someone simply bypasses the elevator's system of safety protocols or thresholds to restore functionality? With a generalization of repair, we would be able to clearly say yes or no, but I would hazard a guess that there are plenty of people who would disagree with that, though there might be some inclined to say yes as well.

An interesting question to pose here, then, is *when does a conceptualization of repair become too far removed from its family of different, but similar emerging acts*? As someone with a background in computer repair for small-medium business clients, it seems a stretch for me to say that I had repaired a computer with a broken graphics card by simply using the motherboard's integrated graphics processor instead, rather than replacing the broken part, and I am fairly certain that most customers would disagree as well. But, for someone who doesn't need the output of the graphics card, who doesn't notice or care about the reduced performance an integrated graphics processor has, this might be an adequate solution. To the customer, the computer would be repaired, but a professional repairer might disagree.

Here enters the importance of 'thick descriptions', also presented by Schmidt, as not only the description of work [read: repair], but also a description of both purpose and circumstance to understand what work is (2011, p. 373). Bypassing the safety measure of an elevator could just as easily be understood as sabotage, as it could be repair, but what was the intent of the action's performer? Which constraints does he work under, what kind of knowledge does he have? To bypass the safety measures might immediately sound dangerous, but perhaps the repairman knows there is a fault with that particular system, where it is often triggered by false positives? We cannot know without an elaborate retelling of the situation; the act, intent and circumstance matters.

Repair can thus be understood as having a certain quality that separates it from other activities, as a *polymorph* concept that emerges differently, but similar in some ways across and within contexts. But repair is not a singular thing, and saying *precisely what that quality is*, is difficult to say without *looking closer at how it can emerge*. It means that we as interaction researchers have to go *out there* and find repair, see and learn what it is (in its habitat, so to speak), and figure out through pushing and prodding where repair can begin and end. Whether we are building "new" things, or improving what exists, investigating repair *in situ* is the most reasonable approach to informing a design *for an interaction based on repair activities.*

2.4 States of repair

To provide concrete empirical examples of repair, I will present the work of Douglas Harper and his observations of Willie the mechanic in rural US during the 1980's. Harper's work is included here not only as an example of how repair can emerge, backlit by the previous conceptual analysis of repair, but also for the conceptual nuancing performed by Harper in making distinction of *traditional* and *industrial* practices of repair.

2.4.1 Traditional versus industrial repair

In *Working Knowledge*, Douglas Harper makes a thorough account of repair, through stories of what repair used to be, how it was back then in the 1980s and through the case of Willie, an old-school mechanic in rural US (1987). For repairmen such as Willie, there is a lot of design as well as engineering going on after use. The working knowledge of Willie, his understanding of materials, such as wood, metal, and plastic, turns repair into a process of both fixing and making (Harper, 1987, p. 31). There is also a linkage between different technologies and techniques used throughout times for the repair of vehicles, farming equipment. Blacksmiths, historically, worked to create and maintain a vast number of common household items. Over time the variation of items dwindled, reducing the blacksmith's presence in relation to households to being primarily a farrier, making and mending horseshoes. In the case of blacksmiths, each new technological step had some resemblance to previous technology. Their knowledge was transferrable, through their material expertise and through the design of new technology, regardless of how the design was intentionally meant to do so.

In here, the work of a modern mechanic is displayed as no longer a process of repair, but rather a process of *replacement*: Defective parts are no longer repaired, but simply replaced. Two kinds of repair are presented: the *formal* and *informal*, or *rationalized* and *nonrationalized*. According to Harper, "rationalized repair leads to repairing that is similar to modern assembly". That is, "a mechanic removes a part of the machine thought to be defective and puts another in its place", while the defective parts are rarely repaired (Harper, 1987, p. 23). Harper points towards the deskilling of repair, largely caused by rationalization, but also further driven by the integration of computers into repair practice. Back then, the repair of cars were becoming more and more dependent on computer-assisted diagnostics, with computers in the car and outside of it. Here, Harper says that mechanics "have become subordinate to machines", where "intuition, the integrative, imaginative, and detailed objectivity" have been replaced "with a consciousness of routine—the limited inductiveness of repair through parts changing"

(Harper, 1987, p. 23); “In a subtle way consumers, as well as repairmen, come to have their consciousness defined by the technique.” (Harper, 1987, p. 24).

What would Willie have done in the case of a broken smartphone or computer? Is there or were there ever a space for informal repair of phones? There are still materials used in phones today which were handled by blacksmiths, but does it matter when the production of parts has to be facilitated by immensely expensive equipment working on the scale of nanometers in a highly controlled environment? On the topic of phones, I find that the closest examples of a 21st century Willie can be found in Bangladeshi phone repair shops.

2.4.2 Phone repair as a craft

Through an ethnographic fieldwork in Bangladesh, Jackson, Ahmed and Rifat gives us a view into the practices of phone repair, with “repair as craftwork, repair as collaboration, and repair as creative repurposing” (2014, p. 905). In Bangladesh, there are different kinds of repair shops: There are ‘brand’ shops, fronted by companies such as Nokia, which follow strict guidelines and rules. It can be understood as a source of repair practice which tended more towards replacement instead of fixing, as well as “less likely to engage in some of the more exploratory and innovative forms of repair”, as apparent in the other, independent kind of repair shops (Jackson et al., 2014, p. 907). The latter type of shop is the focus of Jackson, Ahmed and Rifat, which also relates to my interests here.

Techniques of phone repair

From the independent shops, the authors present three techniques which can be observed in the practice of independent Bangladeshi repairers: *Servicing,* the practice of cleaning internal components of phones with thinner and drying with hot air, to remedy dust or moisture; *Re-balling*, a risky and difficult process of recreating pins in integrated circuits which few repairers employ due to the demanding nature of the technique. Of particular interest is the third technique of *jumpering,* in which “copper wire is melted onto the board in order to bypass (or ‘jump’) faulty elements in the circuit” (Jackson et al., 2014, p. 908). It brings questions of what it means to repair something, as repair is

performed through working *around* the broken part, rather than repairing the phone through fixing the broken part. It is neither replacement nor what might be called traditional repair, but something in between, a combination of craftsmanship in a formalized engagement with materials. Again, we can relate the Bangladeshi phone repair practices to Willie, as their level of understanding *how* phones work and the materials used in them allows the emerging practice, which can be understood similarly to how "[k]nowledge of the materials allows Willie *to redefine the fixability of objects* [emphasis added]. It also lets him adopt the perspective of the engineer who designed the machine, to redesign as a part of repair." (Harper, 1987, p. 34).

All three techniques require a high degree of skill to perform without further damage to the phones. In relation to jumpering, one of the informants, a Mr. J, say that "[i]f you are careless, you may short other connections or you may connect other points instead of the desired point. That could ruin the entire board. You also need to be careful while selecting the wire. If the wire is not thin enough it may short other points" (Jackson et al., 2014, p. 909). The same careful practice can be seen with 'servicing' and 're-balling', techniques that if not performed with the proper knowledge and skill can easily result in permanently broken components. Most repairmen without the necessary competence to do re-balling will discard the phone, while the exemplary Mr. J makes the effort to either repair or replace the faulty component. Being able to perform the techniques arise from practice, an embodied understanding of tools in relation to materials (components), gained through apprenticeships, observations (Jackson et al., 2014, p. 910). The practices of repair observed in Dhaka, to a varying degree, necessitated a range of tools, such as "hot air guns, soldering irons, forceps, multimeter testers, magnifying glasses", tools estimated at a total cost of approximately $ 1,285 (Jackson et al., 2014, p. 907).

Types of phone repair

Here, the authors also create descriptions of three distinct types of repair, the aforementioned *repair as craftwork, creative repurposing* and *collaboration*. The craftwork of phone repair depends on "sharp eyes, efficient hands, and a perfect co-ordination

between the two developed over years of attentive observation and rigorous practice" (Jackson et al., 2014, p. 910). *Instances of creative repurposing* can be found with the repairers ability to place value on leftover components, remnants from phones broken (but not entirely), and finding alternative tools when those commonly used aren't available, such as the substitution of a heat gun with a lightbulb (Jackson et al., 2014, p. 911). On the collaborative end of repair, the repairers search for and share information, locally and through the Internet, to learn more about phones and increase their ability to solve problems; Some repairers enter cross-shop cooperation, to still be able to provide repair as a service, despite not having the skill to perform the repair themselves. Some of these collaborative efforts can be understood as results of the skill ceiling of techniques emergent in phone repair, where mastery requires practice, i.e. opportunities to learn.

Both techniques and types of repair follow from an intimate knowledge of the materials, a respect for the application of heat, ability to "tamper" with complex technology, and a willingness to go the extra mile, so to speak, to make repair possible. All of this shows improvisational capabilities, enabled by the aforementioned competencies. None of this has come easily or quickly to the repairers, as it is the result of "years of observation, apprenticeship, practice and [experimenting]" (Jackson et al., 2014, p. 910). Additionally, we see that the Bangladeshi repairmen have a particular attitude towards the phones they repair, in that they are "never useless altogether. You can use its parts. You can use the display; you can use the ICs of the motherboard. If nothing works, you can at least sell it to the Bhangaris." (Jackson et al., 2014, p. 911). Here we can also see a parallel to Willie's tendency to keep things lying around just in case they might prove to be useful in itself or for other repair projects (Harper, 1987).

Their *repair-ability* were enabled through experience and availability of both tools and resources, while the *repairability* of the phones were demanded by their design. Repairers, in dealing with breakdown, make their efforts to *bridge the gap between things as broken and restored.*

2.4.3 Repair, old and new

The empirical examples retold above makes the case that we can not only learn from contemporary repairers of information technology, but that useful knowledge for interaction design can be found from what some might call "older" recollections of repair, inside and outside spheres of information technology. Their application reaches beyond the time and place they were sourced from. Through these examples, I have given an account of how *repair can emerge similarly and differently across contexts*, and importantly, *between objects*. These examples also show the possibility and value of nuancing repair, as they do not constrict but instead enrich the concept. It is at this point I will depart from the *practice of repair* and venture into the *objects of repair*, based on the philosophical work of Peter-Paul Verbeek.

2.5 What things do and what things are

If we understand objects, at the point of breakdown, as objects rendered unable to function, and repair is the activity which returns functionality to them, what is this "function" that is turned unavailable or made available? Some understanding of this might be found in Peter-Paul Verbeek's *What Things Do* (2005). Here, Verbeek builds an analytical framework for understanding how objects can *mediate*—co-shape how we relate to and act in our world—as based on their materiality and functionality. The creation of that framework builds on a drawing from a mass of philosophical work and through a critique of previous lines of thought. Verbeek is a part of the postphenomenological camp where things are viewed as able to affect "the ways in which human beings have access to their world by the roles that such things play in human experience", and that "things mediate human existence" (2005, p. 119). This means that things are never neutral and passive objects, but influence what we do by ourselves and together, how we perceive and act upon the world, and to a certain degree, what we are.

There are many things worth mentioning from Verbeek's framework, but in the context of this thesis, I will focus on that which relates to design and the materiality of artefacts as a lens to explain our interaction with them. As such, I primarily draw from the book's

final chapter, namely *Artifacts in Design*. In this chapter, the concepts of *functionality*, *symbolism* and *materiality* are used, as dimensions of artefacts, to explain the effects that design can have on our relations to artefacts, in matters of *longevity* and *attachment*. Of particular importance is the concept of *transparency*, which will be used as part of my analysis in chapter 4, but also that which relates to *psychological lifetimes*. Not all concepts will be directly used in my analysis, but they are worth mentioning, as they affect the way *I* perceive them and thus influences my writing and sensemaking.

This subchapter will start off with a presentation of how *functions* and *symbols* are interconnected in design. Following that is an elaboration of how *transparency*, as both a functional and symbolic property, matters in what we are able to do with a thing. This is then related to *completeness*, as how a thing can be interpreted as *complete*, as a finished or pure thing that affects how we relate to it.

2.5.1 Function and symbolism

To be *functional*, according to Verbeek, is for a product to "do what it was designed and manufactured to do" (2005, p. 204), but in industrial design, functionality is not so simple. Taking it one step further, Verbeek presents how functionality as such isn't always easy to separate from the symbolism a thing carries. Within industrial design, functionality and symbolism are not distinctly separate, where what artefacts offer in terms of functionality are both functions *and* symbolism; Products are not only designed to offer a set of functions, but a set of representations as well. In this sense, what a thing is designed and manufactured to do is as much functionality as symbolism (Verbeek, 2005, p. 206). The effects of how mass-produced objects have a merged conceptualization of functions and symbols is visible in product advertisements, which place heavy emphasis on the symbolic aspect of the thing it attempts to sell: Coca-Cola, for instance, with their commercials of young adults partying on rooftops, drinking Coke, or Samsung, with slogans like "The phone that opens up new worlds". Similar advertisement appeared in Oslo during the spring of 2019, where a tire company presents statements which describes in varied ways how *cars* are more or less the same, and that

the way to separate your car from others' is by purchasing *wheel rims* from that tire company (see fig. 2).

Figure 2 - Norwegian wheel rim advertisement – "Does your car blend into its surroundings?" Screen capture taken May 10th 2019, from https://www.dekkmann.no/felg/kampanje_felg.html

What follows from a symbolic emphasis on what objects offer, is a larger risk for their value to falter. Culture, as a theme, is not to be addressed at great lengths in this thesis, but is nevertheless an important aspect of our relationship to things. Symbols are highly connected to culture, which has the tendency to shift rapidly and unpredictably. Thus, if our relationships to things is heavily based on the symbolic nature of the thing, then the relationship is built on fragile grounds. What we might speak of in this instance, then, is a sort of *instability* to the thing as related to people. If a symbol's value is fleeting and fragile, it is unreliable as something to design for, and as a predicate for stable relationships. But, as Verbeek points out, "[t]hings mediate the relation between human being and their world not in a linguistic but in a material way. They fulfil their functions as material objects, and by this functioning they shape human actions an experiences" (2005, pp. 206-207). This *material mediation* happens on what Verbeek calls a sensorial level, through the *concrete physical presence* of objects: "The reason people slow down for a speed bump is connected with the concrete physical presence of the bump, which does not simply *stand for* "Slow down!" but physically compels it." (2005, p. 209).

2.5.2 Material aesthetics and attachment

Moving forward from this point, Verbeek suggests a turn of aesthetics into also including materiality, as a richer source of understanding and explaining how the design of things influence us. A concern for only visual qualities in mass products is "too narrowly conceived", liable to be misconstrued as things of art, rather than things of use, where senses beyond sight matters too: "The aesthetics of products concerns the practical dealings with them and involves their bodily presence, rather than just what they look like or signify, or how they are to be interpreted or read" (Verbeek, 2005, p. 211). It is through use that mediation occurs, not *in* use, but as a *byproduct of functionality*, in how it is "absorbed and incorporated" into practice (Verbeek, 2005, p. 208). By including the notion of materiality in aesthetics, Verbeek aims to "broaden the one-sided approach to products that sees them merely as fulfillers of function that simultaneously refer to lifestyles", and provide industrial designers an alternative perspective (2005, p. 211).

As a means to show how this perspective can be beneficial, with regard to *eco friendly industrial design*, the discussion is directed by Verbeek towards how relations between humans and products might be a better point to discuss from, as it doesn't emphasize just one aspect—human *or* object—where both are important. Using designs by Eternally Yours, Verbeek showcases the value of a postphenomenological view in the context of eco-friendly products, as "the products themselves play an active—and therefore changeable—role". The suggestion is that designers might be able to "inscribe in products an "antidisposal ethics"", where mediation is leveraged as a means to anticipate how artefacts shape our treatment of them (Verbeek, 2005, p. 218). According to Verbeek, Eternally Yours sought to combat the problem of disposal happening before obsolescence could occur at all. Their designs attempted this through, for instance, the concepts of *psychological lifetimes* and *cultural durability*, to prevent disposal happening on the basis of "owners [having] changed their preferences or self-image" (Verbeek, 2005, p. 220). One example is furniture designed by Sigrid Smits, where it had patterns that only appeared through use over time, and external seams which by being worn would

"develop a progressively more expressive character" (Van Hinte, as cited in Verbeek, 2005, p. 222).

This venture into how *a stronger attachment can be designed* forms one of the pillars in the theoretical framework in this thesis. It explains, in part, how the design of objects contribute to how we treat them, as not only based on people being "thoughtless" or objects being "disposable", but that in between, our relations take form. How stable that relation is depends on us *and* the object. Verbeek suggests that those motivated to design for cultural durability should happen on the basis of attachment, and create things which can be placed somewhere in between *heirlooms* or *throw-away items*. It is to "[evoke] an attachment with the user on the basis of this use", which is to say the things used daily (Verbeek, 2005, p. 224). However,

> "[in] order to prevent people from throwing away objects when a newer model appears on the market, when the prevailing fashions shift, or when they need repair or maintenance, connections must be forged with other aspects of product use" (Verbeek, 2005, p. 225).

This brings us to the matter of *transparency*, of *how* objects for use offer their functionality as something available conceptually and practically.

2.5.3 Functional transparency and involvement

How things offer their functionality is explained by Verbeek through Heidegger's notions of *ready-to-hand* and *present-at-hand*. Artefacts being used are ready-to-hand, while broken down artefacts become present-at-hand, as "objects of experience and action", rather than being "[withdrawn] from the field of human intentions", as artefacts are when ready-to-hand (Verbeek, 2005, p. 225-226). A problem here, as explained by Verbeek, is that many products are difficult to return back to being ready-to-hand when they are broken. Using the example of tightly sealed power adaptors for electronics, he shows how such things have a lack of *transparency*, in that they aren't "devoid of obstacles that stand in the way of our being able to restore their functioning", which can be understood as the

dimensions of a thing that reduces their repairability (Verbeek, 2005, p. 226). Transparency is something which

> "[…] makes attachments between people and products possible in two ways. First, it allows people to maintain a relation with products even when they break down. Second, and more important, it makes it possible for people to become involved with products as material entities. For when a product is transparent, it is not only functionally present but it exhibits *how* it is functioning." (Verbeek, 2005, p. 227)

Building on this, Verbeek draws from Van Hinte and shows how seals aren't the only way in which things are made less repairable: Inside artefacts, one might find stickers that demand that one refrains from touching the parts or that touching might result in electric shock (Van Hinte, cited in Verbeek, 2005, p. 226). Products are also viewed as having "two separate territories", the outside being the "skin" or "covering", "freely available for users to look at and touch", while the inside is for "trained technicians to access".

What follows from this "inaccessibility to product inside", according to Verbeek, is that it "does not allow the development of an adequate relation to the products themselves as a material objects, and therefore discourages attachment" (2005, p. 227). Between the lines of Van Hinte and Verbeek's elaboration of products having two separate territories, there is also the matter of being able to move between those territories. With breakdown as a phenomena that reveals that there is "in fact" an inside, a complex machine of interacting parts, practically getting to these parts can be a trouble in itself. Things being accessible in this manner can prevent the emergence of relations with things as *commodities*, "what the products does for its user", where we are not concerned with *the object that offers the commodity,* just that we have access to the commodity. Without this access, there can be no attachment, "[f]or attachment with the product can arise only when the machinery of the product makes involvement possible" (Verbeek, 2005, p. 227). Involvement with a thing, which can accommodate attachment, can also emerge through a certain type of *engagement,* where we are directly involved with the functioning of objects.

2.5.4 What are things?

From the above, we can understand what many of our everyday things *do for us* is an ambiguous combination of *functions* and *symbols*. In use of such things, we engage with their *materiality* through our sensorial apparatus. However, many of the objects we use are designed with an emphasis on unobtrusively offering functionality, rather than allowing a deeper *engagement* or *involvement* with their functionality, beyond enjoying the effects of said functionality. This can be explained through things lacking *transparency*, an ability to make apparent and available how they function, through materials. A lack of transparency can hinder restoration of functionality and make difficult relations of attachment to things. A strong sense of attachment can come from transparent and engaging objects, in an interaction that is not based around acquiring commodities, which can lead to a disregard for the object as a concrete thing.

In the context of this thesis, my focus is set on things, as a way to explain our treatment of them. Verbeek's postphenomenological framework primarily targets the products and practitioners of industrial design, but the framework's applicability reaches further than that. That is, the design of artefacts affects how we interact with them, and in this sense we can understand Verbeek's framework as deeply relevant for interaction design. Through the framework, we can perform an analysis not only of mediation, but how things *materially* influence the range of treatments and relations that can emerge on the basis of design. This framework is what offers me an ability to make considerations of the practice of repair that emerges during smartphone breakdown, foregrounded by smartphone design.

Also of note is Verbeek's drawing on Heidegger, and how a thing's inability to be made sense of, as an object of direct experience (*present-at-hand*) due to being broken, gets in the way of repair. In other words, Verbeek through Heidegger gives us a way of understanding what a thing is in its state as broken, and a possible reason for why repair does not happen, and why alternative routes are taken to achieve restoration of functionality. For instance, if we can't make sense of a broken thing, but still need the

functionality it offers, restoration of functionality can happen through acquiring another instance of the same type of thing or something that offers similar functionality in an adequate manner. This path of achieving restoration is even more likely when we don't have any sense of attachment to a thing, besides relating to it as a *commodity*.

2.6 Why does repair matter?

The above work, by Blevis, Jackson, Harper, Verbeek, and more, is what together assembles into my theoretical framework. Sustainable Interaction Design (SID) is the field within interaction design that I find most common ground with, as it concerns itself with *material effects* of digital artefacts, as composites of physical and digital materials. Together with Broken World Thinking (BWT), SID and BWT becomes the *worldview* that emphasizes looking at and attempting to understand contexts of *breakdown, repair and disposal*. With Verbeek, I gain a foothold into matters of materiality, its effects, and how it can affect our *treatment* of material things. Understanding this treatment as repair is nuanced by Harper, who creates the distinction of traditional and industrial repair. That is, how technology can influence the shaping of repair into an activity more along the lines of *replacement* rather than *fixing*. So here we have a framework that sets the stage and the lens we view it through (SID and BWT), populated by material objects somewhere between the poles of functioning and broken down, and dealt with by repairers in practices formalized by materiality. The theoretical framework, in different but related ways is intended to make sense of how and why repair happens in the context of smartphones.

I understand repair as a fundamental activity worth researching due to its pervasiveness and the *necessity* of the activity. Repair can emerge from use and repair can be a source of knowledge and understanding connected to use, with wear-and-tear as an effect and a sign of use, repair as dealing with use (or abuse), and repair as a form of interaction. Repair is also an activity that supports goals of sustainability, in making devices last longer. Additionally, due to the ubiquity of ICT, I am interested in understanding how repair emerges in relation to ICT artefacts that have become so present in everyday life.

In a complex intertwining of technological, societal, and behavioural matters, it is difficult to give an exhaustive account of exactly why premature disposal occurs, but it is also outside the scope of a single person to handle these matters in their entirety (Fry, 2017). This means that we must work together, but that we also have to choose carefully which aspects we aim to handle on our own. In my own case, I aim to investigate an assumption that modern electronics are in a state of separation, distanced and distancing from and to inter-human relations and human-nature relations. Phones, computers, kitchen appliances, and other examples of (embedded) information technology exist in a sort of vacuum. Previous research has pointed towards a distance between humans and nature (Abson et al., 2017), a disconnect of sorts, as well as "a gap between many people's feelings and attitudes about environmental problems and their own actions" (Nisbet, Zelenski, & Murphy, 2009, p. 734). How might we explain unsustainable treatment of these objects? Do we only care for the things so long as they serve a purpose? Is the purpose in itself the perceived being of such objects? Is an emotional investment necessary for engagement? These questions are not easy to answer, if at all, but nevertheless, understanding how we can land at least somewhere which is better both for the environment and for people requires moving through a landscape of troubles and difficulties.

2.6.1 Alternatives and supplements for longevity

As a method for restoring functionality available prior to breakdown, repair is but one way to deal with breakdown and maintaining longevity.

Jackson, Ahmed and Rifat intimately studied the practices of mobile phone repairers in Bangladesh, where the objects of repair were seemingly of the older generation of phones, judging by the pictures included (2014). Similar studies of phone repair experts and their practices have been done in rural Kenya and Namibia (Jackson, Pompe, & Krieshok, 2012; Wyche, Dillahunt, Simiyu, & Alaka, 2015). One of my goals is to make suggestions on how to improve the longevity of objects with embedded IT, repairability being one aspect of longevity. The investigation of repair practices is necessary to understand how one might

accommodate for it. The topics of interest here are the ways people, repairers and owners, engage with both damaged and undamaged phones, what the different states of being are for these phones, what drives these states, and how materiality matters.

Kalantidou presents a focus on *material longevity* and *material detachment*, repairing and sharing, as means to reframe things without functionality not as waste, but as opportunities to engage differently with things (2015). Here, a website and an iOS app were created so as to make locales for repair more accessible. It is an indirect approach to making repair itself accessible, in the sense that it attempts to point towards where repair happens, but not *in the thing itself* (c.f. 2.5.2).

Cherrier, Ture and Ozcaglar-Toulouse define repair as "restoring by replacing a part or putting together what is torn or broken", while repurposing is "creating a new or a second life for an existent object by making some transformations to it" (2015, p. 481). The authors point out a tendency for studies on disposal and waste to be on the subject side of matters, rather than the object side, i.e. "subjects dispose of the object when they no longer see value" versus "the object triggers or hinders disposal" (Cherrier et al., 2015, p. 482).

From the above, we see a range of ways to deal with things after breakdown, and what can influence our approach to dealing with breakdown. Odom, Pierce, Stolterman and Blevis investigated people's consideration of household items and why "we preserve some things passionately and discord others without thought" (Odom et al., 2009, p. 1053). The authors base their framework on three design perspectives from Verbeek (2005), namely *function, symbolism* and *material qualities*. Through a method called *personal inventories* and their analytical framework, they present a set of implications in relation to design which aims to generate strong attachment to artefacts, digital or not.

From this point, I will elaborate on the methods of this thesis and my considerations that relate to them.

3 Towards an inquiry on breakdown and repair

> *"Visiting is not an easy practice; it demands the ability to find others actively interesting, even or especially others most people already claim to know all too completely, to ask questions that one's interlocutors truly find interesting, to cultivate the wild virtue of curiosity, to retune one's ability to sense and respond—and to do all this politely!"*
>
> *Donna Haraway, Staying with the Trouble*

The collection of methods about to be presented below were selected as means to investigate the interrelational phenomena that emerge in contexts of damaged and broken things, and the practice of repair. When what a thing is depends on what it does for and to us, changing over time and capable of constituting different relations across situations, it becomes necessary to go out into the world and see what and how things emerge into being, and how we in turn are shaped as well. To embrace a view that "our knowledge of reality [...] is a social construction by human actors" (Walsham, 2006, p. 320), extended through the framework by Verbeek (2005), means that there are individual and shared understandings of the world with *things* being part of that constructive process too. Not only can I generate my own understanding of the effect of things for others, but others have their own understanding as well, not necessarily overlapping with mine. Striving to make sense of matters "as best as possible" implies a need to uncover the many ongoing understandings, compare and distinguish them so as to make available a "thick description", the in-depth contextualizing of phenomena (Walsham, 1995, p. 3).

To go "visiting", as Haraway names it, is a practice of exposing one's own preconceptions to the world, to figure out whether they are worth keeping, discarding or reshaping. Visiting requires a certain flexibility in a different sense too, in *how* visiting is done and

what that visiting is. Crang and Cook presents interviews as one of the "primary means through which ethnographic researchers have attempted to get to grips with contexts and contents of different people's everyday social, cultural, political and economic lives" (Crang & Cook, 2007, p. 60). Importantly, the authors also point out that "all social research involves learning through conversation" and that there is a blurring between different methods (Crang & Cook, 2007, p. 60). These are the ways in which I view my own selection of methods, interviews included, as means to understand phenomena situated in social contexts. For instance, in the later stages of my empirical work, I visited a repair shop. During that stay, I observed and spoke with both repairers and customers who visited the shop. This combination of seeing and conversing *in situ* could be understood as *shadowing,* a method where "a researcher [is] closely following a member of an organization over an extended period of time", for a duration between a day to a month (McDonald, 2005). We could also view this combination of engaging with people as *participant observation,* a

> "[…] three-stage process in which the researcher somehow, first, gains access to a particular community, second, lives and/or works among the people under study in order to grasp their world views and ways of life and, third, travels back to the academy to makes sense of this through writing up an account of that community's 'culture'. (Crang & Cook, 2007, p. 37)

However, it seems to me that Crang and Cook suggest that it might not perhaps be as important *how* we name our methods and having a rigid execution of them, but rather that we are aware of and attempt to meet the many possible challenges that can occur in the process of doing research. It is also about making available one's process of thought and action, to offer a story not only of what was researched, but how that research proceeded as well. This chapter thus reads more like an account of my process, the sources I drew inspiration from and how things went, for good or bad.

3.1 Methods of inquiry and related ethical considerations

Coming from a place of curiosity, with a whole lot of assumptions, I set out to better understand the context through talking with repairers, owners, and other stakeholders in the larger scheme of things. This caused a selection of methods that I hoped would bring me closer to those with the knowledge I sought, to make me more able to answer my own research questions of design implications on repair, longevity and attachment to smartphones.

3.1.1 Preliminary interviews

In the beginning of the thesis, most of my empirical work based itself on interviews as an *informal research method,* relatively loose conversations with people who had some sort of relation to issues of repair. Arguably, anyone could be considered relevant, as most people deal with repair in one way or the other, through fixing household items, cars, clothes, bicycles, and so on. In my mind, I was looking for "exemplary" representatives of the different groups involved in repair, people who struck me as particularly mindful of repair or with a great deal of knowledge on the topic. Not to be equated with a hunt for *personas*—representations of *potential users* (Putnam, Kolko, & Wood, 2012)—but rather a personified turn of the concept of "exemplars" or "ultimate particulars", typically used in relation to design artefacts or cases (Höök & Löwgren, 2012). In a sense, it is a person that exhibits particular virtues relating to repair, a certain craftsmanship and particular approach to problems, as someone to learn from, design for and design with, in the context of breakdown.

These preliminary interviews were intended to be one way of untangling the mess of assumptions I had and define some constraints to work within, such as having particular conversation topics. Important for the understanding of what things do to and for us is not only to observe and record it from a distance, but also hear from others how they evaluate the different effects of mediation themselves (naturally, not in those terms). An entirely antagonistic factor in the design of a thing, in my view, might in fact prove to be beneficial to some users.

My preliminary interviews were semi-structured, although they were more unstructured than structured. While this was, in part, due to my lack of a sufficiently scoped problem space, it was also a deliberate choice, as I wished to for an open conversational space in the search for a comprehensible and manageable scope. There were some guidelines to the interviews though: Some were asked about their practices in repair and what kind of problems they see in the design of things they repair. Others were asked about repair in the larger scale of things, such as consumer behaviour and waste management. All of the topics ventured into can be connected one way or the other to the repairability of things, and how it matters to both humans and nonhumans, so to speak. Those I spoke with, foregrounded as interviews, were employees at a university, in charge of a common makerspace at that university, an employee in an e-waste recycling company, and the owner of a used goods store. The latter might seem an odd choice, but at that point in time, I was exploring the possibility of building the thesis on *care ethics*, which meant looking at a range of care activities, not limited to just repair. Over time, care ethics become more of an underlying motivation to the thesis and unfortunately, visiting the used goods store did not pan out as planned, as an opportunity to visit that store never presented itself.

While the preliminary interviews did not end up as results, *per se*, they assisted me in mapping out the problem space to a certain degree, by implicitly shaping the direction of the thesis. To build upon this, I set out to get even closer to places where I might find some answers to my research questions.

3.1.2 Observation in a repair shop

How do repairers fix things? Why are certain things done in particular ways? What don't they do? Answers to these questions can certainly be talked and read about and studied through literary works, such as Harper and Orr's anthropological endeavours with mechanics and copying/fax machine repairers (Harper, 1987; Orr, 1996). YouTube instructionals and forum guides can also provide knowledge about material concerns and practices in regard to repair. What all of these lack, though, are *opportunities for ad-hoc,*

reactive and/or improvised questioning about what is going on, from one's own personal and scholarly interests, in the context of an on-going practice. Reading accounts of repair was beneficial to get a feel for the field, what to look for, and tune into the state of mind of being an observer and those who are observed. However, I fell short of making it my own understanding, connecting it to the repair of smartphones and the theoretical framework I had established. This prompted in me a need to immerse myself into contexts where such repair is happening and asking my questions.

To "do observation" was my idea of being present in a context of ongoing matters that I found interesting. The opportunity to visit a repair shop came through a personal relation of mine, who happened to work in a repair shop for smartphones and tablets. In an exchange of emails, practical and formal conditions of the visit was established with the shop's general manager. In this exchange, I showed papers for consent from repairers and potential customer participants and the probe which was to be shown to customers (c.f. 3.3). The details were agreed upon, but the handling of the practical aspects to the visit did not stop at this point. During the visit, I conferred regularly with the repairers about my presence there, how they experienced this, and possibilities for improvement. A topic that came about several times was that of recruiting customers for my probe. In my mind, I had envisioned the repairers acting as *gatekeepers* for the customers, where the repairers would consider which customers could be appropriate participants, ask for their participation and introduce me. The idea seemed good prior to my visit, and was part of the agreement made before I arrived, but in practice there was one trouble in particular.

The repairers' workload varied greatly within and between days, which meant that they didn't always have time to include more work (being "recruiters"). On the third day of the visit, one of the repairers and I came to the conclusion that I was just as qualified in making considerations of customers' *suitability* for recruitment. By suitability, I mean an impression of the customer as not being in a hurry, seeming relaxed or a kind of person that might be interested. Both the repairers and I didn't always hit the mark on our recruitment, and there were a couple of rejections.

To be sure, this loosely formulated criteria might be one reason for the relatively low number of customer participants, where in the end, four people in total agreed to participate. A more aggressive approach might've resulted in more participants, however, I do not believe that is an *appropriate* approach in this context. First, I consider it not appropriate as a visitor being present on certain demands to aggressively chase participants, within the conceptualization of being a visitor. Secondly, the observation was set in a context where people are vulnerable of sorts, in needing help for the repair of what is, conceivably, a critical device in their everyday lives. Thirdly, a purely numerical criteria—"this study needs X amount of participants"—of considering the value or quality of the method does not seem relevant either, with this project being a qualitative and explorative investigation. On the other hand, the repairers or I might have held back on the recruitment far too much, exaggerating the possible "bother" imposed on customers. Either way, I consider my approach to be fair and reasonable, as it was discussed and adapted as the visit progressed, in tandem with the repairers. In hindsight, it was also interesting to consider the practice of research as a collaborative effort between researcher and participants, not necessarily on a theoretical basis, but on a practical one in which the two parties work together *to make things work* for those concerned.

Notes, write-downs and photographs

Notes were taken intermittently, in a *diary*-like fashion, during the visit. My intent was to keep a somewhat orderly log of activities, impressions and conversations, which could aid me in keeping or shifting focus. The notes proved to be valuable during the stay and later on. For instance, it allowed me to follow up on things that I still was uncertain about or would like to have further conversations about. It was also of great help in writing down my experiences into what became chapter 4 in this thesis. At no point was any personal information noted down. Real names were anonymized by nicknames or just a numbering ("repairer #2 did so and so"). The digital write-down happened without any occurrences of sensitive data either. One problem that did appear after the visit was that not all notes were sufficiently contextualized. This meant that during the writing of chapter 4, certain observations came under scrutiny and seemed lacking or incorrect.

Some of these observation were corrected in dialogue with one of the repairers, but those that weren't verified in this manner were left out from the thesis. At the start of my visit to the repair shop, I attempted to generate a type of coding for the notes, so as to make more apparent, for instance, which repairer a certain quote belonged to, and whether a note was relevant for one or more category (thing, practice, material, brand, and so on). The plan quickly fell apart, as this manner of ad-hoc coding proved to cause more chaos than order in my notes. As such, the activity of coding my notes was postponed until after the visit.

In my effort to create a rich description of smartphone and tablet repair, I also decided to take photographs. Before any photographs were taken, the repairers and I always made certain that there wouldn't be any personal information present in the photograph. This meant that smartphones, parts and tools were the only objects within the frame. IMEI-numbers, unique identifiers for phones, were avoided or hidden by using post-it notes, and the same for any other sensitive information that might be found physically on the phones.

Together with the observation, I had also planned the inclusion of customers into my research so that I could learn about their side of the story in relation to smartphones, breakdown and repair. This prompted the creation of a *probe*.

3.1.3 Probe

Motivated by a curiosity to hear about people's personal relations to things—in the sense of what things are *to them*—I set out to create an object that could elicit thoughts and consideration on that topic. To a certain degree, this way of seeing objects as creating an engagement (or lack of) is inspired by Turkle (2007), where stories of how objects can set in motion acts of retrospection and reflection are presented (see for instance Yee, 2007). Specifically, I wanted to hear what people had to say about broken things and repair that might occur in that context, across different types of technologies and degrees of brokenness. What immediately came to mind was a sort of cobbled-together story of images, stories and questions that would prompt a discussion in the direction of my

interests (see appendix A for a copy of the probe). I drew inspiration from Blevis and Stolterman's *personal inventories* (2007), as well as Gaver, Dunne and Placenti's *cultural probes* (1999). My probe is nowhere near as tangible, creative and interactive as the cultural probes, and it does not attempt to generate a collection of the things people have and how they relate to it. The probe was designed to be reflected upon and given feedback to by customers visiting a repair shop, as a discreet and minimally intrusive introduction to me and my project, and as a stepping stone into what would hopefully be an interview afterwards. That interview would build upon the answers they gave through the probe, acting as points for deeper exploration into the theme of repair and broken things.

The probe allowed for user participation through self-documentation on the topic of repair, and could manifest, ever so slightly, into a small representation of their daily lives, thoughts and consideration of the fictional scenarios I had created. Not meant to be taken home, it was designed to be short and simple, something that might be undertaken while the repairers did preliminary examinations of repair objects or wrapped up their work.

The probe is composed of three primary components: It has an image of an object, it has a story, and it has a couple of questions. Two of the three images used are of clearly, visually broken things, while the third looks to be in fine condition judging from its exterior. All stories contextualize to some degree what the object is in different ways. There is an amplifier, a chair and a phone. These things have some relations presented: The chair is an heirloom from a close relative, the amplifier has survived many transits between homes, and the phone has been in use for a couple of years. Following the sequence of image into story, there are a number of questions. For all objects, the questions relate to whether the brokenness of the object is a matter of repairing, throwing away or using it as a decoration. In the case of repairing, there is a question of how the participant would deal with it: Would they do it themselves or have someone else do it? After, they are asked how much they would be willing to pay for repairing the object. All

of these questions are included in the three cases of the chair, amplifier and phone, but there is an additional question for the phone. Contemporary smartphones are notoriously difficult to repair, and as such there is a sort of warning that repair of it imposes a certain risk that the phone might be entirely broken, beyond its current state of disrepair.

The method was planned and worked as an item the participant could look at, read and fill out on their own as they visited the repair shop. All except one participant used it as such, an exception which was caused by the participant's unfamiliarity with the Norwegian language. In this case, the method became something that I read aloud—translating on the spot—so that the participant could understand and give answers as we worked through the questions, while also having visual access to the document.

3.1.4 Repair shop interviews

Those were intended as a follow-up to the probe, in the hopes that further insight could be gained about the answers given prior to the interview. Here, the probe was intended to act as an interview guide, where the conversation was to be directed on the basis of how they had answered. While it certainly proved to be a source of plentiful information, three of the four conversation derailed. The theme of caring for things is an engaging one, something which pretty much any person can relate to, but the conversations never really stayed for longer amounts of time on topics of consumer electronics, such as smartphones.

In addition to making notes and taking photographs, I had planned to record the post-probe interviews and transcribe them later. That was quickly revealed to not be a good idea either, for several reasons. It was difficult—if not impossible—to only record the conversation between me and the customer without recording other customers that might visit at the same time, who hadn't given their consent. It also become troublesome in relation to the repairers having phone calls with customers as well, due to lack of consent from the party on the other end of the call, and them "disturbing" any conversation I might be recording with a customer participant. Instead, I ended up

writing notes by hand, spread across the probes and in a notebook specifically dedicated to the interviews.

3.2 A case study?

Whereas some might see a problem and define a case around that problem, in a planned manner prior to the actual empirical work, the circumstances here are somewhat different. The empirical work, past preliminary interviews and literature reading, did not start out as a case study, but that the work emerged as something closely similar to being a case study at the point that visiting a repair shop became a possibility. I did not consider it a case study until that point, and I still do not find it a description that entirely fits the project. Part of this doubt comes from how the method described in 3.3 was intended not only as a way to elicit insight about participant views on repair, but also as a means to prompt reflection and nurture future consideration on the topic outside the context.

However, if we base our understanding of case studies along the lines of how Stake presents it, the problem of this methodological quandary disappears, as he states that "[c]ase study is not a methodological choice but a choice of what is to be studied" (2005, p. 443): A case study can be entirely independent of methods, research paradigms, whether it has a qualitative or quantitative angle. I find it important to point out here that my research is not constrained to the case, but that the case is a part of my research.

My interest in the repair shop as a case was very much along the lines of how Flyvbjerg's presents one value of case studies, namely how they are "important for the development of a nuanced view of reality" (2006, p. 223). In relation to my theoretical framework, I found an absence of contemporary smartphones being scrutinized through the lens of a processual and relational perspective. There also seemed to be a lack of nuancing on the topic of what repairability actually is as a concept, and the implications it could have on practice, as based on the components and materials which are dealt with in the practice of repair. While reality is a bit of a loaded term, especially in an interpretive perspective, I

wanted to nuance the reality of which I found something to be amiss. It wasn't intended to be in opposition of a particular argument or to prove an assumption, but to look for information that might nuance the field; Visiting the repair shop was more an opportunity to learn something, rather than proving it (Eysenck, as cited in Flyvbjerg, 2006, p. 224). It was also my intent to provide, through the combination of my empirical work and the theoretical framework, a contribution that was congruent to the field of SID. Although the case of the repair shop is far from sufficient as a basis for generalization, it still has potential value, if we follow the reasoning of Flyvbjerg: "That knowledge cannot be formally generalized does not mean that it cannot enter into the collective process of knowledge accumulation in a given field or in a society" (2006, p. 227).

The case of smartphone repair in a repair shop holds both *intrinsic* and *instrumental* value (Stake, 2005). It was intrinsic, in the sense that that it gives insight to the context of smartphone repair in Norwegian cultures, in a particular time and place. Its instrumental value came from being able to function as a point of comparison to other contexts, and being able to inform others with an interest in a case like this. Again, we find the lines are somewhat blurred, as according to Stake, "[t]here is no hard-and-fast line distinguishing intrinsic case study from instrumental, but rather a zone of combined purpose" (2005, p. 445). My interest in a northern Norwegian repair shop is to understand the "particularities *and* ordinariness" of that place and its activities, but more so to relate those experiences to understanding how the design of smartphones can contribute to breakdown, absence of repair and disposal.

3.3 To go visiting

Most methods typically offer much more than what they are generally prescribed for. When, for instance, interviews are performed on location of where the participants work, it provides an opportunity for "happening upon" phenomena and topics that could be favorable to the project at hand. It could be the observation of a particular object, perhaps being use in an unconventional way, or something intriguing overheard that could be a

topic for the interview. Openness towards this manner of "serendipitous" thinking, of allowing things to happen by chance, given how "things *can* and *do* come together in a research project, *often unexpectedly*" (Crang & Cook, 2007, p. 204), has shown to provide many pivotal insights (Suri, 2011) and something one shouldn't neglect the value of. While structured interviews can be valuable in clinical or experimental settings, the lack of strong rigidity in semi-structured and unstructured interviews allows one to take advantage of unplanned-for circumstances, removed from positivistic assumptions of bias, replicability and so on. Such circumstances could, for instance, be discovering new topics, learning of other opportunities and locations for investigation and establishing partnerships or collaborations.

Seemingly, in the investigation of complex practices and worlds from the point of view that things are complex, an awareness of one's own practice and thoughts is necessary and requires scrutiny. Reflexivity and reflection can be two approaches to "making sure" that one is on a path towards the discovery of insights that can inform a design or the designer(s), so as to be closer to something that fits the approached context. Having finely tuned plans, detailed guides and so on is a decent point of departure, and important for the reasons stated above, but at some point these preconceptions have to face reality. In that meeting, one is tested as both a practitioner and researcher, and how well one *adapts* to the context of inquiry. It is a messy process of realizing that some notions were wrong, having been oblivious to others, and if lucky, finding confirmation that some things were right. Doing "good work", in a sense, requires some way of knowing when to struggle and when to let go, to "kill your darlings" or keep them alive. Experience with this comes from exposure to the world, getting feedback, feeling resistance, and building upon a catalogue of experiences, to hopefully be better prepared for future scenarios.

Based on the above, it seems that instead of planning out and taking into account a wild number of possible outcomes, it is better to dive into the matter: ask, be shown and told by others how they deal with a world that cycles between states of repair and disrepair,

and relate those experiences. Piecing the world back together is very often a collaborative effort, due to its constantly increasing complexity, and being "out there" with others is not only a way to better understand what is going on, but also an opportunity to work together. What is gathered through these methods barely scratch the surface of the problem space that relates to obsolescence in IT. Particularly, the virtual dimension of smartphones is a background actor in most of the empirical examples to be presented here, while the materiality of things is front and center. A material sensitivity, understood through Verbeek, means to take interaction into consideration (2005). Which materials are things composed of, in different configurations, and what does this mean for repair and longevity to those who depend on it?

Second to that is how people themselves deliberate on repair issues, both repairers and owners, the exchange and transformative process between material and immaterial dimensions. How do people evaluate things in a state of disrepair? Being present with people, as their problems are immediately present to them, seemed a fruitful opportunity to learn what it means for smartphones to be broken for those involved, at a point in time where the problems are at their most "real", rather than only relying on recollection and reconstruction.

4 Case: The Repair Shop

"Another flaw in the human character is that everybody wants to build and nobody wants to do maintenance."

Kurt Vonnegut, Hocus Pocus

In this chapter, I will draw upon the theoretical basis of Verbeek, Jackson and Blevis' work to explore aspects of the emergent interactions between repairers and smartphones as objects of repair, in relation to the design of smartphones. This is taken one step further to show how there are qualities to smartphones which acts against repair, but simultaneously able to act against their breakdown as well. These considerations are put into the context of attachment, what smartphone design can mean for person-thing relations and who might benefit more from repair accommodation.

My empirical examples here are primarily sourced from interviews and observations of repairers and the customers in the phone repair shop I visited. Prior to the visit, there were other cases as well, such as an interview with an employee in a recycling company, a visit to a repair shop that specializes in audio equipment, along with everyday observations, conversations and discussions about broken and/or repaired things. Those outlying cases informed my empirical work and analysis, but is not as explicitly present as the visit to the repair shop.

The repair shop (RS) repairs mobile devices (phones, tablets and the occasional laptop), in one of the larger northern Norwegian cities, over the course of four days during the winter months. Important to note is that RS does not repair "older" phones, i.e. phones that does not belong in the more recent, mainstream category of smartphone, such as the Doro brand. Looking at their list of smartphones they repair, iPhones prior to the 4S model are absent, as well as Samsung phones released before the S2—phones released more than 8 years ago seem to not be included in the list of phones for repair. However, customers can get in touch for consideration of other phones and tablets.

Prior to my visit, several ground rules were established, such as the non-disclosure of information related to business and privacy, and keeping my presence in tune with the workplace. After the visit, one of the repairers helped me in verifying that my observation of their repair practices were accounted for correctly, i.e. an accurate description of how repair was performed by them.

I will now disclose the different aspects of smartphone repair in RS:

- The aesthetics of phones and materials used in phone
- How dimensions of material aesthetics matter to repairability
- How repair happens thanks to or in spite of those dimensions, through for instance tools and resources.
- What the necessary practices of smartphone repair entails for smartphone-owner relations

To wrap it all up, I will relate these topics to matters of longevity, attachment and ownership, and what these topics can mean for thing-person relations. In the chapter that follows the analysis, I will connect my analytical work to that of how a more repair- or breakdown-oriented approach can be implemented.

4.1 Aesthetics of smartphones

The shop had a wide variety of visitors, representing nearly all age groups, who brought with them instances of Samsung Galaxy S7, iPhone SE, Sony Z5 Compact, Huawei P20 and more. iPhone models were the most common to appear at the shop, especially the iPhone 6, 7 and 8 series. Samsung phones were the second most common brand, while few sought repair for Sony and Huawei phones. Other brands, like HTC, Nokia and LG, were not seen during the four-day long visit at the shop.

Aesthetically, smartphones have some general traits and some particular traits: Some are smaller and some are larger than others. Some have edge-to-edge screens, or even screens with curved edges. Others have done away with a physical home button, replacing it with

a virtual one with a haptic motor to give it a physical presence. Phone frames were embellished in black, white or gold colours, to name a few, granting them some degree of distinguishability. In general, though, all phones kept within certain visual parameters, diverging little from each other. It is not an easy task to distinguish one phone from the other at a distance without having a keen eye for and familiarity with details like those described above. Even with a somewhat diverse assortment of phones observed during the visit, superficially, one could say that most contemporary phones are more or less the same and the differences present in the phones are lesser brand and/or series particularities.

The observed phones consistently had glass screen covers, and in many cases they also had a rear cover in glass too. Frames – the in-between of screens, buttons and covers – were made of plastic, metal or glass. Buttons made of plastic, spread across the surface area of the phones, differed in their position and numbers. One might expect the placement of buttons to be a stable aspect of phones, at least within brands, but even that is a somewhat volatile design factor. For one phone model, the volume button might be singular, but can be tilted up or down, as it is with Samsung S8+. Other models have two buttons for volume control, as is the case with iPhone 5. Some have buttons on the top of the phone, some barely have any buttons at all. For a long time, most smartphones had a physical home button centred on the bottom of the screen, a "tradition" cemented by Apple. However, the home button as a physical presence on smartphones is at risk of becoming obsolete, as several brands have made home buttons a part of the touch screen interface, in a way simulated as a button through haptic motors. Still, these "simulated" buttons have yet to take over for all physical buttons, and it is rare to find a phone that does not have buttons for powering on or off, locking and unlocking the screen, increasing or reducing volume, and for photography.

Buttons are commonly the only physical, exterior parts that move during use, but exceptions can be found with phones like the Samsung Galaxy Note 2, where the back lid works as a front cover, in that it folds from back to front. Other instances of virtual buttons are present in the navigation bar. Physical buttons cannot be moved about or changed the order of without extreme modification, but these virtual buttons can be represented in different ways graphically (different styles), and one can even change the order they are shown in (window-home-back or back-home-window). There are phones which allow the reconfiguring of button functionality as well, but it is difficult to say how common this is. According to one of the repairers, the iPhone 4 had a home button that could spin around in place with enough wear-and-tear, and it could be pushed too far in.

Figure 3 - Phone resting place

Nooks and crevices, with or without lids, can be found on all phones, supporting data transfer and charging cables, SIM and storage cards, and audio gear. Not all openings are for integration with other of equipment, such as holes for microphones and speakers. Further scrutiny of the phone's exterior reveals components for photography, found both in the front and back. From a non-functional point of view, it's a different story. For

instance, the smartphones I observed never gave access to their insides through prying open via notches in the casing, as was common for phones prior to the era of smartphones.

Functionally speaking, separate from software, smartphones can be understood as highly similar devices: They all have a screen for displaying information, which also functions as a point of interaction. There are speakers and microphones for producing and recording sound. They have cameras for photography and filming. Audio equipment, such as speakers or headphones, can be connected, via cable or wirelessly, to improve sound quality and reach. On a functional level, one phone can easily be replaced by another. If you need to photograph something, an iPhone 5 can adequately fulfil that need similarly to a Huawei P20. The same goes for audio recording, visiting websites, taking notes, paying bills, and so on—as long as the software doesn't create trouble. As such, *smartphones display a high degree of replaceability in regard to function.*

From the above description of aesthetics emerges impressions of the smartphone as a *sealed-off* thing, through its lack of obvious points of entry. While smartphones are sleek, seamless and visually pleasing, *their aesthetics have consequences for practical matters in repair.*

4.2 Material hindrances for repair

4.2.1 Glass

Broken screens are without a doubt the most common trouble visitors brought to the repair shop, which the repairers dealt with on a daily basis. To a certain degree, screen replacements are a routine process consisting of some generic steps: The phone is heated up to dissolve glue (see fig. 4), suction cups are placed on the screen and used to pull the screen off the phone's frame, and a plastic card is used to cut away glue (regular playing cards do the trick as well, seen in fig. 12). Finally, the screen's cable is disconnected.

Figure 4 - Heating plate

This simplified description does not do justice to the practice of repairers, though. Screen replacement includes fine-tuned movements involved in avoiding further damage to other parts that are on the "path" to the part that needs replacing. The repairers need to know when and where there are cables to be removed before the screen can be entirely separated from the frame (see fig. 5). They need to have available and use the appropriate tools, appropriately, with respect to individual differences in each case. There is a bodily engagement with tools and the phone: A little twist here to detach a cable, a quick pull there to remove old glue strips, the body tuned into the phone, listening—for "good" sounds as one repairer in RS called it—looking and feeling for success or failure. In the

instance of removing a shattered screen, suction cups can potentially add more trouble to the case, by just pulling away shards, but can be compensated by scotch taping the entire screen. The glass in some iPhones can even explode when exposed to too much force. Elements to be considered in the removal of a screen applies to other components in phones. Disassembling a phone is a procedure of keeping track of potential interconnected components, how there might be demands for the removal of components in a particular sequence, how they are fastened, and at some point, working backwards through and out of the phone again. Back into its reconstitution as a whole thing again, ready for its next breakdown.

Figure 5 - Screen cable

Cracked glass on a smartphone doesn't necessarily mean that it has to be repaired, as it might still able to function despite its damaged state. Owners might accept that the image isn't rendered as nicely as it used to, or that certain areas on the screen don't respond quite so immediately to input anymore. One customer that visited the repair shop rejected repair of his phone screen after hearing how much it would cost him. There could be any number of reasons behind his choice, but he didn't choose to pay for the repair at that point in time. Perhaps he went home to explore his options, like how he might be able to fix it himself, which another customer had tried. This customer stated

that he needed help to finish his own attempt to replace the screen of his phone. He had followed an online guide, but at a certain point, he couldn't quite get all the parts to fit back together neatly after replacing the screen.

Glass breaks uniquely from case to case. Some have a myriad of fractures almost entirely covering the screen, others have fractures that are few, but travel far across the screen. Some only have minor cracks in the glass localized in one small area, and the Samsung S9 pictured in fig. 6 and 7, is one such instance. Unfortunately for its owner, the trouble didn't stop with just the glass, where the impact that caused the shattering also damaged other components of the screen, resulting in only half of it being functional (the bottom white half).

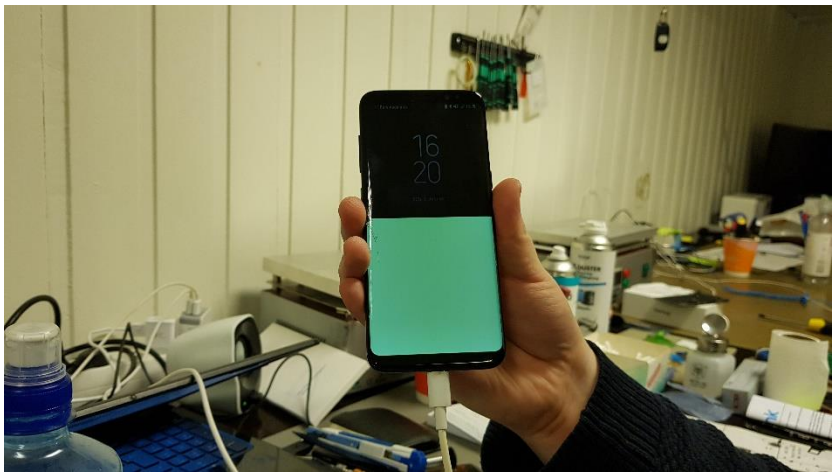

Figure 6 - Defect Samsung S9 screen

Figure 7 - Disassembly of Samsung S9

The Sony Z5 Compact is in a worse state than the Samsung S9 (fig. 8 and 9). There, the screen is not only shattered, but pieces of glass have fallen out of the phone, exposing the inner components. The phone was nearly totaled, except from a few signs of life in the form of still being able to blink its LED (fig. 8, top left corner of the phone) and responding to charging. Hoping to save the images stored on the phone, she came by the repair shop. To prevent any further damage of the phone, and thus less chance to retrieve the images on it, she had covered the front of the phone in scotch tape to keep the bits and pieces of glass in place. Despite all efforts though, it was close to impossible to gain access on a software level without navigating through the screen. The repairer tried to gain access by connecting the phone to his work computer.

In theory, through the brand specific software offered for management of Sony devices, the repairer would have been able to retrieve data stored on the phone. In practice, however, access requires that one unlocks the phone directly, and accepting the connection between phone and computer. This wasn't an option in this case due to the phone's severely damaged state – even a replacement screen didn't remedy the problem of gaining access. On an online forum where a similar problem was sought help for, a user suggested connecting a mouse, specially made for usage with phones, to the phone in question, and navigating "blindly". This blind navigation, it was written, would be possible through practice with a different phone, learning the distance the mouse travels,

where one would have to click to enter the appropriate code for unlocking and grant access to the phone-computer connection. This wasn't a viable option either.

Figure 8 - Sony Z5 Compact LED – circular light in the top left

Figure 9 - Shattered Sony Z5 Compact screen

Had this been a stationary or portable computer, one might have been able to gain access to the data by disconnecting the hard drive or solid-state drive and connecting it to a different computer. A similar operation could've been performed for the customer with the broken Sony phone, but the data she wanted was stored *locally* on the phone, and not on a memory card. Having it locally stored made data retrieval a complicated process, due

to the access-related constraints in the phone. The reduced state of the phone didn't afford any signals of whether the *data* was retrievable at all, and even with the obscure method of blind navigation that was offered online the repairer might have come out empty-handed. There was just the LED that offered any information of the phone's state, intermittently blinking red when a charging cable was connected.

Even if a damaged glass layer of a screen can emerge in widely different ways, turning into a range of troubles and ways to cope, *there is only one realistic, rational way to repair it*, which is replacement of the entire screen. Replacement, rather than fixing, is realistic due to it being highly unlikely that an owner or a professional repairer has the skill to fix damaged glass. On a rational level, replacement is the appropriate form of repair first and foremost due to spatial demands in the phone. The glass has to fit *exactly* with other parts of the phone, without exposing inner components to environmental risks that can harm them. While a person highly skilled with glass as a material might be able to reproduce the glass layer of the screen, but it doesn't matter when the glass is so tightly attached to the rest of the screen that it doesn't allow removal without damaging other screen components, such as the digitizer. The screen, as it is designed, *formalizes repair,* into a particular type of repair that does not involve *fixing*. It cannot be directly attributed to glass, as it doesn't *inherently* have this effect. Windshield repair is a practice of repairing glass through the use of special solutions, i.e. *repair as fixing*, but the glass in connection to glue and other components of smartphones makes it emerge as a praxis of replacement.

Only graced over at this point, glue is another major player in the material sphere of phone repair, and is just as complex as glass, if not more.

4.2.2 Glue

During the first day of my visit, one of the repairers had a look at a repair attempt of an iPad Mini 2 from the week before, where the screen had to be replaced. The tablet had been sitting in a stand with several vices over the weekend, the last stage in screen replacement sometimes necessary for the glue and screen to settle together. A closer

inspection that day showed that the gluing wasn't a total success, with a visible edge on one of the corners, and the home button had sunk into the tablet, with a somewhat loose fitting (see fig. 10). Both issues had to be resolved, as the former could lead to moisture damage (lack of adequately sealed internal components) and the latter could, at the very least, become a source of annoyance for the owner, as according to the repairman, such flaws are things that "many people get hung up on". The repairer planned to contact the customer to ask whether the iPad was to be delivered as is or if further repair was necessary. "Most people gladly wait", the repairer said, "usually there'll be a discount in it for them, and this became a 'poor' repair".

Figure 10 - Spot the flaw this iPad Mini 2 has (hint: right side)

Repair necessitates, in almost all cases, physically opening the phone. Gaining entry to the phone's insides, in many cases, means getting past smartphones' first barrier, namely *glue*. Dealing with glue demands a particular set of tools, which to some degree can be improvised. Glue, as a material, can vary in placement and strength from phone to phone. It's not a given that the practice involved when dealing with glue in one case of a phone is entirely valid in the next. Considering this, as well as in light of the iPad Mini 2, glue might seem like a wholly negative factor for repairability. It can, however, also be a

positive material for repairers, as glue in a best-case scenario for the repairers can be a quick and simple operation of heating up the phone for a short while and "slicing" through it to separate the parts that are glued together. Dealing with glue can be a lot less time-consuming than removing all the necessary screws, keeping them organized, not losing any of them, and putting things back together as it were once the repair is completed.

Figure 11 – Vices used in gluing processes

Important to note here is that the repairers have access to special heating plates, which allow for quick and easy dissolving of glue. Where it gets tricky, though, is determining the properties of the glue used in different phone instances. This bears with it some complications, as without knowing those properties, one can only guess the amount of force necessary, and which parts are glued together. For instance, the iPhone 8's screen glue is so strong that it is easier and more efficient to replace the entire framing, screen included, than attempt to pick things apart piece by piece. The sum of materials used in this repair is much larger, but it saves a lot of time for the repairmen, even including the time spent moving the phone's components between frames. Glue, as such, offers little information of what the implications of interactions with it are, without disassembly or prior knowledge and familiarity with particular instances, a trademark of phones and their black-boxed nature. The material also prompts a type of trial-and-error treatment in those cases, a risky and potentially expensive praxis, especially for smartphone owners who are without the professional repairers' preconditions.

Glue emerges as a *hindrance for repair*, in that dealing with it requires some sort of heating device, tools for cutting, and a careful disassembly. It returns as a trouble again,

after the replacement of components, when reassembly begins and parts have to be properly put together again, with regluing and fitting the screen appropriately.

In itself, glue is not an intrinsically bad thing, but it can act as a hindrance for repair, and can thus be considered a contributing factor to the opaqueness, as opposed to transparency, of smartphones. There is another dimension to glue as well, which is that it protects from residue and liquids. Glue *hinders repair* while simultaneously acting as a *hindrance for deterioration*. Sealing away its inside from its users and the environment, glue contributes to preventing involuntary "tampering" and accumulation of residue. Glue can, on one hand, be interpreted as a material that can *reduce the need for repair*, but on the other hand it has the potential to *increases the difficulty of repair*. Problems arise once the things *do* break down and they always will, at some point.

Figure 12 – Assortment of means for phone repair

4.3 Properties and practices of returning from breakdown

So far in this chapter, I have worked through how the design of smartphones affect their repairability, and what some of the practical implications are of smartphone aesthetics. Repairability is the sum of properties in a thing which determine whether it can have its functionality restored after breakdown. The implementation of glass and glue are just two examples of properties within smartphones that affect their repairability. In parallel,

smartphone design affects how we can become able to overcome breakdown. Whereas repairability is a question of "Can it be repaired?", repair-ability is the follow-up question of "Who can repair it?" or "When can repair happen?". It could be entirely possible to repair a thing, but its design might be constrained in such a way that repair, for most people, is an insurmountable task. In between the dimensions of repairability and repair-ability, we find that which allows repair to occur, the tools and resources we have at hand that bridges the gap between repair and ability.

Repairability and repair-ability are the primary topics from this point onwards: The properties and practices of returning things from breakdown back into functionality, from a material and practical perspective. Here, I will start with a closer look at what smartphone repair as a practice is, as a reflection of smartphone design.

4.3.1 What is smartphone repair?

Repair as a concept is difficult to generalize, due to its polymorphous properties as discussed in subchapter 2.3. But, there might be room to give a general description of *smartphone repair* as it is conceptually closer to the practice it tries to describe. To explore this, I will use Harper's distinction between the industrialized and traditional forms of repair (1987). The former being a rationalized practice which is strongly shaped by formal constraints, such as laws, rules, regulations and technological demands. For instance, specialized computers required for car diagnostics or interface standards that one have to conform to so as to be able to adequately interact with the thing in question. Industrialized repair is, archetypically, a practice of replacing parts, rather than that of fixing. The latter, traditional form of repair is one that is signified by improvisational practices, an intimate knowledge of materials and the ability to manipulate those materials as one sees fit. Within traditional repair, fixing happens to a much larger degree compared to industrial repair, where damaged or worn down parts themselves are repaired, rather than replaced.

From this we can surmise two types of repair: *replacement* of parts or the *fixing* parts. Repair can emerge as instances of treatments in the shape of replacement or fixing, and

although there might be other conceptualizations of repair—restoration, rehabilitation, and reconstitution are terms that come to mind—I restrict myself here to fixing and replacement. These terms seem more appropriate for the practices in repair shops and as terms commonly used in relation to material things, but do these distinctions work in the description of smartphone repair or do they break down when applied? Let's first have a look at which formalities are present in the practice of smartphone repair.

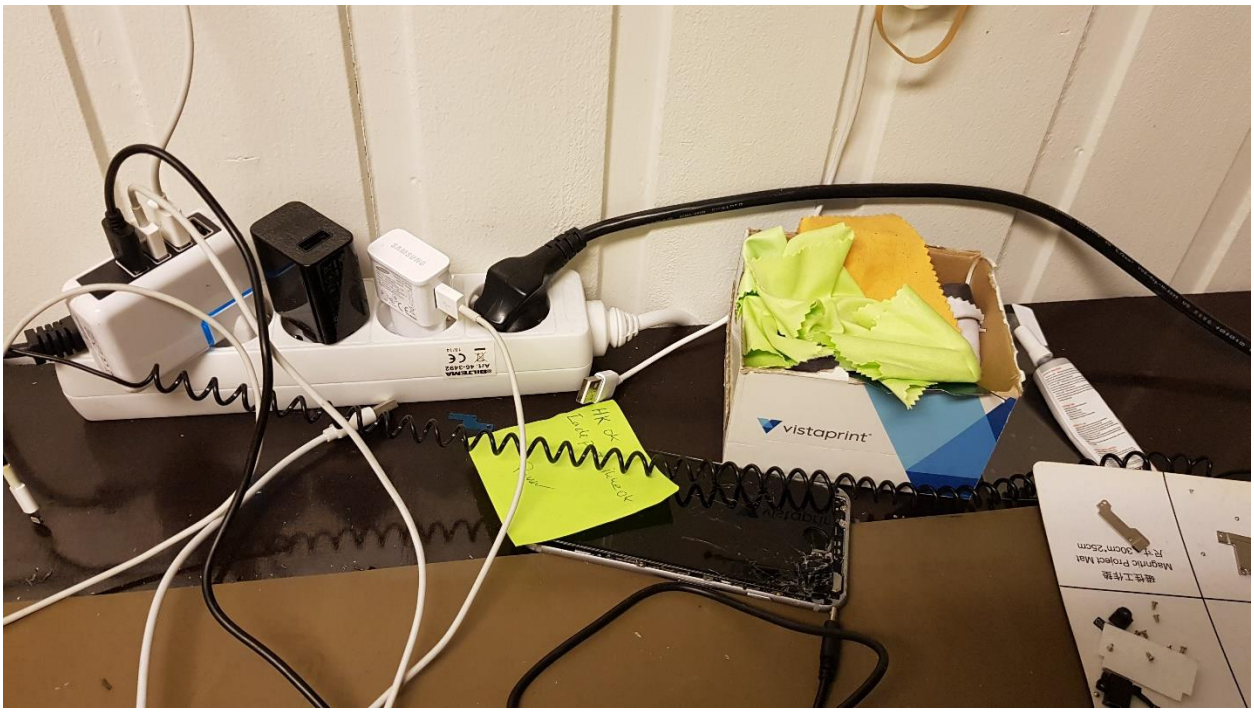

Figure 13 - Smartphone cable standards and adapters

Standards as repair constraints *and* accommodators

There are many standards which the repairers in RS have to conform to. Beginning with the exterior standards, there are several which constrain how a phone can be charged and connected to other devices. For instance, to connect an iPhone 6 to a computer, one would need a cable with the Lightning standard in one end (with respect to the iPhone's port demand). An older Apple phone, such as the iPhone 3, would need a 30-pin cable. In any case, one would have to have the proper end of the cable for the computer, where a USB is typically sufficient. In addition to these two standards, some phones require USB-mini while others require USB-C, most common with non-Apple phones such as Sony, Samsung and Huawei. Not all cables allow data transfer either, so that has to be handled

as well. The practical effects of these standards can be seen in fig. 13, which show just some of the different cables the repairers in RS have lying around.

These cables signify the formalities that repairers have to deal with and the practical effects of design, as they are necessary to test the charging capabilities of smartphones and the retrieval of data. In addition, the cables show how the different designs have propagated into the emergence of more physical things, a wider range of cables and adapters. Implications are not restricted to repairers, but have consequences for users as well. A person who used to have a Samsung S9, which uses a USB-C standard, and has bought an iPhone X, is left with cables—and quite possibly other accessories too—that aren't compatible with the new phone. If one were to need a charging cable, while being the only owner of an iPhone, in a crowd with not a single other iPhone owner, one is likely to not find someone to borrow a cable from. Charging port standards aren't the only part of the "charging ecosystem" of smartphones that manifest more things. Discrepancies in the design of phones, even within brands, have resulted in specialized tools for repair and diagnostics. Repair-wise, there is Apple's own patent for screws (see fig. 15), the tiny tri-points with shallow screw heads which were introduced with the

iPhone 7, and in regard to diagnostics, there is the diagnostics device for validating the health of batteries for the iPhone 4, 5 and 6 series (see fig. 14).

Figure 14 - iPhone battery diagnostics device

Furthermore, repair activities are constrained by the internal shape of smartphones, as their insides in most cases have a highly efficient organization, with little wiggle room, densely populated by components. These qualities mean that there is little room for improvised fitting, as components have to fit precisely, to make sure that the phone is sealed up properly after repair. This was the main reason why one customer came into the shop asking for help to complete a glass replacement of his phone, and also why one repairer in RS had to re-do the repair of an iPad Mini 2 (see 4.2.2). The device in fig. 14 also shows, to a large degree, why a battery from an iPhone 6 can't be used in an iPhone 4S. The battery cable is in a different spot, and so is the component that the cable connects to as well. While some batteries seemingly connect to ports with the same shapes, the positioning of the ports create trouble, and so we can see a type of *spatial incompatibility* for iPhone batteries. It is unlikely that this could be resolved through a "hack", for instance an extension cable (if that even exists for cases such as this), and still be able to seal the phone afterwards.

Figure 15 - Apple's proprietary tri-point screws

Even though Apple's iPhones have a *standardized aesthetics*—and so is the case with most smartphone brands—the internal spatial dimension of their phones are far from standardized. Speculatively, it could be due to the implementation of newer technology, with concurrent change in demands to necessary space, or heat distribution as caused by increased component effects (more GHz, RAM, VRAM, and so on). Regardless of what the reasons behind the internal deviations of iPhones are, the practical effects are component incompatibility between models and series, need for special equipment, and in many cases, particular techniques and practices.

However, standards aren't intrinsically bad for repair, as they allow a streamlining of practice and parts. On a *per-model basis*, smartphones of any brand are identical, and once you've learnt one model, it is more or less a smooth process of the same steps regardless of what *instance* of a model it is or the problem it might have. Trouble appears when instances of *other models and series* have to be dealt with. While in traditional repair, the fine-tuning and improvisational practices occur on a material level, as is the case with wood- or steelworkers for example, there is still a presence of the same qualities to the work of RS' repairers. Approaching an unknown phone with the intent of repairing

it, rather than inflicting further damage, requires a carefulness. Prior knowledge might be applicable to the unknown, but there might just as likely be divergences in the design which might demand new approaches. The iPhone SE, for instance, has *one* screw that isn't magnetized, which according to one of the repairers in RS is consistent in its inconsistency, as compared to other screws in the phone being magnetized. It is in the same spot always, in the top right of the phone internally, and is a pequliarity of the iPhone SE described in a screen replacement guide on iFixit as well (Goldheart, 2019). The Samsung S5 has a daughterboard—a component for charging and audio—unlike other models, where the connector runs from back to front of the phone's internal, meaning the screen has to be removed for replacement of the daughterboard. As previously mentioned, the iPhone 8's screen glue also belongs in this group of deviations across types of smartphones.

Smartphone repair as traditional *and* industrial repair

Traditional repair to a high degree entails the practice of *fixing*, where you take a defective part and fix the part itself, rather than replacing it. The only case of fixing I observed in RS was in the instance of bent phone frames, a common trouble with the iPhone 6 and 7. According to one of the repairers from RS, frames of phones from these series have a tendency to bend, far easier compared to other series. It was difficult for him to say whether the 8 series has the same predisposition, as few phones from that series have been delivered to the shop, but he expects to see more repair requests for it in the future.

The iPhone 6 and 7 series stand out in their frames being easy to bend, resulting in an activity vaguely reminiscent to that of tinsmiths or mechanics, in which the repairers have to bend back the frame. In RS, this is done in an improvised manner with a chisel-like tool and a screwdriver (see fig. 16), a risky process that demands precise, but firm movement. A frame can be

Figure 16 - Tools for fixing bent frames

bent in varying ways, and in some cases the bending is too minor to be worth the risks of repairing, while in other cases it might prevent proper enclosure of internal components. Fixing the latter case depends on whether it can be done safely and adequately, and that it is economically sound for both repairers and customers. Performing such a repair will assist in making sure that the phone vulnerable to damage by moisture or filled with smaller particles that might damage the phone over time.

These observations are just some of the reasons why smartphone repair is a praxis highly formalized, athough not entirely, but it fits the categorization of being a type of industrial repair *moreso* than traditional repair. There certainly are differences between smartphones, and depending on the brand, series and models, one has to handle those difference and adapt ones practice to repair, instead of adding damages. Other than the rare cases of bent frames, repair of smartphones happened as *replacement* in RS. Screens and batteries, or smaller components like cameras or sub-components of the charging feature, were replaced rather than fixed. *Repair as replacement* in RS can be explained, at least in part, by the spatial constraints of the phone described above, and the complex, precise and advanced nature of the components used in and of smartphones is a contributing factor too. The level of quality these components have is largely due to rare minerals and high-precision factory equipment. *Repair as fixing* is an unrealistic option, due to demands in materials, tools and competency (see 4.2.1), and the inability to reproduce the level of quality offered by industrial means.

Both customers and repairers in RS spoke of the activities going on there as repair and fixing, but the usage of the word “fix” and the activities connected to it doesn’t give us all the pieces of the puzzle to resolve whether smartphone repair is a matter of fixing or

replacement. Colloquially, one might say “I need to have the tires on my car replaced”, but can we say that this is a fixing of the car?

Replacement as fixing *on another level*

Figure 17 - Slightly bent iPhone 6

Given a perspective of the smartphone as a whole, one could say that it is fixed through the replacement of parts, while the parts themselves were not fixed. As such, there is both fixing and replacement going on in RS; Smartphones as a whole are *fixed*, while parts of the smartphone are *replaced*. What is and isn’t fixed or replaced depends on the perspective of the thing. Glass for most cannot be fixed, but it can be replaced. In replacing the glass, the phone is fixed, and does not need replacing in its entirety. *Replacement on one level can lead to fixing on another.* As long as either fixing or replacement can happen on any level but the level of device, repair is possible and one can avoid replacement of the device as a whole, which might be conceptualized as a sort of repair. This particular topic will be further explored in 4.4, but staying with repair as it

can be commonly understood, what are the implications of emergent forms of repair for smartphones in regard to longevity?

Repairability and repair-ability can in a preliminary manner be defined as, respectively, *a thing's ability to be repaired* and *a person's ability to repair*; Repairability and repair-ability is the distinction between what a thing allows in regard to repair and how a person is able to perform repair of said thing. Smartphones are, as we have seen so far, devices that certainly allow repair, but it is made difficult by a range of reasons. For instance, the implementation of materials such as glue or glass, and lack of consistency across phone models and brands, externally and internally, can complicate repair. Standards can also contribute to the troubles of repair, such as through proprietary components. One stable trait of smartphones is the usage of glue, and so one can reasonable expect that repair includes dealing with glue. *This narrows down the potential scope of what repair is and how it can happen*, but on the other hand, how glue is implemented varies. In some sense, the aesthetics and functionalities of smartphones are to a certain degree generalized and allow some standardized practices, but there are at the same time deviations which complicates matters. In the context of smartphones, I will now relate some of the observations of how the professional repairers are able to overcome the challenges of repairing smartphones.

Lack of repairability or repair-ability in both owners and professional repairers can lead to unfortunate outcomes. If a screen on a smartphone is busted beyond functionality, but there are no replacement screens available, or replacements are considered too expensive, the most likely move forward would be to replace the smartphone as a whole. When neither fixing nor replacement of parts is possible, replacement of the whole happens, so as to regain the lost functionality through other things.

4.3.2 Signals of breakdown

The apparatus of repair is a collection of means and methods that emerge from the thing that is to be repaired. We have seen how there are certain practices that arise on the basis of aesthetics and materials, situated in the smartphone and its design. These aesthetics

and materials not only demands a constrained set of approaches, but they also afford ways of understanding what is wrong and what is right in regard to how a smartphone should be. This section will be a dive into *signals of breakdown*, and how smartphones in different ways can inform how they are broken down, starting off with the battery. These signals matter in relation to repair-ability, as they can assist us in narrowing down what is wrong and how to handle the problem. Signals of breakdown also signify how things are used or damaged, and in this there is a questioning of what makes something *more or less* through use or damage.

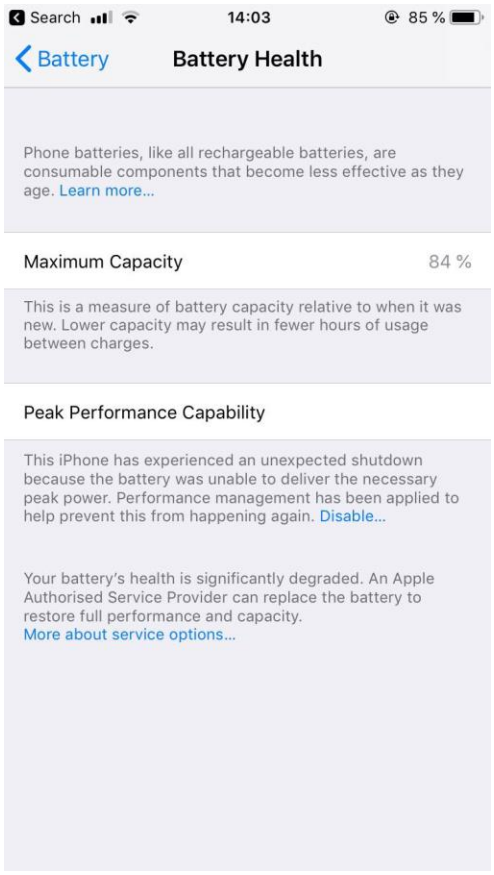

Figure 18 - iPhone built-in battery diagnostics

Batteries

A phone battery on its last legs primarily exhibits its deteriorated state in one way, which is through *experienced functioning*. What I mean by this is that one typically cannot smell, hear, feel or see whether a battery is in good health or not, but it is through using the phone *over time* that one can experience a discrepancy, based on expectations on how it *should last,* compared to how long it *actually* lasts. A nearly-dead battery's worn-out state is experienced primarily *through* use. Typically, one might hear people talk about their phone and its battery lifetime as "the battery's been getting worse and worse, I have to charge it twice a day now, before I could go several days without charging it when the phone was new". Access to the health of batteries happens through use for most owners, apart from those with particular technical skills and/or interests. Repairers, though, have diagnostics tools available for validating battery health. It simply stated a voltage, and the repairers judged whether it was within acceptable parameters or not. These devices are not common household items, and while the one in RS didn't interpret values for the repairers, it allowed the repairers insight into the battery's health without testing through use.

There are exceptions to the lack of sensorial information about battery health. A *damaged* battery typically exhibits two properties, namely by being bloated and/or exhibiting a certain smell. With an inflated battery often follows a bulge on the screen-side of the phone, which can result in a screen being pushed past its breakdown resistance, while punctured batteries have a particular smell to it. Drawing Harper's account of Willie the repairman back into the picture, we might not necessarily see a practice in RS which is quite as explicit in its responsive nature, between craftsman and material. Yes, sounds, smells and physical feedback, to name a few factors, still matter to the practice of smartphone repair, but it is less about concrete fine-tuning of activities, but rather selecting which activities are to happen.

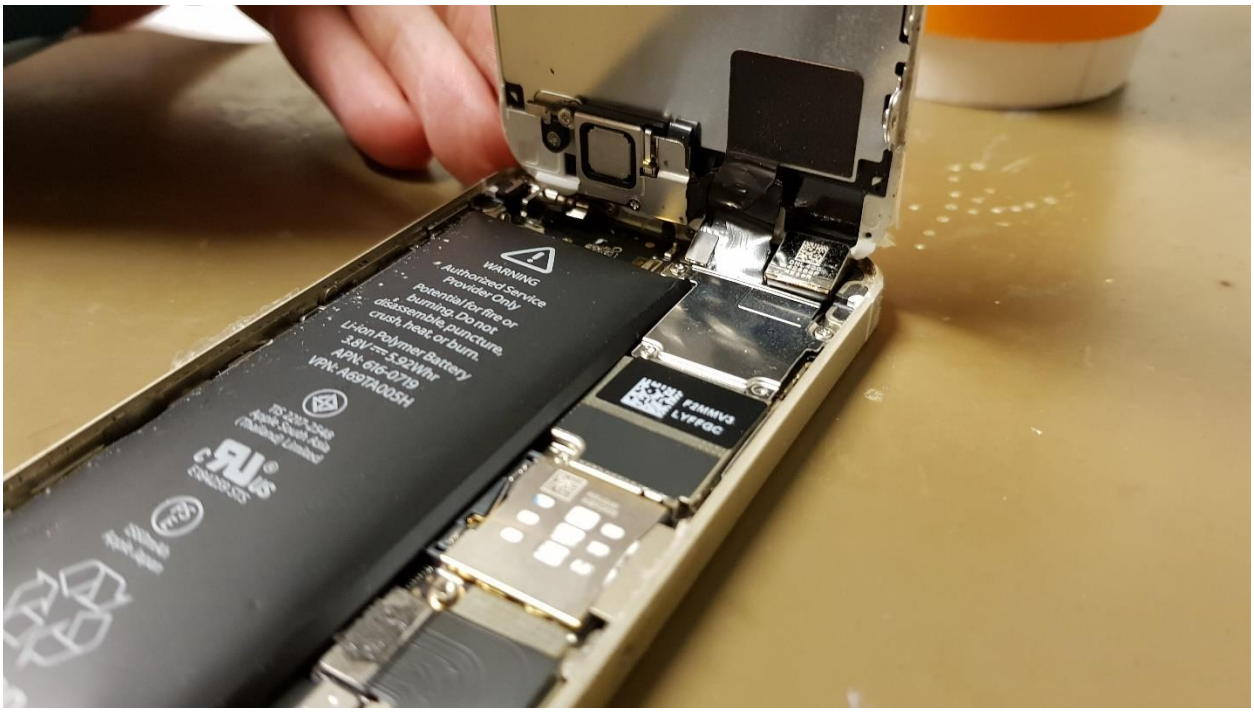

Figure 19 - Bloated iPhone 5S battery

These faults can arise from causes such as impact damage to the phone or production flaws. Here, then, we have two ways in which a battery's state of health can be experienced, spatially and olfactorily. Although these types of signals do not directly function as *denotative* signs, in that they lack an informing of *how* their source can be remedied, they do help to some degree in understanding the problem. This, of course,

requires an ability to link the signals and what they mean to their source, and to select appropriate ways to handle the issues at hand.

Damage or wear-and-tear as detriments or embellishments

Glass and batteries are good examples of how smartphones "wear out", or not, over time. Their different deteriorated states are representative of how smartphones are more prone to needing repair due to damages, rather than wear-and-tear. Scraping the surface of sensorial information and smartphone breakdown, smartphones observed in RS exhibited few signs of wear-and-tear. Possible answers can be sourced from the fact that the materials used in smartphone enclosures—plastic, glass and metal—are materials which are *more durable to use*, but not so much against damage. With wood and leather, signs of use emerge over time, in the shape of faded areas. In other words, one can see *where on the thing use has happened*. With smartphones, *signs of use can be seen as a detrimental form of aesthetic*, where the quality of its functions are reduced. For instance, if the glass on a smartphone could be worn down, visibility of what's happening on the screen would be reduced, and likely to become a nuisance rather than an embellishment. With old mobile phones, acrylic glass was common, which often resulted in the screen becoming scratched over time. In the case of an old chair, its clear signs of use *can* be something other than a nuisance. Certainly, a shaky chair leg is not something one would typically appreciate, but distinct marks from somebody you care for, who is no longer with you, is another matter entirely (see fig. 20). Here, wear-and-tear turns the chair into a thing that

is more than the functionality it offers, *but not at the cost of functionality*. Can damage become a form of embellishment?

Figure 20 - Embellishing signs of use

An important take-way from this subchapter is how the need for repair emerges from a distinction of smartphones as being either *worn-out* or *damaged*, though seemingly more liable to be in the case of the latter than the former. Interestingly, neither cases resulted in any other practice than that of *replacement*: Worn-out parts are swapped out with a new one, and damaged parts face the same treatment. Bent frames are sometimes fixed, and batteries were one type of component that exhibited wear-and-tear. No instances of repair observed in RS occurred due to other components than batteries being worn-out. Whether this was due to chance, that people are more accepting of smartphones as worn-out or that smartphones don't live long enough to become sufficiently worn-out, is difficult to say due to limits in my empirical work. Do the signals of breakdown described above make us more able to repair? Perhaps, but they are more powerful in the sense that they signalize the smartphone as a thing that needs repair, and *make us aware of the risks of having a phone*, practically and economically.

4.3.3 Repair assistance/assistants

Approaching smartphones with repair in mind, we are rendered unable without the assistance of tools and resources external to us. While signals of breakdown to a lesser

degree assist us in the repair of smartphones, the assistance I have in mind here are more explicitly shaped to bridge the gap between repairability and repair-ability.

Testing and diagnostics for repair

With most incoming items, a standard procedure is to test and diagnose. This is done, in part, as a means to check and make sure that the owner's explanation, if they give one, is correct and that nothing is overlooked. Diagnostics is also done after a repair is completed, to be certain that everything is in order and that new troubles haven't been added to the phone (for its owner and the repairers). With phones, the repairers typically test microphones, speakers (ear and loudspeaker), the proximity sensor, both cameras (front and back), and the touch screen. The repairer also checks for any obvious miscolouring of the screen. Some brands, such as Sony and Samsung, have their own diagnostics interface (see fig. 21), accessed by typing **#0*#* into the call field. This interface allows for a different approach to testing a phone's functionality: sound production, sensors, and more can all be quickly tested, rather than having to "manually" test functionality *through* different applications on the phone. These tests can also be an opportunity to learn what the different components are called, what they do (or can do), and how they respond to manipulation. For instance, some of the externally visible components on my phone were a mystery to me, in that I didn't know what they were as a component or what their purpose was. That was remedied by playing around in the diagnostics interface, simply seeing what happens without interfering during tests, and fiddling with the phone while the tests were happening.

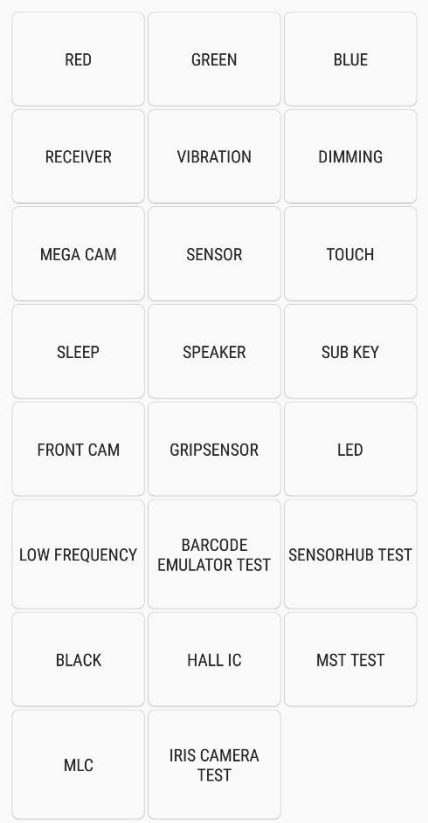

Figure 21 - Samsung diagnostics software

Returning to the battery as an example, other aids for repair-ability can be found in Apple's iPhones, as they provide a sort-of diagnostic tool which gives information about the properties of batteries—"batteries [...] are consumable components"—declares maximum capacity and Peak Performance Capability (see fig. 21). What Apple offers in their iPhones is one step in the right direction of leveraging repair-ability. Apple is perhaps one of the most rigid manufacturers when it comes to restricting access, dividing use and repair, with warranty voiding if a non-authorized repairer "tampers" with the device, and importantly, selecting who can be an "Apple Authorised Service Provider". Still, the diagnostic tool aids in understanding the battery and its state.

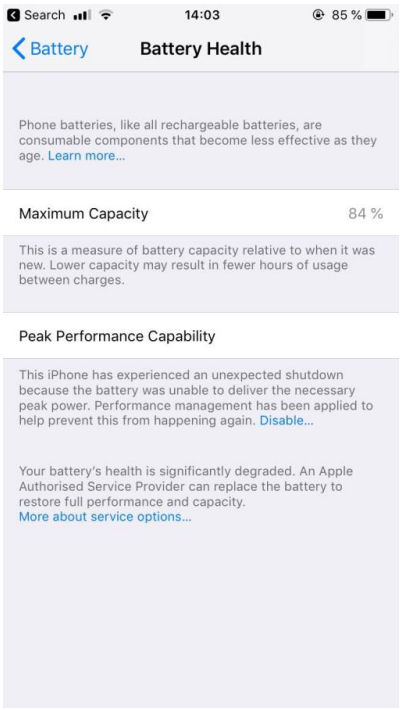

Figure 22 - iPhone battery health-check

Compared to the diagnostics tool available in certain Samsung and Sony phones described above, the iPhone battery health-check lacks opportunities to "toy-around-with", but it does bear with it opportunities to learn more about batteries and how they tie into the phone's functionality and well-being. In other cases, issues of reduced battery charge duration in cold weather are visible in their effects, rather than some material manifestation. To the owner, it might seem that the battery is at fault, but it might just as well be one of the components connected to the battery, hampering connectivity in some way. Figuring this out is a case of trying out things: First, to replace the battery, and secondly, to replace other components related to the battery. Finding charging faults that are localized in parts other than the battery also requires having spares of such parts, which owners rarely have. Batteries were the only components spoken of in RS as *consumer articles*, i.e. explicitly something which deteriorates quicker than other parts, the quality of its functionality reliant on how "fresh" it is. This is similar to how the mechanical hard drives are spoken of, which used to be more common in laptops, but still a staple component in many stationary computers.

Similarly, liquid damage to phones might be hinted from a phone not being able to be powered up, but additional hints might only be found in opening up the phone. There, traces of dried out liquids can sometimes be seen. Perhaps the phone even has a liquid damage indicator, as is the case with the iPhone 6 (see fig. 23). Note the red marker above the battery, which indicates that some form of liquid has been present inside the phone, enough to trigger a change in the indicator from white to red. One can also see faint traces of a liquid on one of the uppermost silver components. Liquid traces and red dots can both be indicators of liquid damage, though the former aesthetics is more likely to be resolved as being linked to water damage compared to the dot that doesn't have its purpose explained. Being able to link the red dot to liquid damage is not something that is clear in itself, at least less so compared to the water residue.

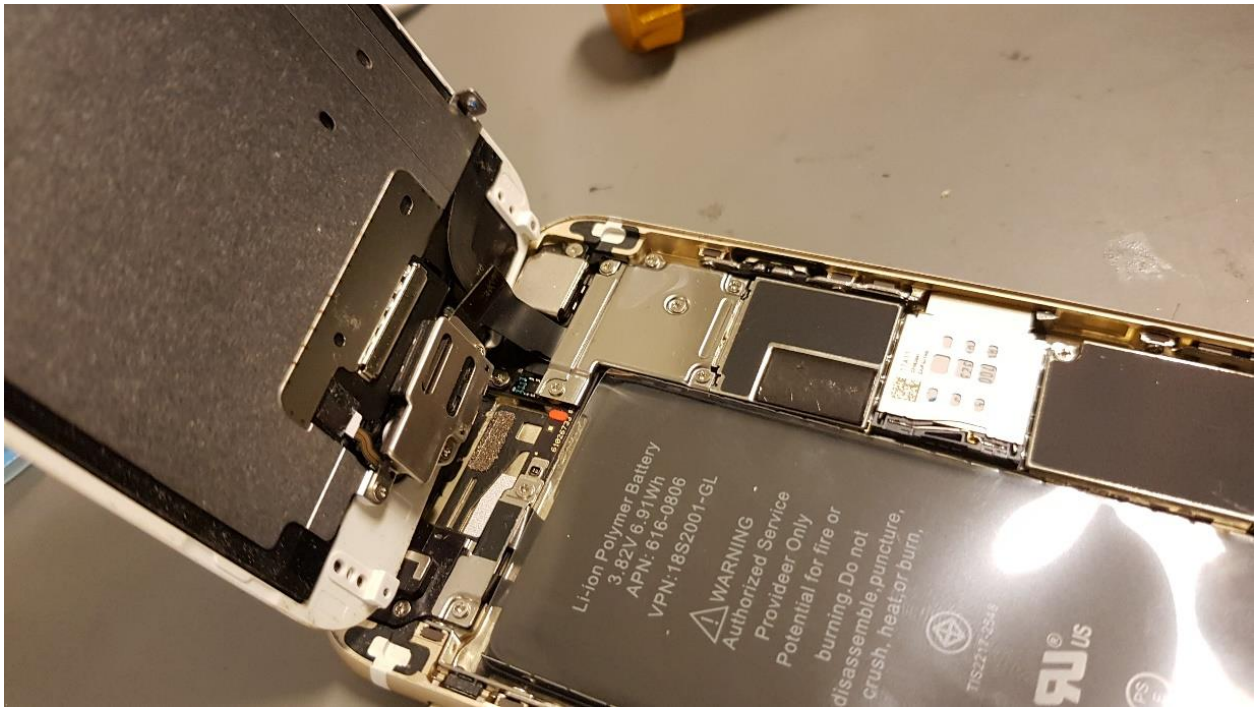

Figure 23 - iPhone 6 moisture damage indicator(s)

Figuring out the cause of issues was not always an easy task. These varied states of disrepair could be unambiguously tied to concrete causes, like the case of a bulging phone means the battery is defective, as nothing else in a phone has the capability of doing so. Many problems demanded disassembly to allow further delving into, and there weren't a single repair case during my visit that didn't require disassembly, an activity

which could in itself be a problem for the repairers. Sometimes, evaluating what is wrong and what the cost of fixing it is, can lead to breaks in repair shop visitors' expectations. Initial impressions might have been an easy problem with a cheap or appropriately expensive solution, but when a problem and its cost is larger than previously thought out to be, visitors might not be inclined to pay the price anymore. In these situations, a customer can choose to donate the phone to the shop, rather than paying the diagnostics fee and still be left with an unrepaired phone. By waiving the fee, the shop gets a phone which still has potential usefulness in that it can be used for parts or testing purposes in the future. Such phones can also be of use in data retrieval from broken phones, where they can take the screen from a leftover phone and connect it to the broken phone, so that data can be accessed and retrieved. The leftovers are treated differently, depending on the parts.

There is an arrangement in place where functional LCD or OLED parts, able to be disassembled from digitizer and glass, can be shipped to a 3rd party for a small sum. Items such as flex-cables, cameras and loudspeakers are kept around in case there might be a later need for replacement. Some components aren't kept, primarily due to sensitive data being stored on them, such as motherboards or other storage components. The repairers in RS are made more repair-able thanks to this arrangement of donating phones, as it means they will have more components available for testing or replacement. In the same vein, lack of repair performed in one instance of a smartphone can assist the repair of other instances. For instance, if one instance of an iPhone 6 is beyond reasonable repair ventures—perhaps it has a broken motherboard—parts of it might be used for another, *less broken* iPhone 6.

Repair of unfamiliar smartphones is risky business, given the possibilities for design differences. One way repairers in RS avoided going in "blindly" was through iFixit.com, a website that offers repair guides for a range of consumer electronics, "teardowns"—disassembly guides—a shop for tools and parts, and more. The repair guides on iFixit.com give detailed step-by-step instructions of primarily *replacement* activities, i.e. how to

change screens, batteries or other components. In each guide, the difficult of the replacement is listed, alongside necessary tools, time required for the procedure, amount of steps, and which parts one needs to complete the job. The steps give descriptions of what one needs to be aware of before starting, how to separate components, where certain tools are necessary, particularities that are important to deal with properly, and so on. These guides have an important role in reducing the risk of repair, dealing with smartphone design differences, and making those engaging in repair *repair-able*.

In a way, the many signals of breakdown with phones form routes for the repairers to follow in their activities. Physical, external manifestations of damage or deterioration can in themselves be that which needs to be fixed, but they can also point towards other matters that require sorting out. Tinkering with materials, components and devices that are highly sensitive to manipulation—due to their size, shape, natural properties and advanced composition—makes repair a risky process. It doesn't take much force for it to become excessive, pushing an already-fragile phone beyond repairable. Assistance for repair can be found from online guides, such as iFixit.com, sourcing spare parts from other phones, and using software for testing.

4.3.4 Repair-ability-for-experts and repair territories

Previously, I have spoken of *repair-ability* in relation to things, as how the properties of things can make people more or less *able* to perform repair. That is to say, a thing can be repairable, but how it is repairable affects *who* can repair it, and so an additional distinction is necessary here, to more clearly represent what the practice of smartphone repair is.

The general design of smartphones is highly *indicative* of a repairability that *constrains repair* in several ways: Smartphone design doesn't point as much towards *repair-ability-for-all*, but rather *repair-ability-for-experts*. This distinction is indicated in the lack of obvious ways of entering the phone, with glue as a likely alternative apparent in the *absence of alternatives*, components that do not have signs of their purpose, and more as elaborated upon in previous chapters (see 4.1 and 4.2). With the many required practices

to adequately repair smartphones as results of what essentially has to happen on the basis of trial-and-error, it is an increasingly expensive practice if something were to go wrong. These are just a handful of reasons why smartphone repair can be interpreted as restricted to experts, while it also requires expertise. Smartphones are devices risky to engage with on an amateur level, especially without appropriate tools, online resources and experience. *When* repair can adequately happen is when all of these repair assistants come together, bridging the gap between repairability and repair-ability, but it is an exceedingly high *threshold* to get past. Tools can be expensive and have a narrow area of application, for instance the tri-point screwdriver for Apple's proprietary screws, only applicable to Apple products. Online resources aren't necessarily easy to find or safe to explore one's way to, as the Internet is littered with websites that pretend to be helpful and relevant, but are in fact sources for malicious software. Even if you find an online resource, such as iFixit, that provides steps to fixing the smartphone in question, an exhaustive account of the bodily engagement necessary to perform an adequate repair is difficult, if not impossible, to communicate. At best, it warns of particularities of smartphones, such as how a glued screen should be approached (see fig. 24), that one has to be aware of cables underneath screens, and the appropriate sequence of disassembly.

Figure 24 - Screen replacement step for iPhone 8, screen capture made June 6th 2019, from https://www.ifixit.com/Guide/iPhone+8+Screen+Replacement/98255#s188093

The doing of repair is built on experience, and professional repairers have ample opportunity to practice repair, with the amount of phones they deal with on a daily basis in mind.

Repair-ability-for-experts can thus be reasoned from two aspects of smartphone repair: The material-aesthetics, in how smartphones indicate themselves as being impregnable, for good *and* bad, and in the challenging nature of dealing with glue, sensitive components, and not entirely obvious ways of approaching disassembly. Externally and internally, smartphones are troublesome devices, and this distinction between two the inside and outside leads us to *territories*.

Smartphones fall into the category of things described by Van Hinte, via Verbeek, as having two *territories*: one territory for the user and another, distinctly different territory for trained technicians (Van Hinte, as cited in Verbeek, 2005, p. 226). In the internal, experts-only territory of phones, there is a lack of denotative signs, of *how* they can be repaired. Of the phones observed, only the Samsung S8 had a distinct denotative sign which showed how *one* (of many) components could be removed by inserting a flathead screwdriver or similar tool into a notch and be flipped out (see fig. 25, top of the black component). Signs that explain what components are and do are few and far between, and is most common with batteries. There is not much space to work with in the interior

of phones, as any space is used with maximum efficiency, and the components have little place for explanatory text and no traces of representative symbols.

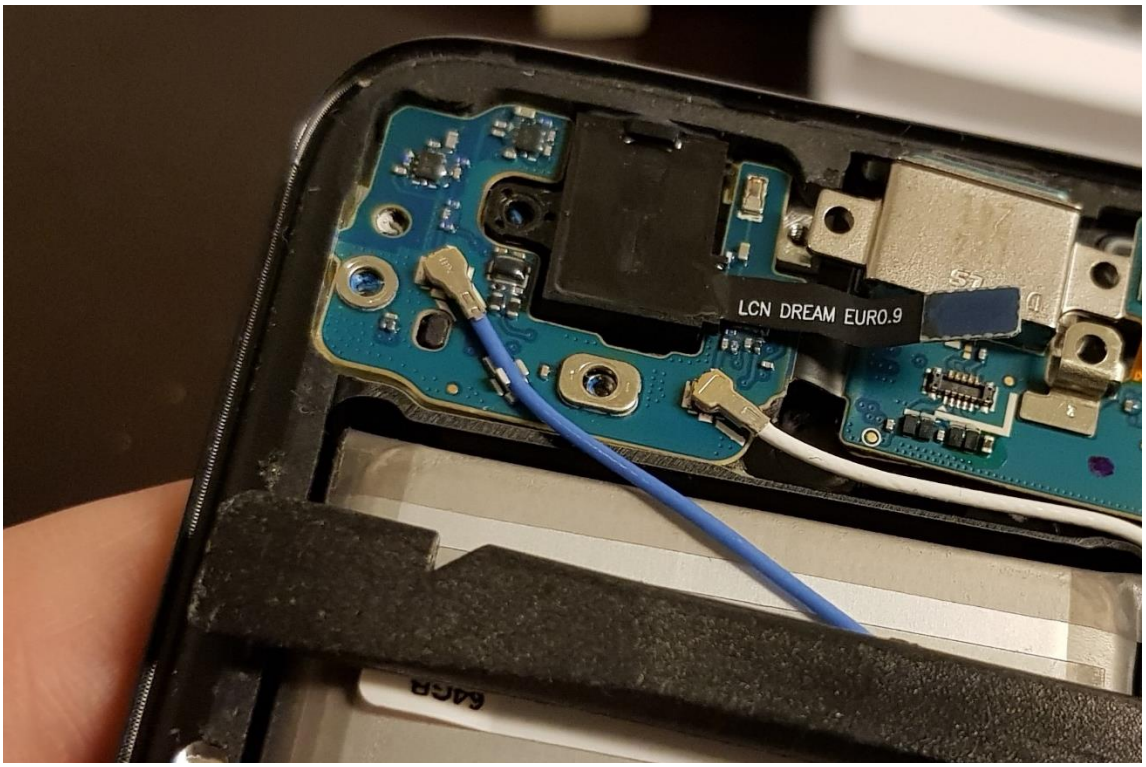

Figure 25 – A component in a Samsung S8 with a denotative sign for repair

Apple both in their software and in the materiality of phones have two fronts that point out the phone's internal territory as a restricted area, to be dealt with by experts. In the battery health app which can be found in iPhones, Apple states that an "Apple Authorised Service Provider" can replace the battery. Even if it doesn't explicitly say that the phone's inside is off-limits, it strongly indicates that a particular authority has to perform the replacement. It furthers the impression of an expert-only territory to be found inside smartphones.

iFixit has a repairability overview for laptops, tablets and smartphones. These are not exhaustive lists of all products on the market, but the lists typically include the most popular devices. Here, they rate products based on how expensive, difficult and/or complex they are in regard to repair, on a score from 1 to 10. Skimming through iFixit's overview gives some impression of how repairable the categories of mobile IT products are. I chose to take their data one step further, and worked through the entire list of

smartphones, put all products and their details in a spreadsheet (appendix B) to generate diagrams which could visualize how iFixit considers the repairability of the different brands and their series of devices (see fig. 26). This was done to gain some understanding of questions like whether repairability has gotten progressively "worse" or "better" through the years for smartphones and the different brands, if there are particular models that stand out in comparison to other series within the same brand, and so on. Looking at the averages of smartphone repairability, most brands keep within a score range of five to seven, with outliers like the Essential Phone, HTC and Amazon's Fire Phone, but overall, one could say that repairability hasn't changed much.

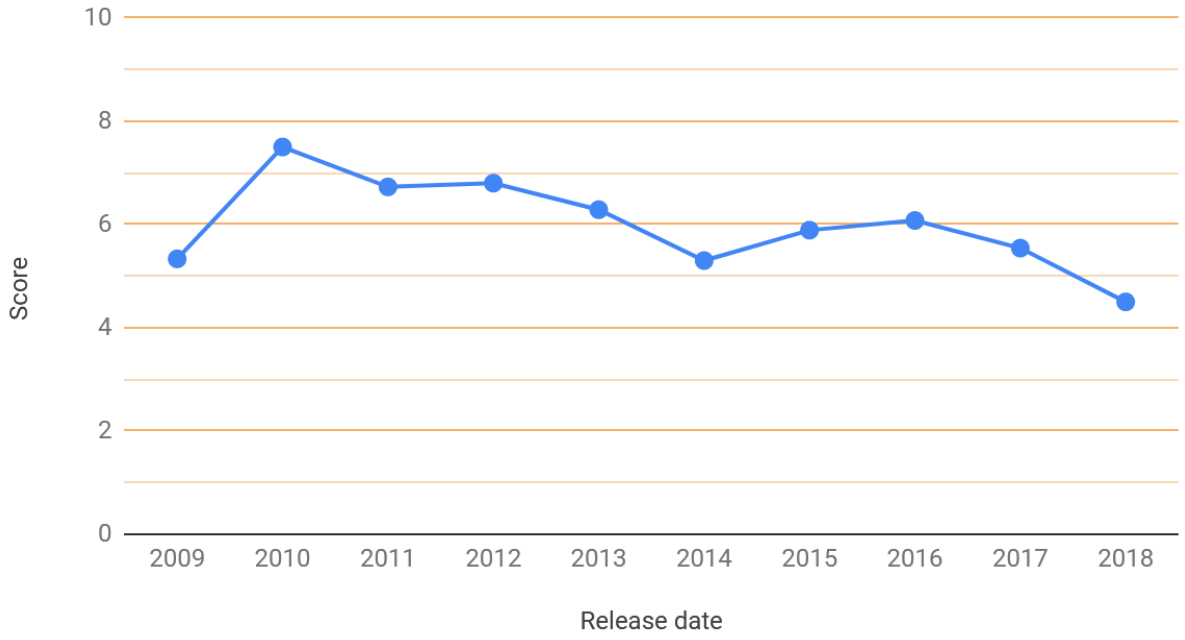

Figure 26 - Average repairability score over time for smartphones

According to one of the repairers I spoke to at RS, Samsung phones have a higher tendency to be similarly designed, and involving a similar practice, as opposed to iPhones and their cross-series internal design deviations. With this in mind, it is interesting to see how Samsung and Apple stand in comparison to each other on iFixit's notion of repairability (see fig. 27 and 28). This might be due to iFixit not scoring phones in relation to other phones, such as cross-series similarities. This matters as well when it comes to repairability, for professional and amateur repairers, in applicability of repair

knowledge across devices. Now, given a very uniform design of smartphone interiors, it would certainly increase knowledge applicability, but it would potentially put us more at risk of making mistakes, if one were to approach repair too laidback.

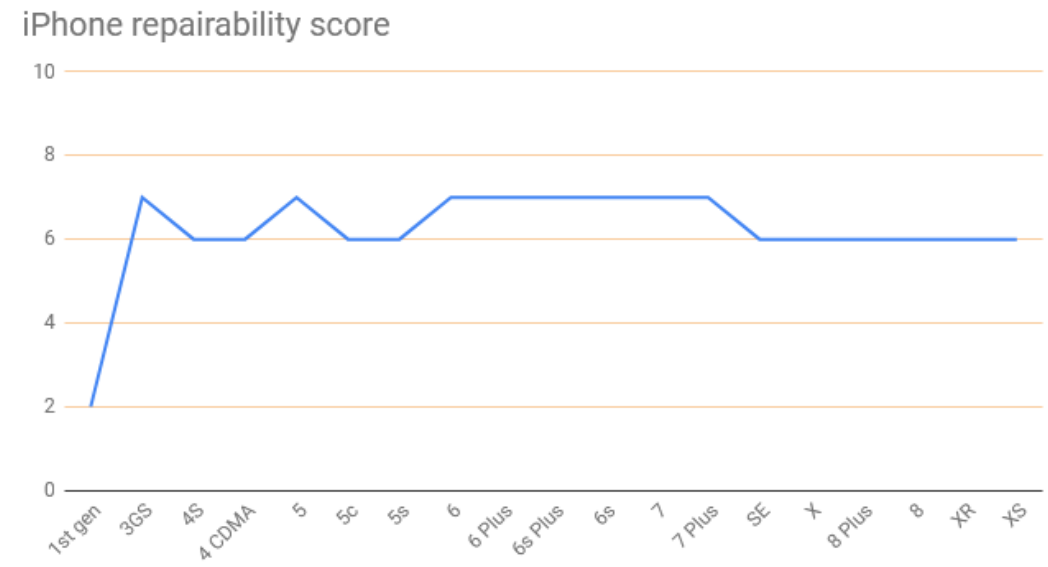

Figure 27 - Brand repairability, Apple iPhone

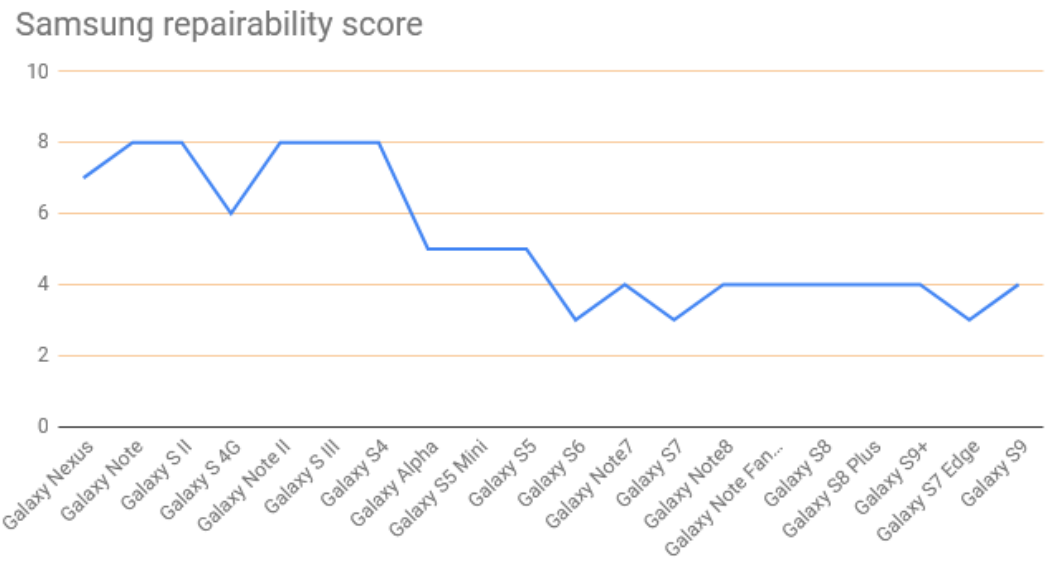

Figure 28 - Brand repairability, Samsung

If every phone was different, repair-wise, one would instead have to approach each new model with care, so as to not make mistakes. With a relational conceptualization of repairability in regard to cross-series applicability of repair knowledge, Samsung stands

stronger than Apple, though it doesn't mean that Samsung, as a brand, provides overall superior repairable products.

In summary, smartphones are not only clear instances of things that have two territories that segregate an owner's ability to interact based on use and on being able to repair. In a sense, the purchase of a smartphone does not "come with" easily available opportunities to repair. This is not a new trend, and while enclosure of consumer products can be seen as a protective mechanism, it sets a threshold in how we can approach them in attempts to repair. In extreme cases, the purchase of a product only entails its functionalities and not the restoration of the product once it breaks down. It can be likened to leasing subscriptions of cars and office equipment. In those cases, you are explicitly not an owner of what you're leasing, and the lease is on a strictly temporary basis. Now, while one might see all relations to things as temporary, with the premise of breakdown as inevitable, how I see it is not quite the same as what leasing agreements make it to be.

Ownership of products is partial in ways more than just in terms of the separation of use and repair. There is a temporal partiality to ownership as well, regardless of whether it is a product leased, in that at some point a thing will break down for good. What that breakdown is and how it can be handled is not always obvious: The use of a knife leads to it losing its edge over time, and so we might sharpen it, but what of a refrigerator? What kind of repair is possible and necessary in relation to such an object as it wears down over time? Strictly materially speaking, and from personal experience, I find refrigerator handles to be the first thing that breaks down, and knowing this, I might be inclined to investigate the design of refrigerator handles when looking into buying a new fridge, as broken handles are a nuisance worth spending time to avoid. From an aesthetic point of view, one might be able to imagine how use of a thing can lead to certain breakdowns

There are many factors in the design of smartphones that contribute to an impression of their repair as being *for experts only*, and the practices in themselves require a form of

expertise. In the next section, I will explore what the possible implications of smartphone material-aesthetics and emergent practices are for our relations to smartphones.

5 Insights: Aftermath of repair

Figure 29 - Smartphone repair post-op, with glue and glass residue

In the aftermath of having looked more closely at the material and practical aspects of smartphone repair, what can be said about them as able to shift between being functional and broken down?

5.1 Smartphone longevity

So far, we have seen how smartphones can fall apart and be put back together—the breakdown and repair of smartphones—but how can we relate this to matters of longevity? Longevity can be understood as a thing's ability to have a long existence, and it can be extended and shortened through different means. A long existence is a relative matter, as it depends on what sort of thing it is, what its use contexts are, its purpose, and more. Longevity of things are often conceptualized via metrics: A pair of running shoes might be built to sustain function through an amount of steps taken, the engine of a car is expected to last a certain number of kilometres driven. In other words, longevity can be a quantified concept, as *number of uses* (steps taken, kilometres driven). Previously, I have mentioned that the materials used in smartphones are more durable in regard to use,

rather than damage (cf. 4.3.2). This will be further elaborated upon in 4.4.1 as directly relevant for smartphone longevity, as connected to smartphone materials, design and practice. Here, my point is that the *way in which we conceptualize longevity* matters too, in addition to making consideration of how longevity is affected by design and practice. Smartphones, seemingly, are highly resistant to use, and so it becomes less relevant to count number of uses. Instead, it might be more fruitful to conceptualize it as *exposures to use contexts*. Exposures to use contexts might immediately seem equal to amount of use, but there is a distinction. Smartphones and breakdown, as I see it in a material regard, is not a matter of wear-and-tear, but damage. It is not in use itself, but in *contexts of use* where damage occurs, as smartphones are exposed to environments where damage can occur—in the vicinity of stone tiles, kids and dogs running about, on boats, riding bikes. As ubiquitous devices, there is an immense number of possible situations where smartphones can be used, but arguably, smartphones don't even have to be used to be damaged. Just moving the device between pockets can be ample opportunity for damage. Comparing smartphones to stationary computers, devices that are hardly ever moved about, we find perhaps the biggest threat to longevity in dust and overclocking, a technique for pushing the effectiveness of components past factory presets. The mobility of smartphones is, in a sense, the worst enemy of their own longevity.

Repair is a practice that causes extension of a thing's existence, a set of activities that strive against smartphones as broken down once, for instance, an accident has happened. Maintenance has the same effect, though it is situated in the before and after of breakdown, ideally, whereas repair happens during breakdown. The absence of those

practices will eventually lead to an end of a thing's lifetime, *even if it might have more potential to exist* with some assistance. Here, I will elaborate upon the following:

- How the design of smartphones constrain possibilities for longevity, in their physical materiality, *before* use, maintenance and repair has occurred.
- How there are hindrances for longevity in the design of smartphones, which makes restoration of functionality *less likely*
- How there is support for longevity as well, where restoration of functionality is *more likely*
- How hindrances and supports for longevity are not mutually exclusive, and whether an aspect of a thing is a support and/or a hindrance depends

To assist in the explanation of these points, I have made a model that is meant to represent *longevity constraints, hindrances for longevity and support for longevity*, gathered in thing-lifetime model (see fig. 30).

A representation of smartphone longevity

Figure 30 - Thing-lifetime model

The thing-lifetime model is made of three components: There is the preset lifetime (left-most, solid box), hindrances for extension of lifetime (vertical stippled lines) and lifetime boundary (right-most, stippled box).

The preset lifetime is built up via measures such as seals and materials that are designed and manufactured, like glue, glass, and metal. A "fresh out of the box" product, put into the world, will last for a given time through use, abuse, storage and neglect. The preset lifetime is how long a thing can sustain its functionality, through use, before intervention in the shape of repair activities has to happen. Naturally, it also hinges on factors such as the amount and type of use and context of use, which makes the preset point in time not a rigid construct. In other words, it isn't about whether a smartphone can survive falling unto the floor 1000 times, or that its buttons can be pushed 20 000 times before they no longer can function; Preset lifetime is a way to describe the *pre-existing constraints on longevity*. An artefact put into the world is where it will have its capabilities realized, and in the context of this thesis, the focus is on how its design holds up to the forces that either attempts to break it down or put it back together.

At the onset of a smartphone's lifetime, numerous properties come into play. The way it is shaped and formed makes certain types of treatments more or less likely, and so the smartphone is used in particular ways. While smartphones exhibited few signs of wear-and-tear during my observation in RS, acrylic glass and old chairs stand as decent examples of how patterns of use leads to patterns of deterioration (cf. 4.3.2). After some time, most things deteriorate and if one is so inclined, maintenance becomes an option to preserve the thing's ability to offer its functions. With smartphones, the maintenance techniques I observed or overheard talk of in RS were primarily 1) cleaning out residue

filters for sound components, or 2) using canned air to blow out residue from headphone or charging ports. The techniques assist in keeping functionality at an adequate level, but they do little to preserve smartphones from abrupt injury, which was the most common reason why phones were brought to RS from my perspective, which is where repair enters the frame of longevity. If a damaged phone cannot be repaired, and it is in an unacceptable state, then the lifetime of the smartphone is at risk, if not at its end.

At this point in time, repair is effectively a matter of life or death for the thing, and how the design of a smartphone affects repair practices is crucial to understanding how such a thing might not live to its fullest potential. The right-most box, made of stippled lines, is the lifetime *boundary*. It is made up of repair activities, accommodation of such, and more. The lifetime boundary is what opportunities there are to keep a thing functioning, in spite of breakdown. Important to point out here is that the model is meant to represent a thing as a whole, i.e. a Samsung S8+, a car, or a chair, and not the pieces and parts those objects consist of. In other words, in the field of the lifetime boundary, we find that which supports a thing's ability to still provide functionality, despite wear-and-tear or damage.

The vertical stippled lines are hindrances for repair, barriers which have to be passed for extension of lifetime to occur. Glue is *also* present here, though its double presence will be explained more closely later on. Components that, for instance, don't explain their function (lack of denotative properties) or demand particular tools also belong in the category of hindrances, in addition to lack of or limited repair resources. Examples are, respectively, most components other than batteries, screens and cameras, Apple's tri-point screws, and guides which are difficult to find or non-existing. Van Hinte's interior territory examples of warning stickers also fall into this category, as it discourages repair, but more explicitly than the lack of signs (Van Hinte, as cited in Verbeek, 2005, p. 226). A smartphone has, in its "factory state", measures against breakdown and for repair. The distinction between *against breakdown* and *for repair* is an important one, as measures can have both effects, and opposite effects. A seal, such as glue in smartphones, might act

against breakdown, but it can also *act against repair*. From my observation of glue's presence in RS, glue seems to be a material that can act against breakdown by protecting from moisture damage. It can also expedite or prolong breakdown as well, if repair is performed inadequately, for instance by not being careful of exceptionally strong instances of glue or performing imprecise repair. Glue can make repair difficult and troublesome, but it also has the ability to streamline the repair process, making it a simple matter.

Employing my observations of smartphones and smartphone repair, we can start to put the smartphone somewhat systematically into a context of longevity.

Longevity constraints

Figure 31 - Preset lifetime, leftmost black box

Preset lifetime is a fairly simple notion, but it affords us some insight into where trouble begins with smartphones. Starting with the preset lifetime of the iPhone 8, we have seen how it is a fairly standard iPhone materially and aesthetically, but the glue used for its screen is above average in strength. Before any repair needs to happen, the glue sets rigid conditions in disallowing entry of dust, grime, moisture and so on. It will also help keep the phone assembled, and play some part in the prevention of tampering. From the observations in RS, other materials used in smartphones, such as glass and metal, seem to have a certain durability in regard to use. While replacement of batteries stands alongside screen replacement as the more common cases of repair in RS, I observed no other cases of repair due to wear-and-tear. The assumption that smartphones seem to be more resistant to wear-and-tear, as opposed to damage, is based on this observation.

Smartphones and their lifetime thus hinges on careful use, or perhaps just being lucky. In theory, it has the ability to last for quite a while given that no accidents happen to it,

although there is probably little comfort in this for those who have to visit a repair shop. Luck is a factor beyond use and its contexts too, where the quality of a product depends on the production of it. Sometimes, instances of the same type of thing, such as a pair of scissors, an iPhone 8 or a cabinet, can vary in quality due to flaws in the production. Two different instances of the same hammer can have different resistances to wear-and-tear or damage, where for instance the head of one hammer just breaks off due to flaws in the metal used, whereas the other lasts for many, many years without a hitch. Means for mass production is not exempt from deterioration and breakdown either.

Smartphones and their preset lifetime are disconnected from the things that *do* happen to smartphones: We aren't always careful, we aren't always lucky and we can't always be mindful either. Here is also the exact point where smartphones' room for an extended lifetime suffer in many regards, as its design is seemingly disconnected from breakdown as inevitable, repair a practice made difficult for owners. As a functional thing, to be kept functioning, what makes a smartphone have a preset lifetime becomes a trouble once the smartphone reaches this preset lifetime. Preset lifetime is about how design, materials included, frames a thing's lifetime, *and the possibilities for extension of lifetime,* through maintenance and repair activities. It is not only about how smartphones can resist breakdown, but also what kind of engagement is likely once breakdown has happened.

5.2 Hindrances for longevity

Figure 32 - Barriers against repair, red vertical lines

Hindrances for longevity follows more or less along the lines of Verbeek's barriers against repair, the aspects of a product that makes repair less available to us (2005). Verbeek ties these barriers to how a thing can be more or less *transparent*, in the sense that we can understand and have access to how a thing functions, and thus be able to "restore their

functioning" (2005, p. 226). From my observation in RS, I consider smartphones to have several problematic aspects that act as hindrances for longevity, in making repair an activity less available.

When a smartphone breaks down, glue is usually the first barrier one has to deal with, a literal barrier for repair, and a barrier in other regards as well. With cars, one usually start off a repair activity with popping the hood, gaining access to the engine room. Some cars might have a simple button for this, which opens up the engine room all the way. In other cases, you might have to push the button, which only slightly opens the engine room, push your hand into the opening, search for and detach the latch that is locking the hood in place, and position the rod that allows the hood to be held open. Another example of an enclosed area for repair activities can be found with laptops. Arguably, well-designed usage of screws in laptops, for keeping things together and restricting access, would be that by turning the laptop around, one can see indentations in the casing, which symbolizes holes where screws can be found. This is not always the case, as those indentations can be covered up by stickers or have rubber plugs to fill the holes.

At the point of breakdown, glue turns from being a protective seal to a barrier for repair. Glue can complicate entry to the phone, necessary for most smartphone repair practices, and as such, influences the preset lifetime of the phone, as well as the lifetime boundary. Smartphones do not have buttons to "pop the hood", latches that can be detached, no rods that can hold it open. In the case of most recent smartphones, you won't see any indentations which contain screws by turning them around. They aren't covered up with rubber plugs or hidden under stickers: *They're just not there*. In place of these entry points we have glue, and it doesn't reveal its presence but *through the absence of alternatives*. One can reasonably expect that there exists a collection of things which we relate to as able to *give access into things,* and I make the assumption here that this collection consists of the objects described above (and more): Latches, screws, handles, indentations, ribbed surfaces, and so on. None of these are present, and you can't push, pull, flip or twist smartphones into opening. You *could*, with enough force, but if your

goal is to repair and not destroy, those are hardly valid options for interaction. You can't see the glue and there is no crack to stick your hand, finger or nail into to find it, as it is so seamlessly implemented and covered up. You would be hard-pressed to find any cases where glue shows from the outside, as that would be a deviation from its seemingly perfect, whole and complete aesthetics. Instead, glue constrains repair in that it demands a very particular procedure that isn't apparent in itself, unless one has previous experience with repairing phones, and their procedure is far from obvious.

To some degree, knowledge of repair can be attained from reading guides, but the aspects of phone repair that involve an embodied practice are difficult to communicate. The example of iPhone 8 glue is relevant here: I can explain what the troubles are and how one should approach it, but to be able to feel and "know the right feeling" when the glue is letting go, is only available through practice and experience. Breakdown reveals glue as a hindrance for repair, and at the same time glue also initiates a breakdown of repair. It sets in motion a troubling engagement, for the uninitiated non-experts:

- It is an engagement that is not obvious or informative,
- It is particular and demands certain tools,
- It has to be experienced to be understandable.

The seamlessness of smartphones, aesthetically and materially speaking, offers little in regard to just opening them up. Returning smartphones back to being these previously seamless things involves more than just the repair of broken parts, the activities necessary to *get to that part* is somewhat of an ordeal in itself. Smartphones *could* have employed notches for prying or ribbed surfaces for pushing the covers off, like older phones, but in those days the screens were not interactive, they simply displayed information and responded to input given via buttons, distinctly separated from the exterior. Whether older phones are the superior repairable thing, compared to the smartphone, is not the point here. Rather, it is about *availability of repair*, in the sense that a slide or pry type of motion is potentially a simpler and more obvious interaction than having to deal with glue.

5.3 Support for longevity

Figure 33 – Lifetime boundary, stippled green box

Glue, as a barrier, functions not only against repair, but also against breakdown. For however long the phone has functioned, glue has kept it more protected from dust, moisture, pocket lint and other residues. Glue is a material not inherently bad for repair, and the repairers from RS displayed an ambivalent relationship towards the material. It can be a hassle dealing with it if they aren't familiar with a particular phone, but it is also a relief from screws. Glue doesn't have to be kept track of or replaced if lost (you can't really "lose" glue), and it doesn't come with the potential of critically damaging components, as is the case with some iPhones. The iPhone 6, for instance, has a component with three screws of different lengths. One screw tightened in the wrong spot and you'll be left with a real mess to deal with. Glue, as it is used in phone repair, is either in the shape of strips or it is already included with the component. With batteries, for instance, you remove the film on the glue strip from one side, place the glue strip on the battery, pull off a protective film on the other side of the strip, and place the battery where it should be. In a sense, whether something is a hindrance or support for either repair, breakdown or longevity depends on where the thing is temporally located in relation to breakdown. Glue is a hindrance for breakdown *before breakdown*, but a hindrance for repair *after breakdown*. And yet, there is more to it than this.

The many elements of a smartphone that acts as hindrances for repair are hindrances for breakdown as well, but when breakdown has happened, they *can* become support for longevity after breakdown, in the sense that repair is accommodated, which allows a restoration from a state of breakdown. This turn from hindrance to support happens *when a person has the right competencies*, i.e. when they are *repair-able*. What makes us repair-able—for example tools, manuals and experience—also makes the thing able to

continue to provide its functionality. This is not to say that longevity cannot come from other sources, but having repair as a possible activity is an important one. Without even repair as replacement of components, we are left with the option of replacing the entire device. While repurposing or re-using the components that are still usable is a valid second-best option, as the latter is performed by repairers in RS (see 4.3.3). But, if we want a thing to live a long life, rather than just some of its component, supporting longevity is critical. And so, glue becomes a material that for one person can be a hindrance and for someone else a support, which is where its effect on the smartphone's longevity is realized. Glue can support longevity when repair is performed by someone skilled with the material and familiar with particular instances of it (iPhone 8, Samsung S10, or Huawei P20). So to a question of "does glue hinder longevity?", I'll answer "it depends". It depends on factors such as how glue is implemented, it depends on whether a thing is broken down or not, and it depends on the person attempting repair.

The possibility of repair as either/or—we can or can't repair and thus repair happens or doesn't happen—is an inadequate description in the account of smartphone repair. Based on my observations, the theory I lean on and the analysis performed earlier, it seems that smartphone owners are very much pushed away from repair as an activity available to them (there certainly isn't much about it that *invites* repair). All of these troubles can be overcome by the repairers. For one, they have the opportunity to experience and practice with a range and an amount of products that hardly any non-repairer will be able to. If we assume that a typical person goes through two to three phones in the span of five years, a repairer works his or her way through that number in a few hours. It allows the repairer to gain both a wide and deep knowledge of smartphones, and their similarities and differences, although it must be mentioned that the repairers in RS chose to delegate phones based on how much experience they had with different brands (personal preferences towards the brands they had the most experience with). They won't become experts in all brands, but they have a base of knowledge that is to some degree relatable to other brands. As a business, they can afford to have a large assortment of tools. As a result, they will in most cases be prepared and able to perform any repair on short notice

without the need to be concerned whether they have the necessary tools available. There are measures in place that give the repairers room to venture safely into smartphone repair activities, in the sense that if something were to go wrong with a repair, both repairer and customer are economically safe. It takes time, effort, tools, competence, and spare parts, not to mention a willingness to succeed.

In spite of the barriers for repair, repairers are able to do their work due to the reasons stated above and these factors make professional repairers *repair-able*. Ideally, such a mesh of necessities for smartphone repair wouldn't be hurdles for owners to overcome. Unfortunately they are, and this is what makes repair a less likely activity for someone other than professional repairers. When repair is a less likely activity in relation to smartphones, repairers are an important group of actors in the context. When longevity is threatened by breakdown, repairers enter the frame and work past barriers to extend the lifetime of smartphones. At the same time, they allow for an extension of the *relation* between smartphone and owner. If the reason someone brings is a smartphone to a repair shop is because they are not repair-able, it is likely that without the repair shop as an option could put the owner on a path of replacing the device as a whole.

5.4 Longevity and relations

Without repairability, repair-ability and longevity, there is no return from breakdown for the device as a whole. A smartphone which falls into this state might be used as a source for spare parts, as repairers in RS did, and can support relations between *other* owners and smartphones, but the relation between the owner and the defunct smartphone is effectively over. If the defunct smartphone had longevity, and could be repaired, then the relation's continuation would depend on the owner, rather than the thing. Here we find place for the reintroduction of *instrumental relations* described and made accounts of by Verbeek (2005). In instrumental relations, what we are primarily concerned with is that functionality is available. When things break down, and concern for the thing is based on functionality, rather than *affection* as an example, we are liable to achieve restoration of functionality through other things that offer functionality similar or identical. Longevity-

wise in relation to smartphones, a worst-case scenario would be that a smartphone is repairable, but *isn't* repaired, where the owner decides to *replace* the smartphone with a *new* phone, and disposes with the old one. This perspective of smartphone-owner relations as purely functional is what I will base my considerations of here, and while relations likely consists more than instrumental concerns, I will restrain myself to the functional level.

Use-repair dichotomy

As interactive devices, smartphones are built for and accommodates use, but repair as a type of interaction does not emerge as having the same intentionality behind it: Smartphones seem to be a case of "use for the Users, repair for the Repairers". What I mean by this is that there is a clear distinction between what use, breakdown and repair is, but I argue here that this is not the case. Use leads to deterioration, and damage occurs in contexts of use. Smartphones are ubiquitous and all contexts are at this point possible use contexts. Breakdown can emerge from deterioration or damage, and repair is the return back to things being usable. Repair is contingent on the design of the thing, which is more or less based on functionality. Breakdown happens as an effect of the vulnerabilities in design. My point is that use, breakdown and repair *flow into each other*, but my account of smartphones in RS reflect a "use first, repair later". This is of course the natural course of things, unless you're extremely unlucky and a thing is unusable from the relationships' onset.

What does this mean for our relationships to smartphones? We are more likely to enter the role as purely a user, rather than also being a repairer: being an owner is being a user. This is not new and can be likened through the increasing complexity of that which permeates our daily lives and ways of interacting. Cars, phones, lighting, thermostats, and more are at an increasing rate being embedded with information technology, and repair means to not only understand the thing as it was "traditionally", but also as a thing *with* information technology, an additional layer of complexity added. Verbeek encourages a more-than-functional relationship to things, as made possible through *transparent* things

which make available their functioning, as a matter of understanding and practicality. But how can we enter such a relationships when there is more than just signs and materials that get in our way of repair activities? An unresolved question at this point is also whether fixing is preferable to replacement when it comes to the constitution of more-than-instrumental relations. If repair on the level of fixing involves a *material* understanding and a sensorial engagement—think woodcarving or blacksmithing—it might be that we are *more* likely to enter a more-than-instrumental relation with the thing in question. While repair as replacement is not quite there, it is still a kind of engagement that involves being in the thing, rather than just relating to functionalities offered by it. It is difficult to say if repair in relation to smartphones can nurture more-than-instrumental relations, but repair activities do extend the possibilities for instrumental relations to exist *at all* beyond breakdown.

Abstraction of instances

Within this conceptualization of hindrances or support for longevity, we can begin to see how other artefacts and services external to smartphones can contribute to a lack of restoration from breakdown. Certain phone service providers offer services where used phones can be swapped out for new ones on a yearly basis. It is problematic that replacement of devices is made less expensive, and effortless, than replacement of components, i.e. repair, as it paves the way for disposable relations and concomitant treatment of things as easily disposable. As I interpret Verbeek's account of instrumental relations, it seems that such relations are attached to the functionality offered by things, rather than the particular instance of what offers it. Lack of transparency is one way of explaining why we relate to things on an instrumental level, which ties to lack of repair.

What Verbeek and many of his sources speak of is an abstraction of things' machinery, i.e. automation, to allow the use of the things without concern for their inner workings, although the effects of such design varies from author to author. It is only naturally, then, that one can see a treatment of the things as something abstract, when how they work is obfuscated to us. Smartphones are not treated as their materially whole being, but there

are few paths available for such treatment to occur. To permit the functions they offer, things have to be abstracted, automated, away, or else we would never reach the point of use. It is not conceivable for one person to have an exhaustive understanding of smartphones, it is far too advanced, but also built up of materials and composed in such a final way that we are left distanced from the thing. Attempts to *close the gap*, so to speak, occur through accessorizing, for instance, where one tries to make a thing distinct, concrete, by coupling it with other things. For the smartphone, one can buy particular covers in plastic, wood, metal or other materials, as the smartphone in itself does not provide opportunities for being made personal *materially*. Smartphones exhibit completeness to a high degree through their material aesthetics. Their composition and the materials used are very much final, in that there is little room for improvisation. Take glass, for instance: As a material, it can be polished, sandblasted, and more. When glass breaks, one might be able to glue it together for a somewhat temporary fix, but in the context of phones, there is little room for any fixing of glass. The frame of the phone demands a certain shape to the glass, and glass in itself *should* be whole. Much like Verbeek's example of a power adaptor for electronics is a sealed thing, indicating finality, smartphones do the same, although the practicality of the matter is different.

The apparent completeness of a thing disintegrates with the thing, but the implications of this can vary. While a couch degrades into a thing rough around the edges, with torn seams and worn-out fabric, it allows patching-up and repair back into some shape. Disintegration of smartphones, as seen in the repair shop, is very often a case of sudden *damage*, and rarely a slow process of *wear-and-tear*, the latter an important source of

Smartphones' state of being as broken down and ways of being broken down, *through* damage, *into* concrete things no longer purely functional, goes beyond longevity. Smartphones, through the lens of breakdown, are things which limit possible and likely ways of interaction—with repair in mind—and ways of relating. On a relational level, repair of instrumental relations becomes a matter of replacement, rather than repair. By

this I mean that if we simply care for the functionalities offered, and relate to a thing as its functionalities, repair can happen through replacement of the device.

5.5 Interlude: Reflections on empirical work and analysis

Based on my theoretical apparatus, inspired by the work of Jackson, Verbeek and Harper, I have shown how an analysis of smartphone design and the emergent repair practice has differing consequences for smartphone longevity, as influences on repair. In the shifting state of smartphones, between being functional or non-functional, their materiality shifts as well from being a hindrance to support for longevity. Glue can simultaneously be a hindrance or a support for repair and longevity, but it depends on whether the repairer is repair-able, a matter of knowledge, tools and resources such as spare parts, repair guides and more. While repairability describes whether a thing can be repaired or not, repair-ability is the description of what is necessary for repair and perhaps more importantly, *when* repair can happen. Whether something is a hindrance or support for longevity is realized *in relation to breakdown*. Similarly, repairability is realized in relation to repair-ability, i.e. repair can happen when the necessary tools, competencies and guides are present. Verbeek's notion of transparency, and material obstacles for repair described by him, is important to understand how things emerge as difficult to repair, and thus hinder longevity.

On the other hand, those same material obstacles can, for instance, accelerate repair and support longevity under the right circumstances. This is in addition to being obstacles, and as a result, the design of smartphones and implications of design for longevity might be better understood by making distinct the *temporal* relation between smartphone design and breakdown: Before breakdown, glue can be a support for longevity, and during breakdown—prior to repair—it can be a support or a hindrance. In addition to this, and unresolved at this point, there is the matter of repair and longevity *after* breakdown, e.g. what a thing's state of having been *repaired* means for longevity, repairability and repair-ability. Naturally, a thing being repaired means to extend its lifetime, but the specifics of this is unclear. Does having been repaired mean ease of repair for consecutive repairs?

What are the implications of "inheriting" a repair case? Unfortunately, opportunities to investigate implications for repaired smartphones on longevity were missed and is a weakness of the empirical work.

The practice of smartphone repair is not a simple matter, as it cannot be neatly placed within either category of traditional or industrial repair (c.f. Harper, 1987). It is a practice dictated to a high degree by material rules, standards and other formalizing means, but the practice is still situated. As an example, glue can be similarly, and reliably, implemented in instances of the same smartphone model, but the transferability of this knowledge to other models varies. Due to this variation, a careful approach is necessary when repairing different types of smartphones. Disassembly is perhaps the step in repair processes most contingent on particularities of phone models. In the end, past disassembly, repair happens primarily in the shape of replacement, rather than fixing. It must also be said that the distinction between fixing and replacement is troublesome. Looking at components, they seem to be replaced, rather than repaired, but looking at the device as a whole, it is fixed, rather than replaced. Capturing the essence of smartphone repair is just as difficult as defining repair as a general concept (c.f. 2.3) and is most likely an effect of it being within the same conceptual "family", as based on polymorph and situated properties. If longevity of *devices* is a goal, then it does not matter whether repair happens on the level of replacement or fixing, as long as the device as a whole is not replaced.

Bringing sustainability into the picture, here might be a good opportunity to look at how *frequent* instances of smartphones are repaired. As a matter of longevity, the existence of repairers is important for the possible extension of smartphone lifetime not only due to their repair-ability, but also as *mediators* for relations between smartphones and their owners. Repairers can in this regard be conceptualized as *extenders of smartphone lifetime,* although the implicit objectification can be somewhat problematic. Nevertheless, when smartphones break down, and their owners are *not* repair-able, regardless of

willingness, ability or other factors, repairers allow the relation between thing and owner to continue. Repairers make room for relations to persist, despite breakdown.

The understanding of smartphones and repair I have built so far is through a world view driven by Jacksons broken world thinking. Broken world thinking led me to the investigation of breakdown and repair contexts, and a perspective that makes related phenomena apparent. Breakdown can be used as an analytical lens for a particular understanding of how things break down and the contingent repair that happens. Here, I have looked at the how, and to some degree why, of smartphones' breakdown in RS, as well how the repairers' in RS handled different, but similar breakdown cases.

The discussion chapter that now follows will primarily be centered on questions of longevity and relations. My analysis has been focused on the material aspects of smartphones, but as artefacts of embedded information technology, software is also a crucial dimension of smartphone design. This dimension will be brought into the discussion to illuminate how software can be a contribution or detriment to the longevity of smartphones. Breakdown as a concept will also be discussed, in the light of it being an analytical device.

6 Breakdown of longevity

"Repair inherits an old and layered world, making history but not in the circumstances of its choosing"

Steven Jackson, Rethinking Repair

In chapter 4 and 5, I presented a view of how the materiality of smartphones can affect repair and longevity in different ways. For instance, the effect materials have on repair as a practice depends on factors such as access to tools, availability of spare parts and competencies (c.f. 4.3.4). The materiality of smartphones can, in ways other than through repair, also hinder or support longevity. Furthermore, materiality affects longevity differently depending on the state of the thing in question. Materials can support longevity prior to breakdown and hinder it during breakdown (c.f. 4.4.3-4). The theoretical framework created in this thesis, inspired by Jackson, Blevis and Verbeek, succeeds to some degree in explaining the materially situated ways in which the design of smartphones can fail to support repair and longevity. This, in turn, can be used for a critical view of what a materially oriented design for sustainable smartphones is. To a lesser degree, it also enables a conversation of how attachment, or lack thereof, emerges in relations between smartphones and people.

This chapter will be a discussion of attachment, on a physical and digital level, as a means for longevity, what place repair and use has in this context, and the possible implications of attempting to accommodate for attachment through design. I set out with two research questions in mind:

[RQ1] *How can the design of smartphones affect our ability to repair them?*

[RQ2] *How can smartphones be designed to accommodate longer ownership?*

In the closing section of the chapter, the research questions will be revisited and answered in light of theory, empirical work, analysis and discussion performed in this thesis.

6.1 Longevity through attachment

When smartphones break down, people seek resolution for their material troubles, for instance through repair. If they cannot perform repair themselves, they might attempt to seek those who can repair. Should this fail as well, a likely path forward is *replacement of the device as a whole*: New phones can easily be bought in just about any electronics store and several phone service providers offer to swap customers' "old" phones with new ones. In this sense, repairers such as those in RS provide an important service as *mediators of relations*. By this, I mean that repairers not only extend the longevity of the smartphone, but the owner's attachment to it as well. Even if that attachment is based on an instrumental relation, and even if the practice of repair is that of replacement, rather than fixing. Other efforts than repair, into reducing replacement of electronics *as a whole,* can be found in the work of Kim and Paulos, who built a *reuse composition framework* (2011). Their intent was to encourage "creative reuse of obsolete electronics by everyday people", to broaden the horizon of possible ways in which people themselves can redefine not only functionality, but shape and form as well of "e-waste" (Kim & Paulos, 2011, p. 2395). This is a manner of thinking *differently* about the functionality of things, particularly in their state of being non-functional, i.e. as "e-waste" or as "obsolescent" things. Being caught up in efforts of maintaining functionality, Kang and Jackson provide an alternative perspective on breakdown, where

> "[a] typewriter is always a typewriter while a typewriter; once broken, as our artists show, it can be just about anything. In this way, function can constrain and obscure, locking objects into a world of necessary dependencies that limits the kinds of relations we may imagine with them (though rarely as completely as designers may imagine or perhaps hope)." (2014, p. 457).

The authors make the case that objects, in the state of being broken, have a different potential purpose, beyond that which was designed. This, of course, hinges on a creative inclination to do so and an ability to perceive that potential. Longevity here becomes a matter of how we engage with a thing, where functionality *itself*—and not just practical effects of dealing with materials that allow certain functionality—can act as a hindrance or support in how we relate to it. This also relates to the framework by Kim and Paulos, who attempt to bring this creativity to the level of non-artists. Being part of an art project or having an artists' perspective, as is the case with Kang and Jackson, or having our creativity steered by a framework of concepts for reuse are ways of initiating an alternative approach to extending the lives of things.

The work of Kim and Paulos, and Kang and Jackson, both show how we might be able to find use and longevity of things which are broken that can be considered "waste", through particular mindsets or frameworks external to the thing. A considerable part of my analysis bases itself on a view of the smartphone as offering few invitations into engaging with the device as a thing to be repaired. The framework for reuse attempts to solve a similar phenomenon, in that reuse seems constrained or obscured by the design of consumer electronics. To make use and repair—or other means of reinstating functionality—more intimately bound, as they are apparent through the literature I have built this thesis on, could be a way out of the use/repair dichotomy and its material effects.

An ontological shift can come from a particular type of *seeing*, like being an artist or being directed by a framework. It can, however, be considered to also come from the thing itself when, for instance, it breaks down. In its turn from functionality into brokenness, it becomes something else for us, but still within the framing of the functionality lost. Understanding the functionality of things as restricting our imaginative abilities for what we might be able to do with the thing during breakdown can be considered *a cost of functionality*. Another cost is how design, which allows certain functionality, also becomes a practical matter in breakdown, such as how the

replacement of a broken button for adjusting sound demands opening the phone. The *cost of functionality* available through design *emerges in the absence of reuse, and is paid for in repair*.

I will now look more closely at how the *things themselves* can prompt longevity, rather than obsolescence, with physical materiality as a source for attachment. As a framing not entirely in functionality, but also in attachment, directing a type of treatment that is in support of longevity.

6.1.1 Physical attachment

My empirical work is a look into the smartphone as a thing, and as a gathering of components and materials, which have effects that propagate into numerous needs for tools and competencies, and emergent practices. For instance, dissolving glue demands heating plates, proprietary screws require special screwdrivers and care is necessary not to damage closed off, sensitive components. Smartphone repairers can work through these physical demands in things through experience, a wide assortment of tools and immediate access to resources that assist acts of repair. Not everyone owns special tools for smartphone repair, and many of the online resources repairers know of are unknown to users. Achieving *repair-ability* in the context of smartphones is not necessarily an easy or cheap task, with one particular outcome that is unfortunate for more-than-instrumental relations.

Using the services offered by repairers is a *loss of opportunity* for stronger attachment to smartphones. As presented by Verbeek, repair is a type of engagement that can foster a deeper understanding and mastery of the thing practically and functionally, which can lead to a more-than-instrumental relation (c.f. 2.5.2). That is, if the thing to be repaired is *transparent,* i.e. its functioning *available* to us physically and conceptually, not filled with hindrances for repair. For the reasons above, amongst others, smartphones emerge as things with a low degree of transparency, in being physically closed off, advanced and complex digital artefacts. When smartphones turn from “simply” functioning into

brokenness, they do not present their functioning in a readily available manner, and similarly so for repair as an activity.

To engage with repair is one way to reinstate functionality and in doing that, create room for opportunities to enter more-than-instrumental relations *through use*. It is through use that we can enter a *strong sense of engagement*, where personal histories can be generated, "as a byproduct of use over time", and leave traces that can become a form of *patina*, i.e. become embellished as more than strictly instrumental objects (Odom et al., 2009, p. 1061). As the inquiry into preservation and disposal by Odom et al. shows, such relating to things are more likely to emerge when there is an "involvement in the motor-tactile nature of using an object for a function". It can also emerge when there are materials "that can record in the form of patina or otherwise histories of use" or that those materials allow users to "reconstitute, reuse, renew, customize or otherwise augment" artefacts (Odom et al., 2009, p. 1061).

Relating it to my model of thing lifetime (see fig. 34), the *hindrances for longevity* (red vertical lines) that exist in smartphones, as an example, sets a high threshold for repair to occur, through the presence of materials such as glue and glass which demands particular tools and competencies, as *longevity constraints* (c.f. 4.2.1-4.2.2). At the same time, these materials protect from damage through use—the glass being resistant to wear-and-tear, and the glue keeping moisture out—but at the point of breakdown, their ability to act as *supports for longevity* requires these tools and competencies. While troublesome and to a certain degree impractical, the presence of these materials are not deterministic in relation to longevity. This is shown through the ability of repairers in RS to successfully repair smartphones. It is in my view better for repair to occur *at all*. That is to say, regardless of its emergence as industrial or traditional, or as replacement or fixing, or performed by professionals rather than users. As mentioned briefly in the introduction to this chapter, the repairers act as mediators for relations between smartphones and owners, in spite of smartphone design which heavily problematizes repair for users. Repair is that which sustains further relations and continued functionality, whichever

form repair has. Whether one or the other is more or less sustainable is a different matter, although it has importance.

Figure 34 - Thing-lifetime model

Viewing objects through the lifetime model is a way of engaging with how a thing can *constrain*, *support* or *hinder* its own lifetime, varyingly so at different points in time *relative to breakdown*. The potential insight to be gained is not restricted to materials in themselves, but also in relation to interaction, of how we together with the thing *in use* and *in repair* are able to continue in a relation with the thing. The model is inspired by Verbeek's concept of transparency and Jackson's broken world thinking, while also adding dimensions to the perspective of objects as being processual and relation things, in their *ability to materially influence their lifetime through its relations to people*. Breakdown and its effects on materials—as able to act both supportive and as a hindrance for longevity—is an important insight drawn from applying my model to objects. It has similarities to Blevis' analysis of a GPS device, which was performed on the basis of his principles (Blevis, 2007). There, it was shown how the device was capable of having both *sustainable* and *unsustainable effects,* through a *design criticism.* What that design criticism does not do, however, is make apparent the aforementioned *breakdown relativity*: A thing's material effects on longevity happens differently, depending on a thing's state as functional or broken, and materials can *shift* between being a support or a hindrance for longevity.

Odom et al. suggest, amongst other things, that digital artefacts become more *modular, reconfigurable and adaptable*, to accommodate *augmentation*. Smartphones, as observed in RS, seemingly have a low degree of *modularity, reconfigurability and adaptability*. With stationary computers, one can swap out components, upgrade and downgrade the system at will on a physical level, as means to repair or repurpose the computer. This practice

was entirely absent with smartphones during my stay at RS, even though the practice of repair happens on the level of *replacement* rather than *fixing*. Smartphones seem to demand that an instance of a component is replaced with an identical, but different instance of that component. I would argue that this is an effect of the extremely formalized nature of repair in the context of smartphones, due to physical constraints and technological standards in their design. Materials and components, disregarding batteries, used in smartphones also seem to be highly resistant to wear-and-tear, rather than damage, based on my observations in RS. This complicates use as a source for *ensoulment*, a "high strength of attachment" (Odom et al., 2009, p. 1056), through wear-and-tear as an *embellishment* instead of tarnishing a thing's value.

If we are to consider which materials to use in smartphones to accommodate ensoulment, leather and wood emerge as immediate alternatives. These are materials which we typically find able to record physical traces of use, as representations of affection for moments in time or people we care for. Do we design for smartphones to be more like the objects which we more commonly have deeply set, personal bonds with? Can a smartphone with an exterior that allows ensoulment on a physical basis be combined with the functional quality that is made with precise manufacturing instruments? I have not been able to find literature that looks closer at the balancing of materials in digital artefacts as accommodating stronger attachment and what that might entail for their functional quality.

A preliminary assumption of mine on the topic is that a compromise must happen here: If a strong attachment is to emerge on a physical level, through wear-and-tear, as a type of *embellishment* via materials *not* resistant to wear-and-tear, we might have to waive a level of functional quality available through current material usage in smartphones. The physical and digital dimensions are dependent on each other, where efficiency in the digital relies on the power of the physical. The question then becomes if people will accept this "cost" of being able to enter more-than-instrumental relations. There is also the matter of sustainability, and a potential issue of which materials we turn to, in

designing for this type of strong attachment. What are the implications for environmental sustainability if the smartphone industry embraces wooden exteriors for their devices? *Designing for attachment might be at the expense of functionality*.

So far, I have shown some of the more problematic areas of attachment based on the physical materiality of smartphones and how these considerations can be related to other types of digital artefacts. To be discussed next is the *digital dimension*, what some of the existing literature has to contribute on the topic and my own concerns that follows from proposed approaches.

6.1.2 Digital attachment

Figure 35 – Apple's AssistiveTouch, screen capture taken June 2019, from https://support.apple.com/en-au/HT202658

If we reject the notion that smartphones have to be different *physically*, to accommodate more-than-instrumental relations, we have other opportunities that might support such relations. Digital artefacts have the benefit of existing in two dimensions, namely the

physical and the digital. In literature, we can find suggestions to use the digital to prolong longevity, but not quite in the way that Apple's digital home button does. It is an example of *software as capable of stepping in when the physical breaks down*.

Apple have, for a range of their devices, a function called “AssistiveTouch”, which adds a button to the screen (see fig. 35). Within that button, a range of areas on the phone can be reached, as well as give access to different functions. Of particular interest here is the “home” function, which acts similarly to the physical home-button found on most iPhones. Consider the following scenario: You’ve had your iPhone 8 for a year, and over time, the home button has gotten less and less reliable. One day, the button simply gives up, no longer offering its functionality. What do you do? If you go to a repairer, you might end up being presented with a repair cost beyond what you’re willing to pay for, and buying an entirely new phone due to one failing button seems like a drastic measure.

AssistiveTouch is an alternative to repair and replacement of the button, which might not be an entirely simple matter, in that the button’s functionality is made available *digitally*. While a reading of Apple’s own page about AssistiveTouch makes it seem that AssistiveTouch came from considerations in regard to accessibility, I view it as an exemplar of *breakdown-oriented design*, a design that accommodates longevity (to be elaborated upon in 5.2). As a digital alternative to a physical thing, AssistiveTouch provides the iPhone owner with an opportunity to continue use, and sustainment of relation to the thing, without potentially costly repair activities. In this sense, software can act as both a hindrance and support for longevity. It is an idea that combines software and the concepts of *augmentation* and *support for longevity*. Software, in this case, does not reduce a digital artefact’s capabilities in meeting breakdown or factors that can lead to breakdown, but instead *increases it as more capable*, not hindering, but supporting its lifetime. While Apple has emerged in a negative light across contexts of repair and longevity (Blevis, 2007; Koebler, 2017, 2019), AssistiveTouch can be found on a more positive end.

Taking it one step further, to not only allow the digital to emerge as a replacement for buttons, but *also allow users to decide the functionality of buttons themselves* might also reduce worn-out or damaged buttons to a non-issue for longevity. This can function as a *support for longevity*, but a challenge here is how to make software alternatives for physical components present and available, in what could be understood as a digital turn of Verbeek's transparency. The clue is to not make it obscured and hidden away, as is the case of the diagnostics tool found in certain Samsung and Sony phones (c.f. 4.3.3). Conceivably, the presence of this manner of software might not even act as a hindrance or constraint of longevity, although its absence almost certainly will.

Blevis presents software as "a material that *prompts physical qualities* in the sense that it drives the demand for new hardware" (2007, p. 508). As software is improved upon, new hardware-related criteria are set. Better hardware leads to better capabilities for more powerful software, which puts devices with embedded information technology at risk of becoming obsolete, as hardware cannot keep up with software (Blevis, 2007, p. 508; Forge, 2007). This, in one way, can be understood as software's capability of hindering the longevity of smartphones, for instance, as their hardware is effectively rendered into waste by software (Forge, 2007, p. 12).

The implications are that even if one were to design a smartphone with common screws, simple disassembly procedures and high transparency, software can render all of that moot through *one* update. If we depend on a smartphone for a particular functionality offered through an app, and that app is made unavailable due to an update—for reasons that might be related to security or performance constraints—then the smartphone is at risk of being replaced. The perspective of physical materials as able to act as both hindrances and support for longevity (see 4.4) is also applicable to digital materials. This coincides in part with Blevis' critique of the Garmin nüvi 350 GPS, and how it is capable of having both *un-sustainable effects* and *sustainable effects*.

Approaches to digital attachment and longevity can be found with Odom et al., who suggests that we look into ways of making the software side of digital artefacts

accommodate attachment. In exploring possible approaches for a form of *digital ensoulment,* the authors state that data

> "[…] could be used to establish a non-physical, or perhaps physical in some way to be imagined but certainly digital, patina which makes a particular physical computing device and its associated personal data history hold personal and nostalgic value" (Odom et al., 2009, p. 1061).

One of the benefits of digital devices is how data produced and stored locally can also be accessed from other devices, independent of the device it originated from, through cloud services. Online, cloud based services, such as Google Drive and Spotify, offer the same functionality and content across types of devices, for phones, stationary or laptop computers and tablets. This allows us an *independence* from devices as particular instances, making us less vulnerable to loss of concrete objects, allowing us (practically speaking) indefinite access to valuable photographs, videos, texts and more through other devices. From a perspective of longevity, independence can also be considered a downside, in that we don't *need* to have strong bonds to our things, since they are *replaceable*. This points back to Verbeek's inclusion of *commodities* as a concept in his theoretical framework, from the work of Borgmann: When we enter purely instrumental relations, what matters is the functionality offered, rather than the particular instance of a thing which offers said functionality (as cited in 2005, p. 177).

Jung, Blevis and Stolterman suggests how digital devices and "advanced networking technology like Cloud computing might actually foster more instances of physical interface that could be easily acquired and thrown away" (2010, *"Sharability: fostering ownership of sharable resources"*, para. 3). Opposite to this, they also note that independency from devices can lead to more sustainable effects through sharing of devices. This is another example of how software might contribute positively to sustainability, but it has the potential to stand in opposition to attachment and longevity. Risk and reward stands apparent here again, as similar to my view of smartphones' materiality on longevity and repair (c.f. 4.4).

With a high degree of replaceability, it is conceivable that "abrupt careless disposal occurs" (ibid., para. 3), where either approach to breakdown-oriented thinking—longevity or impermanence—is sidetracked. No matter how similarly a thing can be manufactured to replace another thing, manufacturing cannot embed sentimental value into it. How do we then make the digital irreplaceable? One immediate possibility would be to make it bound to that particular instance of a device which produced the data. This could compel us into taking more care of the digital artefact, but then again, it comes at the cost of convenience, ease of use, accessibility and other positive, valuable factors which cannot be ignored.

Many of the things we cherish are not replaceable on the level of what we have in the digital dimension, and their value stems from their irreplaceability. Our care for such things also comes from an understanding of how they cannot last forever. From precisely this notion of things as *passing*, in line with Jackson's processual aspect of BWT, Tsaknaki et al. suggest that we perhaps look at "cautious and careful letting go, downgrading, or cutting back on technological use", a "perspective of impermanence" (Tsaknaki, Cohn, Boer, Fernaeus, & Vallgårda, 2016, para. 3-4). However, irreplaceability complicates matters of longevity for reasons that relate to use, breakdown and repair.

In its most literal sense, irreplaceability means that what a particular instance of a thing provides cannot be provided by any other instance. If a thing is both functional and irreplaceable, use becomes problematic as it can drive the thing towards breakdown via wear-and-tear. If, for instance, a thing's irreplaceability stems from traces of use localized to a particular component of that thing, replacement of that component can be understood as nullifying the thing's irreplaceability. Were this to be a critical component for the functionality of the thing—with longevity through repair constrained by demanding replacement rather than fixing—one would be stuck between the choice of restoring functionality or keeping irreplaceability. Not only does that object's irreplaceability become a *hindrance* for longevity, but so does use of it, in the sense that the object is moved closer to breakdown through use. There are parallels to

irreplaceability and the effects of glue for smartphone longevity: Glue can act as a support for longevity *up until the point of breakdown*, where its effect can emerge as supportive or a hindrance. Irreplaceability can act in a similar way, but it can be a problematic basis for attachment, particularly for functional objects. Thus, to aim for attachment via irreplaceability is not a simple matter.

Insight on how to create irreplaceable digital artefacts for attachment, bound both physically and digitally in concrete instances, could be found in fields of *preservation and conservation*. Although these fields are typically connected to the safekeeping and extension of physical objects of art and culture, the digital has been leveraged for purposes such as ease of access and storage (Hedstrom, 1997; Yee, 2007). However, both Hedstrom and Yee make several interesting observations, two of which I would like to present here. For, in Hedstrom's perspective, "[i]t seems ironic that just as libraries and archives are discovering digital conversion as a cost-effective preservation method for certain deteriorating materials, much information that begins its life in electronic form is printed on paper or microfilm for safe, secure long-term storage" (1997, p. 194). From Yee, we find a view of what is lost in the conversion from physical to digital, for in viewing the work of Le Corbusier through digital means, there was "no sense of the architect who drew it" (2007, p. 35). The irony of the smartphone is that its immense mobility is its own worst enemy, in that use *as such* is not what threatens its longevity, but rather the exposure to a vast number of contexts with potential for damage. Another trouble of the smartphone, and other digital artefacts, is that the power they offer is to a large degree due to their replaceability. By this, *I mean that what we care for in the smartphone exists only digitally and can be reliably accessed from nearly any other digital device.*

Another important factor on the topic of material effects, based in the digital, comes from personal data. Through use, we produce personal data that gets stored on components in smartphones. Its presence is enough to render smartphone motherboards, for instance, unusable for reuse, with respect to laws and rights of individuals. As presented earlier in 4.3.3, certain components in smartphones are not reused in phone repair due to the

possibility of sensitive data being stored on them, with respect for privacy and laws that concern it. Due to this, functionally sound components are disposed of. This leads us to another essential dimension of artefacts with embedded information technology, which is their capability to contain sensitive data. Artefacts can contain traces of its owners through *signs of use or abuse*, i.e. wear-and-tear or damage, as elaborated upon in 4.3.2. This is distinctly different to sensitive data, in that sensitive data is an *explicit* expression of information that can, for instance, identify a person, reveal medical conditions, and so on. While an armchair can have unique markings due to use by a person with a particular medical condition, it is more of an *implicit* type of sensitive data. Without further contextualizing, it doesn't mean much more than wear-and-tear in itself, but if we are to aim for digital ensoulment, the effects of sensitive data on materials—*software as prompting physical qualities*—must be taken into account as well.

There are numerous concerns here for things which are replaceable, in light of longevity and sustainability: How can we become independent of a thing, but still care for it? What things do we share, but not own? Answers which might inform future design of digital artefacts, which still have a high degree of replaceability, could be sourced from areas such as public spaces, collective objects and other places where phenomena of sharing occurs. HCI is, after all, not a stranger to looking towards other fields for inspiration.

At this point, it is tempting to make suggestions on how the design of smartphones could be different, to reduce the threshold for repair, accommodate attachment and strengthen relations. From the perspective of *repair as a polymorph concept*, with *the relational and processual properties of breakdown and repair* in mind, repair activities and cause for repair can vary greatly across contexts. Can longevity perhaps be extended for the thing, not in the thing or the person, but elsewhere?

6.2 Longevity through other means

Repair as a polymorph concept (c.f. 2.3) implies that as a practice, repair can emerge in widely different ways throughout the range of possible contexts. This is further supported

by Houston and Jackson, who states that "[...] repair relies on information and artifacts generated during moments of design and production, however repair can never be fully codified in these resources, as phones go out into the world and fail in multiple and idiosyncratic ways" (2017, p. 204). Rosner and Ames chimes in on this subject as well, and find that "breakdown and repair are not processes that designers can effectively script ahead of time; instead, they emerge in everyday practice" (2014, p. 319). In other words, repairability and repair-ability not only hinges on what we design and how it is produced, but also the contexts and (ab-)use we expose our things to, and the breakdown that follows. Following this, designing for repair based on one context might support repair and longevity *in that context*, but it might turn into a hindrance for other contexts.

Earlier in this thesis, I have gone into detail of how design for functionality turns into practical concerns in relation to repair (c.f. 4.2-4.4). A conceptualization of use and repair as a dichotomy, in opposition to each other or distinctly separate, can be one way of explaining the prevalence of premature disposal, obsolescence or hindrances for longevity (Blevis, 2007; Jackson, 2014; Verbeek, 2005). In addition, when the design of an artefact does not adequately support the use that occurs, the risk of breakdown for an artefact is increased. As an example, repairers in rural Kenya reported that one cause of water damage in phones was due to phone owners holding the devices in their mouths for lighting purposes in work and household contexts (Wyche et al., 2015). Because the phones' design did not take into account in-mouth use, the design hindered longevity. Now, this does not mean that one should accommodate for such use when designing phones. However, perhaps one should look more closely at *why* such use happens, and extend longevity for phones by *other means*. For instance, how can rural Kenyans be provided with other solutions for their lighting troubles? Whose responsibility is it to sort this out? Are phone manufacturers to step in and provide electricity infrastructures, to make their phones last longer? Wyche et al. make an interesting point here, in that design for "there" doesn't have to be in conflict with design for "here", i.e. one design can prove beneficial across widely different contexts. That is, participants in their study suggested "shock-absorbing lining" for phones as a measure against broken screens, a

design suggestion that can be considered beneficial in not only developing countries, but industrialized ones as well (2015, p. 470).

If I were to suggest the empowering of repairers—not users—to ease their process of repair and increasing their repair-ability through the design of artefacts and services, it would be at risk of furthering strictly functional and instrumental relations. That is, it could allow users to continue a non-repair oriented relation to the thing, and not enter an engagement with opportunities for more-than-instrumental relations. Dealing with the current design of smartphones, it is perhaps a task too difficult *to make users repair-able*, an approach which has been sown doubts about by Remy and Huang:

> "[...] not everyone might have the technical knowledge required or the desire to acquire such knowledge and execute it themselves. However, if bringing your device to a local repair shop were to be significantly cheaper than buying a new one and offers other benefits (*e.g.,* minor hardware or software upgrades, it could yield new opportunity for businesses" (2015, *"Transitioning into a future of limits"*, para. 2)

Then again, taking the perspective offered by Wyche et al. into account, designing for repairers can turn into a design which raises the repair-ability of users as well. At the very least, it accommodates for repair to happen at all.

Combined, the studies and insights reported on above provide a conceptual framework that enables a view of use and breakdown of things as situated. Simultaneously, there are possibilities for design suggestions on repair, longevity and attachment in ways that can affect repairers and users positively, directly and indirectly. The above also shows different approaches to realizing longevity, in the thing itself, through our treatment of it and through other means.

6.3 Breakdown and repair pragmatism

In this chapter, I have shown the relational and processual nature of use, breakdown and repair. Use and breakdown, at their worst, sets both object and relation at risk through

tarnishing and non-functionality. At their best, use leads to embellishment or ensoulment and breakdown leads to repair or reuse. Importantly, it is in use and breakdown that the effects materials have on repair and longevity emerges. This means that we cannot exhaustively conceive, plan for and design into artefacts the means to handle the entire range of possible breakdowns that can occur to an artefact. Thus, any design suggestions I make for smartphones, intended to improve repair-ability of smartphone owners or repairers, might backfire and end up hindering repair instead.

The implications of the above, for what one might call a *breakdown-oriented design*, through changing repairability and/or repair-ability, are much the same as attempting to generate an account for repair (c.f. chapter 3). That is, one has to go out into the world: Observe the ongoing, varied ways in which people use, wear down, abuse, and experience accidents. Draw on these insights in design, but critically and expectantly so. My investigation into practices of repair and material effects of that practice follows the work of others, although with a varying similarity to those contexts. However, it does not answer questions of *why* repair happens on a personal level. Why do people bring their smartphones to a repair shop, beyond a need for restoration of functionality? Of my observations in RS, expressions of reasoning beyond a need for restoring functionality for smartphones was absent. During that visit, I conversed with some of the customers, and found that several of them could easily relate and express acts of care about objects *other than digital artefacts.* This coincides with the findings of Odom et al., who mostly found that the digital was not ensouled, while other types of things were ensouled (2009).

Again, it might seem appropriate to translate and apply properties found in non-digital objects that accommodate care, attachment and longevity to digital artefacts. I hope I have established sufficient reasons for why that is a far from unproblematic approach from the above discussion. Whereas Verbeek calls for the *anticipation of mediation*, I interpret Jackson's work in *broken world thinking* as a call for *anticipation of breakdown.* To the extent that it is possible, as *responsible designers,* we should anticipate breakdown, engage our imaginative abilities, and direct our empirical work at how we can design with

breakdown in mind and what breakdown does to what we design. From a view of the physical, there must be concern for implications on functional quality, while replaceability must be taken into account concerning the digital dimension. Looking for ways to accommodate attachment through physical and digital, as sources for *more-than-instrumental relations*, seems to be a valid, but challenging path.

A different angle might be to explore how *the physical and the digital can act in a more breakdown-embracing relation*, such as the example with the digital home button by Apple. Current literature does not seem to contain examples of such relations, at least not in the perspective suggested here. On the other hand, having both the physical and digital as dimensions which can accommodate attachment allows for a potentially rich exploration of ways to design for attachment. Not only is an investigation into repair an activity that can inform how one might accommodate an easier *return to functionality* for things through design. There might also be potential to find ways in which repair is not only a "patching-up", but also an opportunity to *strengthen* the object. For Willie the mechanic, in relation to welding of farm or industrial equipment, repairing through welding wasn't just about "welding it together again—it's the idea of welding it so it *wears right* [emphasis added]" (Harper, 1987, p. 70). This might serve as an inspiration for the perspective proposed here. In his idea of welding, an anticipation of breakdown seems apparent.

6.4 Repair-ability and ownership

Here, it seems appropriate to return to the research questions. How might they be answered at this point?

> **[RQ1]** *How can the design of smartphones affect our ability to repair them?*

The design of smartphones can affect our ability to repair them in several ways: Firstly, in their material aesthetics as *opaque*, rather than transparent, they make repair an activity that is less apparent, available and understandable. This aesthetic comes from a selection of materials and their composition, which sets constraints on likely and appropriate

repair activities, thus defining the repairability of the smartphone. Due to these constraints and other formalizing properties in the smartphone, repair emerges as a treatment based on *replacement* rather than *fixing*. However, the practical challenges of smartphone design can be overcome through tools and competencies, physically and digitally, which empower us into becoming *repair-able*. Unfortunately, the repairability of smartphones sets demands on repair activities which is outside reasonable reach for many users. In summary, the design of smartphones shifts repair activities more into the realm of professionals, away from users, which leads us to the second RQ.

[RQ2] *How can smartphones be designed to accommodate longer ownership?*

From the answer to RQ1, we can surmise that professional repairers act as an important link in relations between smartphones and their users. Implicit to RQ1 is *longevity*, as an object's ability to provide functionality for an extended period of time. Repairers make possible longer ownership by restoring the functionality of smartphones, allowing owners to remain in a functional relation to the devices which doesn't involve repair activities. The *model of thing longevity* from chapter 5 has relevance here, as it leads to a perspective of things as having their longevity *constrained*, *hindered* and *supported* by their design. Longer ownership—a type of relation—is contingent on the ways in which an object can support longevity. The effects on longevity and ownership which an object's design has—considering constraints, hindrances and support—is difficult to predict, based on the emergent nature of use and breakdown. For smartphones, longer ownership is *constrained* by its materiality but simultaneously able to be hindered or supported. As an example, glue accommodates longer ownership in the sense that it protects (sustains longevity) from moisture, but *hinders* continued ownership at the point of breakdown in practical demands. However, *for experienced and well-equipped repairers,* glue can make efficient the process of repair, and thus accommodate longer smartphone ownership. One immediate design suggestion is to introduce more opportunities to physically gain access to the insides of smartphones, and in doing so make repair an apparent and available practice. However, this might lead to unexpected consequences that emerge as

hindrances for longevity, rather than supporting it. To accommodate for longer ownership of smartphones through design does not have a simple answer.

7 Views on materiality, repair and longevity

In this thesis, I have explored theoretically and empirically how functional artefacts are things of use, seemingly shaped *for use*. Their shaping *for repair*, on the other hand, is at times questionable, especially in relation to smartphones. Nevertheless, in designing for use, practical effects for repair emerge. As material objects, smartphones hamper their own ability to *remain* functional and *persist* through breakdown, by hindering repair as the activity that allows the restoration and continuation of functioning. The components and materials found within smartphones are so complex and advanced that they cannot be understood in their entirety by one singular person, and their composition places constraints on how they can be interacted with beyond functioning. In their materiality, smartphones sets demands on their *repairability*, but for them to be repaired, people must be *repair-able*. Repair-ability can be achieved through tools and competencies that makes one able to deal with materials. Despite the design of smartphones, professional repairers have numerous advantages that make them repair-able, such as access to spare parts, wide selection of tools and opportunity to practice on a large number of devices. Their repair-ability makes them able to turn a material's effect from being a hindrance, to being a support for longevity in making repair activities efficient and manageable. As an example, glue is a material that, at its worst, does not reveal its presence but in the absence of alternatives and demands a careful and precise engagement with little room for failure. In relation to smartphones, it is a material that contributes to such devices' lack of *transparency,* in making their functionality less likely to be understood and available. For users who do not have the same opportunities to reach repair-ability on the level of professional repairers, the materiality of smartphones is difficult to overcome. *How smartphones are designed affect our ability to repair them in a way that seemingly shifts heavily into that of hindrances, but are overcome due to experience, competencies and tools*.

Through the theoretical framework and my empirical work, a *model for thing-lifetime* was built and applied to smartphones, to elucidate how it in different ways can *constrain*,

support and *hinder* longevity, through its materiality and effects on possible treatments. Its areas of applications is not restricted to the physical dimension of digital artefacts, and can also highlight how software can shift between being a hindrance or support for longevity, in a manner of *graceful deterioration*. This model is not only a device for critiquing how the design of a thing can affect possibilities for longevity. It is also a representation of a relational and processual perspective that takes into account and works with the emergent nature of use, repair and breakdown. As a contribution to SID and others who might be interested in a material analysis of artefacts with regard to longevity, it foregrounds possibilities of how digital *and* physical materials influence an artefacts lifetime, positively and negatively, across its timeline. The analysis performed through the model revealed the role of professional repairers as mediators for relations between users and smartphones: When breakdown threatens a relation, repair can mitigate that threat. In not being repair-able, users are left with few options in keeping even an instrumental relation to the smartphone, but professional repairers can assist in making sure that instrumental relations persist. In this sense, the materiality of smartphones are critical to relations as well. While the thing-lifetime models leads to a view of a thing as hindering its own lifetime, it also speaks of how relations also are put at risk through materials.

In a relation that is based on instrumentality, there is a risk for breakdown of a device to result in replacement of the device. However, the materiality of smartphones make difficult more-than-instrumental relations: Physical attachment on the basis of use is made unlikely due to smartphone materials that are highly resistant to use. This hinders the traces of use to emerge, an aesthetic that can act as *embellishment* to the device, which is a source of *ensoulment*. Smartphones' lack of transparency also hinders a tangible and conceptual engagement with them, which can be another source of more-than-instrumental relations. Given this perspective of smartphones as hindering both more-than-instrumental relations and sustained relations past breakdown, engagements and practices that make relations possible to exist at all—such as that of professional repairers—are a blessing for the longevity of smartphones. Smartphones, in many ways,

resist suggestions of attachment, both physically and digitally, presented by authors in fields that combine sustainability and interaction design.

Thus, the thing-lifetime model can be understood as an *instrumental device*, for direct application in investigations of longevity, and a *conceptual apparatus*, for indirectly nurturing an understanding of things and longevity as not deterministic, but driven towards or away from breakdown in different ways at different times to different people. This thesis, along with the model, contributes to the field of HCI and SID by nuancing the discussion of how we are to approach the design of digital artefacts in light of longevity, as a means to, for instance, combat lack of repair and premature disposal. It builds on and applies the analytical framework to objects that not only are mass-produced, but also digital in nature. My work here is also an attempt to engage with matters of clarity and questions of compatibility in the discourse, in a manner that not only problematizes but also suggests potential paths forward.

Designing for longevity

My investigations into the repair shop and practices of professional repairers revealed how smartphone materiality can hinder longevity, but that the same materials are also able to support longevity. The conceptualization of materials as able to shift between being hindrances and support for longevity does not make it simple to design for longer ownership or attachment. It lends itself to a view of the world and things where what an artefact is does not stabilize as it departs from the hands of designers, but continues as it is used and broken down in more ways than it is possible to imagine. Thus, our imaginative abilities as designers are important to *anticipate breakdown*, but insufficient in being adequately equipped in regard to designing for repair and breakdown, as they are emergent and situated phenomena. Compensation of this insufficiency should happen through investigations closely situated to contexts of use, repair and breakdown.

From a design perspective, longer smartphone ownership can be accommodated by supporting users or professional repairers. Based on the smartphone as materially making repair an activity with a high threshold for entry, it seems more beneficial to find ways to

support *professional repairers.* In the view of designing for "there" as not necessarily in conflict with "here", and possibly benefitting both, accommodating for repair by professional repairers can positively influence longevity of smartphones and relations between users and smartphones.

Additionally, I believe that if our goal is to create digital artefacts which we can have attachment to, on a more-than-instrumental basis, we must leverage *both* the physical and digital dimension of such artefacts, and break with the *use-repair dichotomy*. Longer ownership of smartphones can be accommodated by supporting professional repairers. A positive outcome for longer ownership of smartphones is questionable in regard to suggestions of physical and digital attachment—ensoulment—as based on the theoretical and empirical work in this thesis. Whichever way one might want to further the project of artefact longevity, there does not seem to be any simple answers to the question of how one might accommodate for longer relations.

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9 Appendix

9.1 Appendix A

Appendix A contains the probe used during the visit to the repair shop and is elaborated upon in chapter 3.1.3. A page shift was added to preserve the design of the probe.

Stolen

Du har en trestol fra 80-tallet hjemme som du har hatt i mange år. Den er ikke spesielt pen å se på, men du fikk den av en nær slektning som du er glad i. I det siste har stolen sånn delvis begynt å ramle fra hverandre, og det er nå blitt så ille at den ikke kan sittes på lengre.

Ville du…

- ☐ Reparert den?
- ☐ Kastet den?
- ☐ Satt den til pynt?

Hvis du ville reparert den, ville du da…

- ☐ Gjort det selv?
- ☐ Fått noen andre til å gjøre det?

Hvor mye ville du vært villig til å betale for reparasjon av stolen?

Forsterkeren

Du har en eldre forsterker fra 90-tallet hvor volumbryteren ikke lengre fungerer. Forsterkeren har opp gjennom årene overlevd en rekke flyttelass og fungert knirkefritt frem til nå.

Ville du…

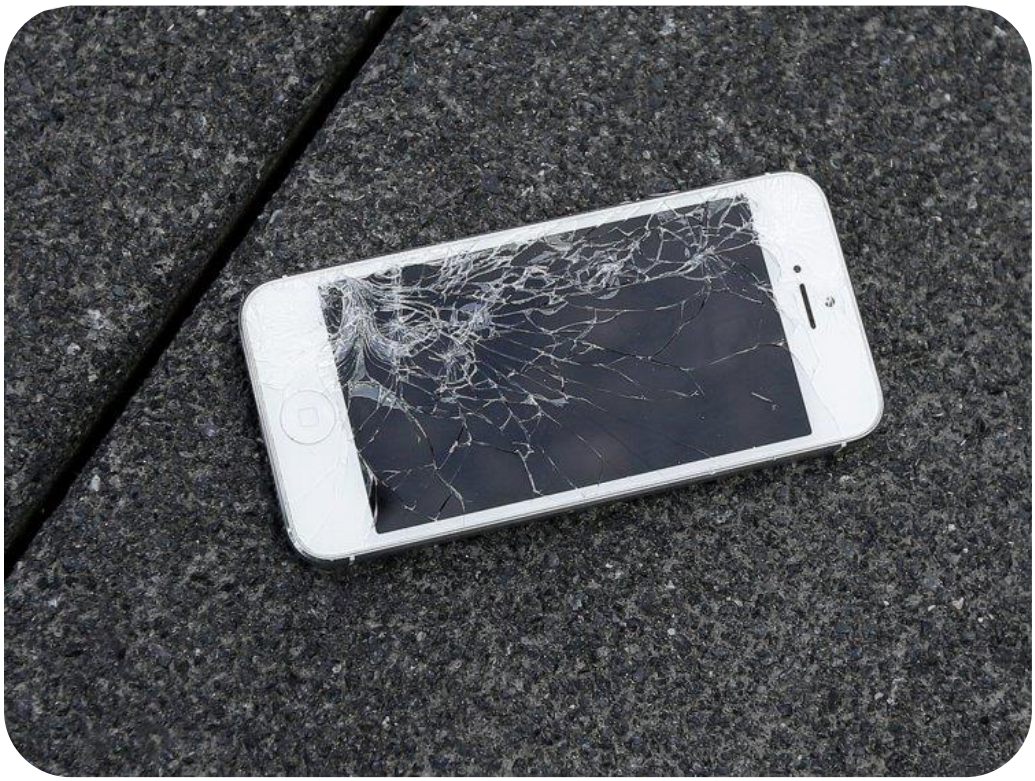
- ☐ Reparert den?
- ☐ Kastet den?
- ☐ Satt den til pynt?

Hvis du ville reparert den, ville du da…

- ☐ Gjort det selv?
- ☐ Fått noen andre til å gjøre det?

Hvor mye ville du vært villig til å betale for reparasjon av forsterkeren?

Mobilen



Din iPhone som du har hatt i et par år gikk i gulvet forleden dag, og skjermen ble knust. Mobilen fungerer helt fint, men det er ikke alltids like greit å se hva som skjer på skjermen.

Ville du…

- ☐ Reparert den?
- ☐ Kastet den?
- ☐ Satt den til pynt?

Hvis du ville reparert den, ville du da…

- ☐ Gjort det selv?
- ☐ Fått noen andre til å gjøre det?

Hvor mye ville du vært villig til å betale for reparasjon av mobilen?

Reparasjon av denne mobilen innebærer en risiko for at hele mobilen kan bli ødelagt. Vil du fortsatt gjøre det?

- ☐ Ja
- ☐ Nei

9.2 Appendix B

Here follows the spreadsheet that was generated by collecting the different repairability scores given by iFixit to different smartphones. It has been converted into a table here.

Manufacturer	Model	Release date	Score
iPhone	3G	2009	7
iPhone	1st gen	2009	2
iPhone	3GS	2009	7
Nokia	N8	2010	8
Samsung	Nexus S	2010	7
HTC	7 Surround	2011	5
iPhone	4S	2011	6
iPhone	4 CDMA	2011	6
Motorola	Droid RAZR	2011	4
Motorola	Droid Bionic	2011	9
Motorola	Droid 3	2011	6
Motorola	Atrix 4G	2011	9
Samsung	Galaxy Nexus	2011	7
Samsung	Galaxy Note	2011	8
Samsung	Galaxy S II	2011	8
Samsung	Galaxy S 4G	2011	6
iPhone	5	2012	7
Motorola	Droid 4	2012	4
Nexus	4	2012	7
Samsung	Galaxy Note II	2012	8
Samsung	Galaxy S III	2012	8
BlackBerry	Z10	2013	8
HTC	One M7	2013	1
iPhone	5c	2013	6
iPhone	5s	2013	6
Motorola	Moto X 1st gen	2013	7
Nexus	5	2013	8

Samsung	Galaxy S4	2013	8
Amazon	Fire Phone	2014	3
Fairphone	1	2014	7
HTC	One M8	2014	2
iPhone	6	2014	7
iPhone	6 Plus	2014	7
Nexus	6	2014	7
OnePlus	One	2014	5
Samsung	Galaxy Alpha	2014	5
Samsung	Galaxy S5 Mini	2014	5
Samsung	Galaxy S5	2014	5
Fairphone	2	2015	10
HTC	One M9	2015	2
iPhone	6s Plus	2015	7
iPhone	6s	2015	7
LG	G4	2015	8
Nexus	6P	2015	2
Nexus	5X	2015	7
OnePlus	2	2015	7
Samsung	Galaxy S6	2015	3
Google	Pixel XL	2016	7
Google	Pixel	2016	7
Huawei	P9	2016	7
iPhone	7	2016	7
iPhone	7 Plus	2016	7
iPhone	SE	2016	6
LG	G5	2016	8
Meizu	MX6	2016	7
Samsung	Galaxy Note7	2016	4
Samsung	Galaxy S7	2016	3
Samsung	Galaxy S7 Edge	2016	3
Shift	5.1	2016	6
Wiko	Pulp 4G	2016	7

Asus	Zenfone 3 Max	2017	6
Essential	Phone	2017	1
Google	Pixel 2 XL	2017	6
Google	Pixel 2 XL	2017	6
Huawei	Mate 10 Pro	2017	4
Huawei	Mate 9	2017	5
Huawei	Mate 8	2017	6
iPhone	X	2017	6
iPhone	8 Plus	2017	6
iPhone	8	2017	6
Lenovo	K5 Note	2017	6
LG	G6	2017	5
Motorola	Moto Z (1st gen)	2017	7
Oneplus	5	2017	7
Oppo	R9m	2017	7
Samsung	Galaxy Note8	2017	4
Samsung	Galaxy Note Fan Edition	2017	4
Samsung	Galaxy S8	2017	4
Samsung	Galaxy S8 Plus	2017	4
Sony	Xperia Z5 compact	2017	6
Vivo	X7 Plus	2017	7
Vivo	X7	2017	6
Xiaomi	Mi 5	2017	6
Xiaomi	Redmi Note 3	2017	8
Google	Pixel 3	2018	4
Google	Pixel 3 XL	2018	4
Huawei	Mate 20 Pro	2018	4
Huawei	P20 Pro	2018	4
iPhone	XR	2018	6
iPhone	XS	2018	6
LG	G7 ThinQ	2018	4
OnePlus	6	2018	5
Samsung	Galaxy S9+	2018	4

Samsung	Galaxy S9	2018	4