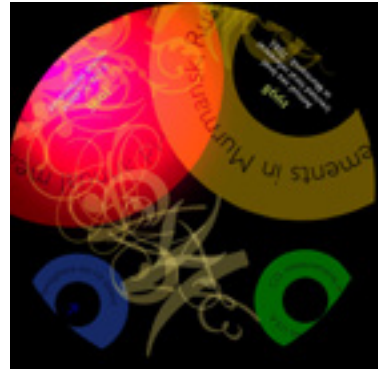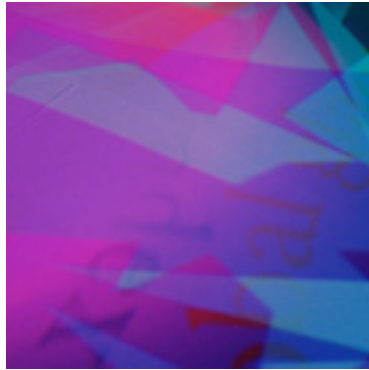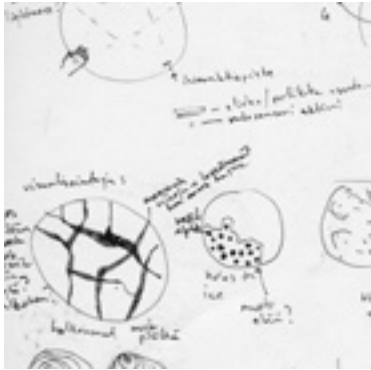TOMI KNUUTILA

Qualities of Simplicity in designing interactive art

Tomi Knuutila

Qualities of Simplicity in Designing Interactive Art

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Rovaniemi 2018

Abstract

Qᴜᴀʟɪᴛɪᴇs ᴏғ Sɪᴍᴘʟɪᴄɪᴛʏ ɪɴ ᴅᴇsɪɢɴɪɴɢ ɪɴᴛᴇʀᴀᴄᴛɪᴠᴇ ᴀʀᴛ presents a constructive design research process in the field of Interaction design. In the study, the creative process of an interactive art installation *Climatable* is documented. The installation is also included as a creative part of the research. As a result, from designerly practice and research, literary review and user experience evaluations, the research defines the concept of simplicity as a set of qualities: reduction, organisation, affordances, tangibility, intuitiveness and familiarity. The main outcome of the research are the discussion and demonstrations around the Qualities of Simplicity — how they can be used to aid designing interactive art and on the other hand how they can be observed in interactive artefacts to construct an experience of simplicity. The qualities are gathered together to create a Simplicity Framework, and based on this framework they are mapped to a Simplicity Matrix related to the work *Climatable*. Validity of the framework and the matrix are also researched by conducting three user surveys of different interactive artworks which provide deeper understanding of the applicability of the framework and the matrix for Interaction design research. Besides qualities designed or qualities experienced, the research also discusses Artefact Functions, qualities which can be thought to be aesthetic qualities of interactive artefacts.

In this research Interaction design is also considered to contain presentational design aspects, such as spatial and physical design, graphical design and audio design as well as the information and programming interaction itself. This research discusses the field of interactive art as a sub-field of media art, and considers it to contain similar features and practices as design exploration carried out by Interaction designers. The underlying thought is that when interactive art is presented, it is used and activated by people other than the artist, and therefore artists should also consider how the works are used and how the work behaves. This moves the role of an interactive artist closer to the field of Interaction design. This idea is present also in the title of this thesis.

In the end of the research, three modes of operation of interactive artefacts are discussed:

real-time immersion, social interaction and embodied participation. Discussion of how these modes are related to the Qualities of Simplicity illustrates ways in which interactive (art) works create experiences between machines and humans.

Tiivistelmä

Qualities of Simplicity in designing interactive art on vuorovaikutussuunnittelun alaan liittyvä tutkimus, jossa muotoilukäytäntöön perustuvalla tutkimuksella luodaan ja rakennetaan uutta tietoa vuorovaikutteisen taiteen käyttö- ja muotoilukokemuksesta. Väitöskirjatyöhön liittyy vuorovaikutteinen teos *Climatable*, jonka suunnittelu- ja muotoiluprosessia sekä vuorovaikutustilanteen kokemusta käyttäjän näkökulmasta tutkitaan yksinkertaisuuden (*Simplicity*) käsitteen kautta. Yksinkertaisuus -käsitteen tarkastelu ja määrittely on tässä tutkimuksen keskiössä. Se on määritelty rakentuvan eri ominaisuuksista, joita voidaan sekä muotoilla että havaita. Ominaisuudet ovat: rajaaminen / vähentäminen (*reduction*), järjestäminen (*organisation*), käyttömahdollisuudet (*affordances*), käsitettävyys / käsiteltävyys (*tangibility*), intuitiivisuus (*intuitiveness*) sekä tuttuus (*familiarity*). Yksinkertaisuuden käsite on konstruoitu kirjallisen tutkimutyön lisäksi tekijän omaa vuorovaikutteisen taiteen tekemisprosessia reflektoimalla, haastattelemalla toisia vuorovaikutteisen taiteen tekijöitä sekä analysoimalla vuorovaikutteisia mediataideteoksia. Yksinkertaisuuden ominaisuuksien avulla on rakennettu viitekehys (*Simplicity Framework*), ja viitekehyksen avulla on tarkasteltu *Climatable* -teosta. Yksinkertaisuuden suunnitteluun, muotoiluun ja kokemukseen liittyviä asioita on listattu taulukkoon tai matriisiin (*Simplicity Matrix*). Viitekehyksen ja matriisin hyödyllisyyttä vuorovaikutussuunnitteluun ja muotoilun tutkimiseen on myös testattu tekemällä käyttäjätutkimus kolmesta eri vuorovaikutteisesta teoksesta. Tutkielmassa käsitellään yksinkertaisuuden piirteitä ei ainoastaan suunniteltuina tai koettuina, vaan myös vuorovaikutteisen teoksen esteettisinä ominaisuuksina (*Artefact Functions*).

Tässä tutkimuksessa vuorovaikutussuunnittelu käsitettä käytetään laajassa merkityksessä: ohjelmoinnin ja informaatiosuunnittelun lisäksi se sisältää myös esillepanoon ja esityksellisyyteen liittyviä asioita, kuten tilallinen ja fyysinen suunnittelu, graafinen suunnittelu ja äänisuunnittelu. Näitä tarkastellaan käyttäjiä varten rakennettuun vuorovaikutustilanteen osa-alueina. Tässä tutkimuksessa vuorovaikutussuunnittelu tapahtuu osallistavan mediataiteen kontekstissa, tuoden uusia näkökulmia vuorovaikutteisen mediataiteen käyttäjäkeskisempään suunnitte-

luun. Lähtökohtana on ollut ajatus vuorovaikutteisesta taiteesta taiteenlajina, joka aktivoituu vasta sen käyttötilanteessa. Vuorovaikutteisessa taiteessa taideyleisö osallistuu teoksen toimintaan aktiivisesti, konkreettisesti, fyysisesti — tämä luo osallistujan ja teoksen välille muista taiteen lajeista poikkeavan suhteen. Osallistumisen voidaan sanoa luovan vuorovaikutteisen taiteen merkityksen. Vuorovaikutteisen taiteen tekijä ei voi jättää tätä huomioimatta. Tässä tutkimuksessa taideteosten vuorovaikutusta tutkitaan pääpainotteisesti suunnittelun ja muotoilun näkökulmista, osallistujan avainrooli teoksen tavassa toimia huomioiden. Tutkimuksen otsikko viittaakin tähän näkökulmaan: puhutaan vuorovaikutteisen taiteen suunnittelusta ja muotoilusta (*Designing interactive art*).

Tutkimuksen lopussa keskustellaan myös kolmesta eri vuorovaikutteisten teosten toimintatavasta: reaaliaikainen immersio, sosiaalinen vuorovaikutus sekä kehollistunut tai ruumiillistunut osallistuminen. Näiden suhteita yksinkertaisuuden käsitteeseen sekä yksinkertaisuuden ominaisuuksiin käsitellään vuorovaikutteisen taiteen kokemuksellisuuden — ihmisten ja koneiden kanssakäynnin luoman erilaisten suhteiden — havainnollistamiseksi.

Acknowledgements

Contents

1 Introduction

In a gallery room, a skeleton-like figure made out of junk (melted vinyl LPs, some metal strips, screws and bolts, some electronics) is suspended from a hangman's noose. The figure remains static in the air quietly, until a visitor of the exhibition turns a crank attached to the body of the hung figure. Two motors inside the figure are activated, and the figure starts to shake and shiver for a period, until the convulsions stop and the last death throes are over.

The interactive artwork Infinite Loop (*Picture 1*) by Finnish new media artist Matti Niinimäki (2011) is a sad, scary and humorous, yet incisive statement on the way interactive art functions: the work literally does not become active — or live — without its user. However, "life" is only given momentarily to the figure in order for it to die again. The physical action needed from the audience member to give — and ultimately take — life creates a momentous change compared to art which is merely consumed by watching or listening. The audience member becomes the one who makes the work live. You, not the artist alone, give life (or death)

Picture 1. Giving life to Infinite Loop by Matti Niinimäki.

to interactive art. The experience of using is different from watching a static statue or a moving robot, different from attending a puppet or theatre performance of the same subject — even different from seeing a film documenting the same interaction (LOVEJOY, 2004).

Niinimäki's artwork involves time and space: the activity of the user has been triggered or invited by the interactive work, and physical actions take place in a spatial surrounding: a life-size figure is hanging on a museum wall. What is important here however is the way the interaction is invited: how does the user know that he or she must turn the crank? This work was installed in an exhibition of interactive art, hinting that all the works should be used in one way or another. Cultural habits are also present: in the context of the exhibition space — the

museum — we have been taught not to touch anything, and encouragement for interaction with interactive art needs exhibition visitors to overcome their normal museum behaviour, who are brave enough to physically try the artwork out.

The artwork was displayed at *Saa Osallistua! - Please Participate!* — an exhibition at the art museum of Saarijärvi, a small town in Central Finland. In the exhibition, just before the opening, we held a press conference. I gave an explanation of the artwork, encouraging three local and county newspaper journalists to try it out. They hesitate and timidly try out the work, and one can observe from their body language their discomfort towards interacting. During the exhibition opening later on that evening, similar patterns of behaviour can be observed with the participants, more or less with all the interactive artworks present. One can tell that the majority of the elderly people are interested in culture, but not familiar with new media art, or interacting in a museum setting. In this context, there is a gap between the work inviting inter-action and the visitor taking part in the action. To encourage people to cross this gap requires creating the work in such a way that the museum visitor understands that action from their part is obligatory in order for the work to be experienced fully. The way the interaction happens should be obvious, clear, and simple enough to be understood. The threshold to interact in a museum context should be lowered and the curiosity of the visitors for actively trying the inter-active artwork out should be evoked. When the exhibition is over after three weeks, I was glad to hear from the museum director Kari Kotilainen, that the exhibition had been a success with local school classes and teenagers — in his words an audience whose interest towards typical displays in museums is difficult to invoke. Again, even in the same display context one can ob-serve different kinds of behaviour. All this creates an interesting and challenging starting point for an interactive artist. In this thesis, while acknowledging the context of different interaction patterns of people in various situations, solutions for lowering the bar of interacting are sought. I will focus on simplicity as a designed quality, which guides people toward interaction, and on the other hand simplicity as an experienced quality, which relates to curiosity.

In Interaction design and art making processes, there are many hidden design decisions, which are made before the work is presented to the user: the selection and organisation of content; creating interaction options; choosing a graphical and an audio style; selecting which information to present. The creative person makes adjustments, which affect how the work is experienced by the user. These design decisions define how users identify active parts of the interface, how they notice differences between system states and how they are able to physi-

cally interact via the changing interface. An artwork can be perfected endlessly, probably at some point only the artist would even notice the last changes made. But artist or designer-made major and minor decisions can only partially complete an interactive artefact. It is impossible for the creative person to know how his or her creative decisions are understood without seeing the work in use, or without carrying out user research. There is still work to be done to refine interaction.

1.1 Motivation

ONE OF THE MAIN MOTIVATIONS FOR the research has a personal motive: for a long time, I have been interested in how can one create interactive artworks that are interesting yet easy to use. It would be fruitful for interactive art research to illustrate different kinds of tools and methods useful for lowering the threshold of audience participation with interactive art. It would be interesting to create an artwork and to document the creative process in detail, from a point of view of simplicity. The research could then provide practical hints and tips which would help create easier-to-use interactive art in the future. Perhaps there are common design patterns or issues which should be considered before the artwork is published for the first time.

This motivation emerges from personal encounters with hard-to-use interactive art in various exhibitions. My experience is that in interactive art the fact that the artworks are meant to be *used* by someone else than their creators is often ignored. The interactive art audience — participants — have already been curious and brave enough to interact, and if the response from the interactive work doesn't reward this, confusion is created. It should not be the users' fault if they do not know how to use an interactive artwork. The active participant: the user, the player, the interacting member of the audience, makes the artwork alive by exploring and interacting with it, often discovering the rules of operation without needing to read instructions (KWASTEK, 2013). Not figuring out how the work is operated, or technical hindrances such as installing cutting-edge software or plug-ins for a computer, browser or mobile phone in order to access the work, turns the potential audience away.

This thesis holds the position that if there is a difficulty using interactive art, it could and should be solved by better design for interaction. Instead of museum staff telling you what to do, or instructions on the wall, interactive works themselves should guide users, teaching the

ways they can be interacted with. Interactive artists need to think about their audience as active participants. Out of necessity, terminology and practices from the field of Interaction design studies need thus to be imported to the artists' production process. In this research, the two research disciplines (art and design) are brought together, in a practical approach. This study contains not only theoretical discussion, but also practical design methods, including sketching, reflections, iterative design and user studies; and art methods including background research, production, exhibiting and fine-tuning. The interactive installation *Climatable* will be used to inform this research. Creative art and design work has fuelled the research and vice versa.

Although diving design and art into separate fields is often impossible and even impractical, both fields carry cultural connotations, which affect not only the experience of art and design, but also their creation. For many designers, the people and their needs and behaviours are the starting point. The idea of artists thinking about their audiences as users is a rather novel concept. This is one reason why in this research the term designer appears more often than the term artist, when the person who is creating interactive art is discussed. While I see the difference between the two words is small, for me the word artist carries with it the cultural burden, the romantic views of individuality and creativity which others — the audience — are merely allowed to enjoy through observation. The term designer however always implies that design is for someone: there is a person or people out there in the wild, who will use, read, handle, interact with, wear, sit on, navigate and even perform our products or services. These people are not only observing, but actively, physically participating with the created artefacts, and creating emotional bonds with them.

The main thread in this thesis is to construct a working method or a set of tools for evaluating and creating interactive art, in which curiosity toward and attachment to it is achieved by introducing simplicity in various areas. This is done by both art and design based research methods.

Another motivation has slowly emerged during the research process. Current research into design and usage of interactive art from its creator's viewpoint seems to be scarce. A lot of the discussion into this research consists of documenting and analysing the many creative

choices made to improve — through *simplicity* — the act of using interactive artworks. Design choices are observed in the wild, and researched through user surveys. Combining interactive art discussion with Interaction design practices ensures that interactive art is not created in a vacuum, without its users. This thesis is an addition to the growing library of self-reflective interactive art research.

Thus, this thesis originates from these two starting points — insufficient research in general and interest in simplifying the mode of interaction for interactive art. While the limited interest in interactive media art research is discussed, the most important role for interactive art within this research is to provide a context and a background for a Simplicity Framework. In other words, the research can be applied to a broader field than only interactive art. This research introduces ways to discuss interactive art through the lens of simplicity. The concept of simplicity is presented as a collection of design methods and as a perceived set of qualities of interactive art and design.

As a pre-research hypothesis simplicity in design is seen as a possible key for the participants' involvement with the artwork — too much confusion will turn them away, while intuitive and clear enough interfaces intrigue them, turning a visitor into an active participant, and perhaps hooking him or her up to become a user. In this research, the initial focus was mostly in lowering the threshold for trying out interactive artworks, and raising curiosity as the interaction processes were just starting. During the research process this idea and the idea that designed simplicity is a quality which increases ease of use was rethought and even challenged. Simplicity clearly means more than a set of rules which increase the ease of use. A substantial paradigm change took place, in which the research process focused on experienced simplicity in addition to designed simplicity. Simplicity as an aesthetic quality of the interactive artefact also became an interesting area for consideration. The interaction process was looked at as a more complex process, which is never in the same state. The encounters with artworks are situational: not only do their spatial, visual, aural and physical characteristics matter, but also the time-based context, where the interaction happens. The concluding sections of the research discuss the role of simplicity in public and social situations, and its relationship to playful interactions.

1.2 Positioning the research
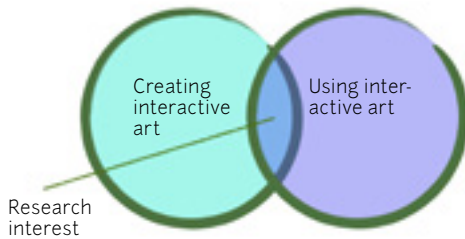
Figure 1. *The interest of the research.*

This research is situated in the cross-section of two different worlds: discussions related to creating interactive art and discussions related to using interactive art (*Figure 1*). The term *user* is not typical concept in art research. This research uses terminology and methods related to *user research,* which are familiar in human-computer interaction (HCI) and Interaction design research. In this study, for example, interactive art users were observed and their behaviour and performance with a given interactive artefact was analysed. This terminology and these methods can bring new insights to the research of interactive art. In addition to the focus on users, designerly methods including sketching, creating demo versions, programming examples, and fine-tuning the interaction were also used. These creative methods are in many cases indistinguishable from the practices an artist engages in. It is possible to say that the research, and the artwork created to accompany it, are situated in the meeting point of two fields: (interactive) art and (interaction) design (*Figure 2*). Both fields contribute terminology to the research. Terms like participation, audience, context and interpretation belong more to the realm of interactive art. Terms like user, prototypes,

Figure 2. *The position of the research.*

information, accessibility, interface, feedback and satisfaction relate more to the field of Interaction design. Some of these terms do overlap: it is, for example, common to talk about viewer or listener *experiences* related to art, but the term is also widely used in usability and design

studies — where creating or producing experiences is discussed. Another example is *sketching,* which is also a term used both in design and in art. This research is a meeting point for terminology from both fields.

1.3 A design space for interactive art

According to a strict reading of institutional art theory, the art object does not have to have a function in the real world. A common man's view when thinking about art might still be that artists are seen as individuals who create art for no set purpose or audience. To experience art, one needs also the viewer, who also is an individual, completing the artwork with his or her own perceptions in an art world context, so as to close the full *art circle*, as famously argued by George Dickie (1997). This version presented here is simplified for the purpose of this research. However, in thinking and talking about art, there often is a clear separation between two entities (the artist and the viewer or the audience member). For simplification's sake, the artist has no specific target audience in mind, and the art object does not need to have a certain, fixed use or clearly defined purpose outside the art world context: e.g. exhibitions, concerts, performances. The connection or communication between an art object (in a traditional sense) and the viewer happens most often on a sensorial/mental level, whereas a design object is to be held, touched, used, adapted, learned: interacted with physically. The field of Interaction design assumes

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The research talks about artefacts, which can be labelled both as interactive artworks and Interaction design examples. It studies both usage and creation of such artefacts.

that there is a user — another person — who has to be taken into account by the designer (see, e.g. Austin & Vogelsang, 2003). In interactive art, this is equally important. The interactive artwork is also manipulated physically — it can be argued that the user creates the artwork (Huhtamo, 2007). The methods of interactive artists should get — and in some cases, are getting — closer to the methods of Interaction designers (Costello & Edmonds, 2007).

For the purpose of this study, the text above has exaggerated viewpoints. Continuing
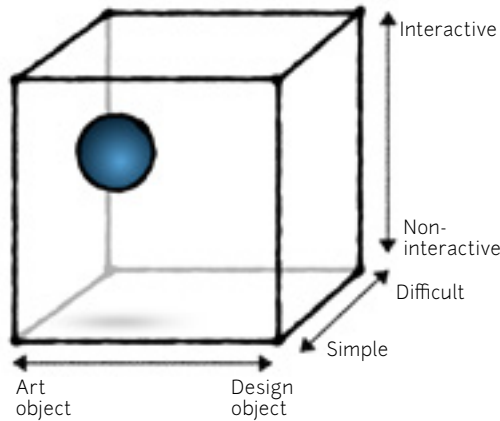
Figure 3. Position of simple interactive art artefacts.

simplification to illustrate where to position the interactive artworks in this research, a three-dimensional possibility space is created (*Figure 3*). In real life, distinctions between art and design are fluctuating, and there are various cases where one artefact can fit into either or even both categories. Each artefact can thus be then plotted on a line with an art object on one end and a design object on the other. This position can change over time and is also context-related. This is plotted in the x-axis of *Figure 3*. The same can be applied to interactivity: there are interactive and non-interactive artefacts and everything in between. Interaction is not a binary on-off system, but a quality which can build up based on levels of various components such as feedback, collaboration, control, and co-operation (SHEDROFF, 2002). The more these qualities or components are present, the more interactive an artefact can be. Again, interaction with the same artefact can vary based on the context, the same object can feel very interactive for certain users, while for others the artefact does not appear to be interactive at all. This is plotted in *Figure 3* on the y-axis. The last z-axis, which is illustrated in *Figure 3*, represents simplicity vs. difficulty — not only of use but also of understanding what is at stake. This theory can be found in both design and art. In design it is closely related to user-centred studies: is the design something the users understand, fitting their mental image and world-view? Simple things, such as a light switch, have only one purpose, which is obvious, already learned early in life. There is no fun or excitement in very obvious things. On the other hand,

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The creative works presented in this thesis are more simple than complex, more interactive than non-interactive, and more art objects than design objects.

learning to use difficult systems can be confusing and sometimes even presents an impossible task. Most things are positioned somewhere in between the two extremes. Many new gadgets, interfaces, tools and systems take time to be accepted and learned, but after this, they can provide new augmentations to the users' daily lives. Again, what is difficult for some is simple for others. In art, this axis is related to questions of the avant-garde, new movements in art and art perception: if the work is too original, not understandable at all, the work might not even be regarded as art. However, artworks which are on the far end of complexity or difficulty will eventually broaden the realms of expression, creating new ways to make, think about, and also experience art. On the other hand, if the artwork presents ideas which have already been seen too many times, it becomes banal and boring. Again, individuals interpret art differently on this axis as well. The similarities in all of the axes between design and art are obvious.

In this thesis artefacts, which are presented in the domain of art, are discussed. The interactive artworks have been exhibited mainly in museums, galleries and other places in the context of art exhibitions. Some of the artworks have also been exhibited in science centres and new media technology centres. The people who have made them typically call themselves (new media or interactive media) artists. The artefacts have been used and experienced as new forms of art. The works presented are also interactive. For many of them, the typical time spent interacting with them is short: the focus of this study is on works, in which the interaction is perhaps limited, and the possible actions — the control, creation and collaboration from the user side is limited. This research is not about scouting out all the possibilities of long-term interaction with massive user groups and systems which need to be learned in a longer period. The selected artworks are thought to be also closer to the simple, already existing and understood position in the z-axis. The artworks are analysed through the lens of simplicity, which will be mapped out in later chapters with more detail. The position of the works selected and discussed in this thesis is also illustrated with the blue ball in *Figure 3* above.

1.4 Structure of the research

This practice-based research consists of two parts: a written research — this document; and *Climatable* (*Picture 2* and *Picture 3*) — an interactive installation presented in public on five different occasions between 2008 and 2017. The written research and the design of the

Picture 2. Climatable waiting for users in Levi Summit.
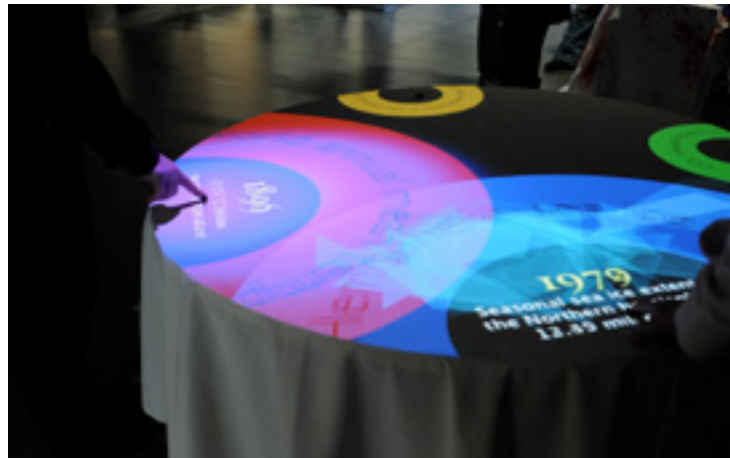
Picture 3. Climatable in use at the lobby of the University of Lapland.

interactive work were carried out side by side, as an intertwined research and development process, both the paper and the artwork going through many versions, design changes and outcomes. *Climatable* is an interactive installation about climate change. It has a central role in this research, but it acts also as an individual artwork in its own right. In the various exhibition contexts, the presence of the research was more or less invisible, users of the artwork were not aware of the role of the artwork as a part of a doctoral dissertation. I wanted to create an easily operated interactive piece based on climate change data, which would allow experiencing the effect of climate change through a vivid visual style, incorporating animation and audio. This type of emotional experience created by the installation is a minor thread in this research. It could be said that possibilities for emotional experiences are opened up through simplicity. Definitely the relationship between simplicity and a larger palette of human experiences is worthy of further research.

Along with the artwork created as a part of this thesis, creative interactive art making processes are discussed from many perspectives. My own interactive artwork *Climatable* is analysed by documenting the cyclical and heuristic design process, and discussing it through

the Simplicity Framework which was built as part of the written research as well as through design research methods. The work was observed in use, and informal communication with the users took place, both affecting the research as well as the design. Other perspectives on interactive art brought into this research by interviewing interactive media artists and analysing my other interactive installations as well as interactive art works made by other artists. Lastly, user surveys are used to analyse the framework created in the research, and simplicity related to interactivity in art installation contexts is discussed.

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The study handles simplicity in interactive art through a constructive research design process, aiming to create a Simplicity Framework which can help to design simplicity, but also display how simplicity in usage is perceived and experienced.

Chapter 2 presents an introduction to terminology which is needed when the audience turn into active participants: *2.1 Interaction and interactivity*, and *2.2 User interface*. In this thesis interaction is understood to happen with or through electrical devices and/or systems which are located in computational domains. Increasingly, interaction needs to be discussed beyond the graphical user interface: Physical and spatial design, graphical design, audio design all help construct the user interaction experience with interactive installations. Tangible and natural interfaces are discussed, along with the idea of interacting with everyday objects as an already learned skill is a starting point for Interaction design. After the subchapters presenting the terminology, both unique and shared features of the fields *2.3 Interactive art* and *2.4 Interaction design* are discussed in more detail.

An important part of this research is the documentation of the processes regarding how the artwork *Climatable* was created and improved due to new discoveries in the written research between the times the artwork was exhibited publicly and, conversely, how the changes and observations related to the artwork improved or influenced the written research. These iterations are presented in chapter *3.1 Constructive design research*. A timeline and two phases of the iterative cycles with changes in the thesis hypotheses, research questions and motivations is presented.

It is also good to remember, that the position as a researcher of one's own artistic material is not totally unproblematic (Timonen, 2004). In this type of research the role of the creative

person mostly steps away from the discussion of artistic merits, aesthetic values and philosophies of art. The role is that of a practical worker in the field, documenting his or her creative journey. As a cultural worker in the field of interactive art, the researcher can actively discuss his or her own strategies and working methods. In this research comments from other interactive artists are also heard, and other interactive artworks are discussed.

Examples of user research in art installation contexts are discussed in chapter 3.2 *User studies of interactive art*. Also, academic dissertations which contain artistic research are fairly new phenomenon, and while many studies exist where personal creative methods are discussed, not many exist in the field of interactive media art. The approach in this research is that, when interactive art is created, more designerly methods are needed. Chapter 3.3 *Interaction design methods and interactive art* illustrates how Interaction design methods have been used in this research.

The research material is more thoroughly presented in chapter 4 *Research material*. It also introduces the concept of three different kinds of knowledge related to interactive artworks: knowledge which the creator holds, knowledge which the user possesses, and knowledge situated in interactive artefacts, which are referred to as Artefact Functions. Relationships between the different research material and the different domains of knowledge are presented. Throughout the chapter, it is discussed how interactive aesthetic qualities are designed, experienced and also how they manifest themselves in artefacts.

The research circles around one main theme or topic: *simplicity*. This term is constructed in chapter 5 *Building Simplicity*. It is impossible to convey everything about an interactive art creation process, and to reflect on all the possible solutions — or even the executed design decisions — which happen during a creative process. Simplicity was chosen as a good focal point: a lens through which to look at the design of *Climatable*. Other artworks are also analysed through this lens, hoping to reveal certain patterns or details of the design process of interactive art. Simplicity was also chosen as a design element ideal for a constructive process of creating an interactive artwork. The term also appears when analysing the usage of the interactive installations as *experienced simplicity*.

The term simplicity is a topic, which is certainly unfamiliar in art — simplicity as defined in this thesis does not mean minimalism or naïveté. In the field of design, there can be said to be a general understanding about simplicity as a remedy against over complicated and messy interactivity. However, the term is researched surprisingly little. The term needs to be opened

up: what do designers and people who talk about design mean by simplicity? The verb *building* in chapter 5 refers to the fact, that for this thesis, simplicity has been constructed from many categories and sources: from literature review, by looking at three of my other interactive artworks and by analysing interactive artworks created by other artists. The chapter 5.2 *Qualities of Simplicity* presents a set of qualities which in this research construct simplicity. They can be located in various aspects of interactive artworks: in graphic design, audio design, information design, Interaction design, physical and spatial design. A framework for both designed and experienced simplicity is created in Chapter 5.3 *The Simplicity Framework*.

The main design decisions of the interactive installation *Climatable* and their relationships to simplicity are presented in chapter 6 *Simplicity Matrix — case Climatable*. The interactive installation design process is looked at by discussing it from a multisensory perspective: the work is analysed from visual, aural, tactile, bodily and spatial points of view, not forgetting information design and design of interactivity. A Simplicity Matrix is created based on the Simplicity Framework and filled with findings related to *Climatable*. In chapter 7 *Evaluating simplicity*, design solutions are evaluated via Interaction design research methods. In chapter 7.1 *Observations of Climatable in the wild*, results gained from user observation are analysed. In chapter 7.2 *Evaluating the Simplicity Framework* user testing of three different interactive installations was carried out in order to test the framework and the matrix validity.

During the research process the conception of the term simplicity has been changing: at an early phase, it was mostly considered to be a set of methods designers could use, but later on it became apparent, that it should also be considered an aesthetic quality of the artefact, which the end user can experience. Thus, the term is discussed as both a created and a perceived entity, and also as an embedded quality of an artefact. This is presented in chapter 8 *Emerging themes*. The chapter also introduces three models or domains of interaction. They can also be consid-

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The main core of the thesis presents a Constructive design research approach to an interactive art installation Climatable, which also is the artistic part of the thesis work. In particular, I illustrate how the idea of simplicity has guided its design process and how simplicity appears for its users.

ered basic construction blocks or even aesthetic characteristics of interaction, which are related to the experience of interacting with spatial installations specifically from the user's point of view. Their relationships with the Qualities of Simplicity is also presented. The main results of the research are collected in chapter *9 Discussion*.

1.5 Research questions

THE GOAL OF THIS RESEARCH IS to develop a Simplicity Framework which helps not only design simpler things, but also illustrates how simplicity is experienced by the users. The thesis introduces terminology and methods from the Interaction design field to interactive art creation and observation processes. This is something I refer to as *designing interactive art*. This term is also visible in the research title and the main research question of the study. The main question in this research is: *How can simplicity provide new insights for designing and experiencing interactive art?* Since this is a rather big question, it has been split into two parts: *What kind of framework covers different Qualities of Simplicity in interactive art?* and *How can this framework be applied for the design and usage of interactive art?* Answering the first question of these two helps to define simplicity in an interactive process, as a framework. This will reveal — or rather construct — a design strategy and a user research toolkit focusing on observed or experienced simplicity. The second question is answered by carrying out practical work and by analysing existing works. For this a Simplicity Matrix is created: with the help of the framework, designed simplicity features and experienced simplicity features are documented. Ultimately, the relevance and validity of the toolkit is tested. Different kinds of

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The main research question is: How can simplicity provide new insights for designing and experiencing interactive art? This is further investigated with two questions: What kind of framework covers the different Qualities of Simplicity in interactive art? and How can this framework be applied for the design and usage of interactive art?

creative practices from the fields of art and design are needed to answer the main question, as well as different kinds of research methods. The research problem is deconstructed and the framework is built by constructive design research: by creating, presenting, analysing and improving the design of *Climatable*, and by analysing interviews, heuristic evaluation and user surveys. Both the design and usage is thus researched.

The framework is based on the Qualities of Simplicity, and should cover both designed and experienced simplicity. The framework should give the designer a set of insights and their related questions which can be used to check whether the designed choices have been made with simplicity as a main focus. For detecting experienced simplicity, the framework has another set of insights and questions which should guide user observations, questionnaire making and other user research.

The artwork *Climatable* has a central role in this academic research. It was created as an independent artwork, but also as an Interaction design artefact, which is a product of the thesis research process. When exhibited, it has been on display primarily as an interactive art installation about climate change, not as a research artefact — in fact in most cases the users were not aware of the research aspect. As a research tool, it has helped me to answer the research question by illustrating the concept of simplicity as a designed and experienced phenomenon. In this thesis, thinking about the users of interactive art is crucial and natural, not something which is contradictory to the essence of art practice, as it has been claimed to be (e.g. Paulos, 2007).

Ultimately, answering the research question can provide insights related to simplicity as an aesthetic quality of the interactive artefact. Interactive artefacts create different aesthetic situations based on their contexts (Häkkilä et al., 2016; Jääskö & Mattelmäki, 2003), and creates emotional state changes (Spillers, 2004). This leads to thinking about emotions as active aspects affecting the interaction process, not as by-products of it (Spillers, 2004). In this research project simplicity is seen as increasing the pleasure of interacting, initiating curiosity and answering to it. This goes beyond ease of use, although the relationship of simplicity with longer term interaction, complexity and pleasurable and playful experiences needs more explanation. While some of these relationships are touched upon in this research, they are not the main focus of this study.

2 *Research context: Designing art*

IN THIS CHAPTER, THE USAGE OF the main terminology undertaken in this research is defined. First of all, the terms interaction, interactivity and interface are discussed. I also discuss Interaction design and interactive art which have different meanings and connotations, while also sharing many things. The explanation of these key terms opens up doors for later chapters where designers', artists' and users' roles, as well as the role of the artefact, are discussed in more detail.

2.1 Interaction and interactivity

IN THIS RESEARCH PROJECT, THE TERM interaction is used to describe time-based, two-way

activity that takes place between humans (users) and artefacts (objects or systems designed to be used) mostly in the computing domain. Social interaction between people caused by an interactive art installation is also discussed, but is not the focus of the research. Interaction is a time-based process, which brings forward the soul, or the gestalt of the digital artefact (Löwgren & Stolterman, 2004). As users operate interactive systems, the artefacts react — the visual, textual, audial, sometimes also physical and even spatial elements change, taking different forms. New options are shown and old ones hidden. It has been argued that basic handling of digital artefacts is not really interactive since the devices or tools do not change their behaviour, and interaction is born only afterwards, when messages in sequence relate to one another (see e.g. Rafaeli & Sudweeks, 1997). However, the position in this is research is that an important concept in interactivity is perceived or experienced interaction (see e.g. McMillan, 2006; Löwgren, 2002). Not only interactive but also reactive systems can be experienced as interactive, changing the way we perceive, use or think about the objects, systems or artefacts.

It is also important to remember that interaction is not an inherent quality of an artefact, but a designed one. The way the elements can be chosen and how they behave is based on the way the system is programmed, designed in time and space, in a chosen visual and audio style. The designer expresses him or herself with the design they produce. The design of interaction is essentially about creating possibilities for the user to act and for the artefact to react in real time to the user's actions. Similarly, interactivity in this study is thought of both as a property of the artefact and, on the other hand, as a behaviour — a quality which is experienced only during interaction (Svanaes, 2013). This experience varies between each system, each user and even each time the artefact is used, affected by users' beliefs and previous interactive encounters. Essentially, this is a question of interaction aesthetics.

Interactivity leads users to respond to the artefact, as also noted by the standard on human-centred design for interactive systems (International Organization for Standardization [ISO], 2010). The way the work behaves affects users' actions: they have possibilities to keep still, try something else, retry the same thing, walk away, come back again. Fundamentally the work can also change the way the users understand and experience interactive things, perhaps even changing the way they think about life itself. In the chosen context of the study — new media artworks and installations — there are often many simultaneous users (and perhaps more than one system or artefact), than in a typical human-computing interaction study. This brings to the foreground additional layers of interaction for this research project: public and

social contexts and interaction between different users and observers of interactive works will also be discussed.

Furthermore, the discussion of interaction in this study looks at three aspects: the designer, the user and the artefact. Humans are involved in two of these aspects: first, interaction is looked at from the viewpoint of the designer, which can also be called the creator or the artist. The creator of the interactive artwork most likely has assumptions about the users' knowledge levels, skills and perhaps even emotional states. However, this assumption is an estimate only, and only more dedicated research can complement the mental picture. In this research, assumptions about users and their behaviours were reviewed, as the work was displayed in public. Observation was used to find out how users were actually interacting with the work, changes were made, and finally a user survey was conducted.

The human side is also looked at from the viewpoint of the user. The users' needs, emotions, actions, experiences, behaviour, and preferences have been analysed in thousands of pages in books, papers, presentations (see e.g. Hassenzahl & Tractinsky, 2006; Law et al., 2009; Rogers et al., 2015). The user has built his or her knowledge of how to interact based on previous experiences — both personal and observed. Different users have different levels and skills and assumptions related to interactive systems (Benyon et al., 2005). Although the users are not neglected in this study either, early on, the research concentrated on creative design and art-making processes. However, during the research process, the focus shifted more and more towards the affective qualities of Interaction design — aesthetics the users experienced through interacting.

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> Interaction in this study is seen as a spatia l and temporal process between a human and an artefact. Interactivity is the potential for interaction, an aesthetic quality of a certain artefact, which can be designed and experienced.

The context where the users encounter the interactive artefact also affects the way the work is interacted with (Beyer & Holtzblatt, 1998; Vilela dos Santos, 2018). It is more likely that the public try out interactive installations in science centres than in art museums — the first context is typically perceived by the users to be more welcoming in terms of interacting with computers and installations than the latter context. The context also creates different

roles for the users. In this study, also the role of the user as a performer of the interactive work is discussed. In public and social situations, the interactive installation might be operated and observed by many people at the same time. Interacting with installations which produce interesting visual, haptic, spatial or audial outcomes attracts certain users to start experimenting and performing with the installation. This is often observed by other audience members.

Input devices, software and technological solutions, physical design, spatial design, aural and visual input and output all have their peculiarities They contribute to the form of the interactive artefact and create different interaction possibilities. These elements are manipulated or moulded by the designer into an interactive artefact. Knowing when and how to use them constitutes the designer's knowledge, and depends on the designer's skills and personal preferences. As the designer learns more about the artefact's users, and how they behave, this new info can introduce new changes to the design, and this process is repeated. The designer should see and test not only how the artefact performs but how it is performed with: how the

Designer

designer's understanding of the user

User

interaction process

Artefact: designer's view

Artefact: user's view
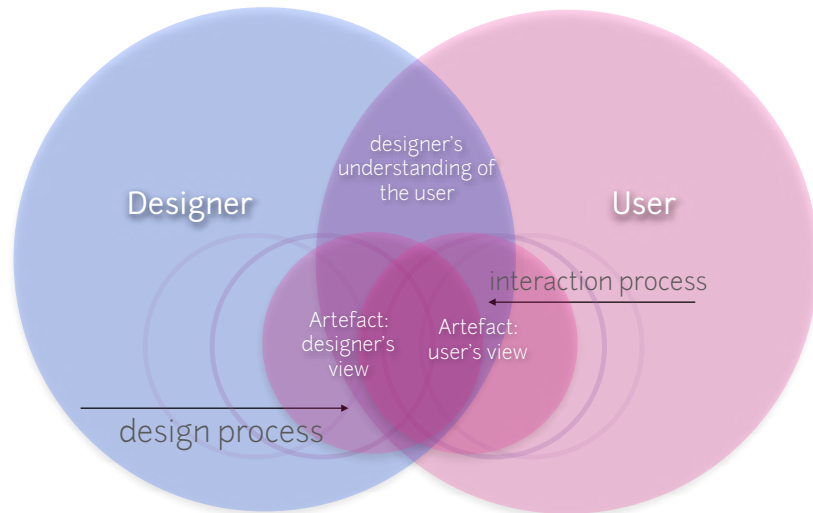
design process

Figure 4. The designer's knowledge, user's knowledge and the artefact.

designed elements are perceived and manipulated during the interactive process by the users. This is crucial in ascertaining how well the interactive experience matches the intended design, but equally important is how new interaction patterns emerge, as ways of operation or social situations which were not designed for in the first place. This is a vital part of the iterative constructive design research process, and user observations should influence design changes to the interaction possibilities. It can be said that by changing or improving the interaction possibilities, the designer tries to situate the artefact to a know-how area, which is shared both by the user and the designer. So, the interactive artefact position moves from more designer-centred knowledge towards user-centred knowledge.

As the state of the interactive artefact — as well as the user's state — changes during the interaction process, the way the artefact performs and is perceived, understood and used by the user changes (EDMONDS ET AL., 2004). The user begins with a mental model of interaction, drawing assumptions on how the work is used. If the work behaves in the way which was expected, the model strengthens and interaction can continue. If something unexpected happens, different mental strategies and interaction actions are needed. Finding the correct way to use an artefact slowly reveals the designer's intentions, and the artefact position can be said to move from the user's initial assumptions (user knowledge) towards knowledge that is shared both by the user and the designer. However, it is argued, that the designed and interacted artefact models never meet completely (see e.g. NORMAN, 1986a). There will always be things in an interaction system, which the designer knows better, and on the other hand the users might interact with the artefact in a way the designer did not intend. Thus, there are two mental images of the artefact: the designers view and the user's view. The desired meeting of the two models related to the interactive artefact is illustrated in *Figure 4*. It is also worth remembering, that the artefact is experienced differently by different users and in different use contexts, so in a way there are many user images, and it is impossible to design for all of them. It is also worth noting, that both designers but also users *create* interactions with tools, artefacts and systems. There are devices with interfaces with only one or few explicit functions, but we still might interact with them in a way which was not originally intended by the designer: using a cigarette lighter as a bottle opener, or the two hands of the wristwatch as a compass, or a door key as a screwdriver, and so on. In this way, new implicit possibilities open up, devices may not change, but the realm of what is possible to do with them does. Interactions can be both implicit and explicit (LANDIN, 2009).

It can be said that a bigger interaction cycle and interactive experience contains a lot of smaller, lower-level interactions. The artefact has functions, and they are accessed by interacting through the interface. The interface can consist of graphical elements such as menus, typing inputs, buttons, but also physical sliders, knobs, etc., with designed algorithms and functions programmed to execute simple or more complex actions. Thus, interaction and functions are inseparable (see e.g. Landin, 2009). The usage can have many appearances, e.g. trying to understand its mechanics, playing around with it, collaborating with other people through it, or performing with it. A larger cycle of interaction is related to an emotional bond between the user and the interactive artefact, which forms typically in a longer interaction period. In computer science, the cause-effect relationship is often an explanation of interaction. However, the concept of interaction goes beyond more or less binary mouse clicks or keyboard presses and the system's response for those events. To be able to interact, we as users need to have a predisposition to know how to interact, what to expect when we are interacting, and to judge how well the interaction answers our expectations. We as people and users have developed a mental image of interactive things. However, often the design is faulty, and users are creative people, who will at least try to break the *rules* and do things that do not seem possible with the interactive artefact. This research focuses mainly on ways of improving the discovery of the explicit (intended by the designer) Interaction design features, but also discusses how to guide for exploration of the interactive artefact (including implicit functions) by using simplicity as a guiding tool in design. The relationship between the artefact and its users is not fixed — users might do things which are unexpected, not designed by the designer or created by the artist. There is always room for improvisation in interaction (Petersen et al., 2004).

2.2 User interface

In this research, the term interface refers to the ways and methods in space and time, where machines and humans meet and interact. Most of the time, the term interface is used in lieu of the common term user interface. The user interface has a strong connotation to the graphical computer or a smartphone screen, and the work discussed in this thesis extends interactivity beyond the flat surface. Interaction happens through interfaces, and they let us do, learn or find things easier — extending our skills and knowledge and augmenting our minds

(Krippendorff, 2005). Interfaces and interaction are relatively new field of research under design studies, but growing in importance since our communication with others and the world happens through increasing number of constantly renewed devices and their interfaces. Again, interfaces are both designed and used. Interfaces are designed in order for interaction experiences to happen.

With digital tools, the participants' experiences are mediated through an interface. If the interface is understood or learned easily, it guides us to be able to interact with underlying content and technology naturally and effortlessly (Krippendorff, 2005). This notion suggests that the interface acts as a sort of gate or negotiator between the content and the user. Often this is illustrated by comparing an interface to the layout of a book: a good layout and typesetting allows for good readability, as the page numbers, headers and footers tell the reader on which chapter and page he or she is, chapter titles offer a pause with each new chapter, the table of content acts as a map or guide to the content, and so forth. On top of this, we can consider the way a book is handled, pages are turned, how the book feels in your hand — interacting with a book is natural, and we do not think consciously about *using* it, about turning pages, about finding a certain chapter or page. We can concentrate only on the content, forgetting the interface in

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Interfaces are designed and used; they act between the technology and the user. Interactive art is often interested in novel interfaces.

between. This kind of transparency, organisation and reduction of clutter of an interface are often endorsed qualities in design guidebooks. It is important to remember that the interaction happens in time through the interface, which can change: it behaves according to the rules it has been programmed by, and according to how it is manipulated. The interface gives feedback based on the user's actions, which change their emotional state. This guides the interaction process forward towards exploration or investigation and can produce shifts in attention or even change the dynamic of a social group (Spillers, 2004).

Tangible and natural user interfaces

Tangible interfaces relate to physical objects, which have been augmented with digital information, in a spatial installation setting, instead of a graphical user interface (Ishii & Ullmer, 1997). Virtualisation of the interface has become a huge trend, as computers with graphical user interfaces and smartphones dominate our work life and our free time. Representations of real-life tools and actions have been replaced with desktops, icons, menus, virtual buttons, sliders and switches. This allows us to write, draw, manipulate text and data, create music, etc., with mouse clicks or finger presses. However, it is possible to detect another trend in Interaction design. We interact with everyday objects with all kinds of user interfaces: auditive, visual, haptic and combinations of these for various devices, services, instruments, tools, vehicles, objects, apparatus. Most of them are not computer-related, and all of them need to be learned at some point in life: how to use a rotary dial telephone, how to use an e-book reader, how to operate a disposable camera. As we have been using various tools and systems every day, in most cases interaction with these objects seems natural.

In this research, the discussed interactive artworks are mostly situated in the cross section of the digital and the physical world. They interact with tangible user interfaces. The interface is not only graphical and aural, but extends to, for example, physical buttons, sliders, even everyday objects such as umbrellas and towels, which have become part of the interface. Certain physical things are touched, manipulated or controlled to access and manipulate digital information systems. The way the physical elements are laid out, the way they are situated in the space needs to be discussed. The physical things can also act as outputs, or they can present back media to the physical world — for example sounds, text and graphics (Fishkin, 2004). Interactive installations discussed in this thesis explore these kinds of Interaction design spaces. These kinds of tangible, natural and multimodal interfaces can be seen as a departure from common desktop-based user interface metaphors: windows, icons, menus and pointers (Oviatt, 2012). With minor exceptions, interacting with the artworks presented in this thesis does not take place using common interaction tools or input devices such as the keyboard and the mouse, or even with the nowadays ubiquitous touch-screen device used with fingers. This is certainly not the first time such interfaces are used or presented, though this research is being carried out at an interesting time when traditional user interfaces are changing to be used in multimodal ways. We are already in the age of touch and gesture-controlled artefacts, with more and more

speech and machine vision-based interfaces on the market. The common goal for alternative interfaces is to gain direct control of tasks, without the interface getting in the way. This thesis presents these kinds of physical interface solutions via interactive art. Many of the discussions and findings presented in this thesis can be applied to other products besides interactive art and interactive computing, including systems or artefacts which do not possess the computing component.

Interactive artists are not the only ones searching for novel ways to interact with computers. The seamless-use interfaces can be called natural (user) interfaces (see e.g. Raisamo, 1999; Rauterberg et al., 1998). In natural interfaces the focus is on interactions which mimic everyday actions, such as speech, hand movements and gestures, facial expressions and other non-verbal communication. Although natural user interfaces are often nowadays related to touch and gesture-based interfaces, in this thesis the term is also understood to incorporate interfaces which involve natural objects and materials such as coffee cups, handbags, clay, sand, etc. In this research the development of interactive artworks, experimenting with tangible and natural interfaces, is seen as an essential skill and practice of an Interaction designer (Fallman, 2008). Exploration as part of an Interaction designer toolkit is explained in more detail in the chapter 3.3 *Interaction design methods and interactive art*.

2.3 Interactive art

While using constructive design research methods, the area of interest in this monograph is still interactive art. The interactive installation which is part of this research, and the other interactive artworks presented in this thesis, could be labelled under many categories: Interaction design, new media art, digital art, computer art, and finally interactive media art. The usage of these categories is often rather ambiguous, but in this study the term interactive art has been chosen, whenever possible. Not all digital or new media art is interactive — e.g. generative art, real-time based image manipulation or image detection carried out with the latest AI algorithms do not necessarily involve any audience participation. It is also good to remember that not all interactive art is digital. The interaction and interactive artworks which are studied in this thesis are completely or mostly computer-run and digital, most of them extending to the physical world outside the screen, speakers, mouse and keyboard. Also, in order for them to

function, they need active user input — the work becomes alive only through physical actions undertaken by someone, who is not the maker of the work.

Participatory art exists in many art genres, including music, theatre and dance, even analog (i.e. not digital or virtual computer-based works) interactive fine artworks, sculptures and installations are not uncommon. In the fine arts, early attempts for participation have been documented during the early 20th century, typically related to different avant-garde movements. The Futurists wrote manifestos about random and voluntary audience collaboration in theatre. During some of their events, Dadaist artists invited the audience to participate in the alteration of viewing methods, or even the creation of the artwork (DINKLA, 1996). Later experiments in the 50s and 60s included happenings, and artworks (performances, imaginary art pieces, actual sculptures) which were to be carried out according to the artist's instructions. Electronic, mechanical, even robotic art were made by artists such as Jean Tinguely, Thomas Wilfred, Marcel Duchamp and Nam June Paik (HUHTAMO, 2007). Further, artworks and performances which involved electronic technology and which were described as reactive, cybernetic or responsive were made in the late 50s and 60s by such artists as Nicolas Schöffer, James Seawright, Robert Rauschenberg, John Cage, Merce Cunningham and Billy Klüver (DINKLA, 1996; KWASTEK, 2013). The term interactive art was first used in 1969 in the description of an installation called *Glowflow,* by MYRON KRUEGER and University of Wisconsin scientists (HUHTAMO, 2002; KWASTEK, 2013). It is noteworthy that this installation was a computer-controlled system that was to be operated by the audience. However, the term started to be used more widely in the context of art only in the 1990s (KWASTEK, 2013).

One more term which should be discussed here is media art. Media art is ubiquitous in the contemporary art world, though the vast majority of media art displayed take the form of linear video artworks, typically presented with one or more screens as video projections or on monitors. Sometimes the word "new" is used in front of media art as a means to distinguish computer-based artworks from this video-installation or -projection based media art. Although technology gets old quickly and various terms have been suggested for new media art, the idea is that *new* media artists bring forth new ways to combine art and technology and provide new ways to think about our media and technology rich culture. Although some contemporary museums and galleries have featured shows by new media artists and exhibitions of new and even interactive media, mostly it still remains a curiosity in the largest art biennials in the world (FRANCO, 2013; POTTS, 2007). Also, worthy of note is the fact that in many texts about new

media art, the terms *new media art* and *new media design* are used almost synonymously. The traditional role of a romantic, modern, or even a postmodern artist is also often neglected by people who present new media works: few come from a fine art background and many have a day job in design or the IT industry. Most work in a transdisciplinary or multidisciplinary way, seeking help from other disciplines and professions to support their own work (see e.g. Biggs, 2009; Simanainen, 2004, 2005). Design and engineering skills are needed in executing interactive art installations. (Huhtamo, 2002).

Interactive art emphasises interaction as a central feature of the artworks. The works are presented in a public context: in museums, galleries, festivals, events, science centres, etc. There is always an audience: art connoisseurs, visitors, passersby. This is a normal practice for all the arts: there are always actions of creating, presenting or performing and on the other hand observing, watching, or listening related to a piece of art. Through observation, the viewers or listeners gain an aesthetic experience. There is a paradigm shift when interactive art is presented: interactive art engages the audience in a way fine arts, music, theatre or cinema does not, since on top of the action of perception, it requires physical participation from the viewers or listeners, which changes the work (see e.g. Brouwer et al., 2007; Kwastek, 2013; Lovejoy, 2004; Mulder, 2007). The viewer not only perceives the work, completing it mentally with his or her cultural viewpoint, but also becomes a participant or a user, who makes the work come to life. The interactive artwork can be changed, performed — even sometimes co-authored. All these activities present a different relationship to the artwork other than just viewing, listening or even experiencing. In interactive art, the aesthetic experience is not something that happens or is given to you (as in visual arts, music, cinema or theatre) but something that you do (Kwastek, 2013; Laurel, 1991; Rokeby, 1998). This experience can include, for example:

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In interactive art, the aesthetic experience is not something that happens or is given to you but something that you do.

exploring, activating, controlling, selecting, navigating, exchanging, communicating, etc (see a taxonomy which collects keywords for interactive art and the way they operate and are operated, Kwastek, 2009). Various categories of interactive art have been defined even before the home computer age (Cornock & Edmonds, 1973). In this thesis, interactive art is seen as a dis-

tinct art form or method for art making, which differs from participatory happenings or performances in which the audience is guided to act in a certain way. In interactive art, the artist does not assume the role of a leader or director of the event or the work, such as in happenings or in theatre acts. The artwork is typically mediated through technology — although not always with a computer: examples of non-computer-based interactive art also exists. Bernie Lubell's interactive wood machines — e.g. *A Theory of Entanglement* (2009) and *Conservation of Intimacy* (2005) — are prime examples of analog interactive installations. Interactive artworks are experienced voluntarily by interacting with them; the social interaction between people *through* the artefact is considered important, but its role and functions are mostly framed outside this research. This thesis supports *old school* interactive art, in which physical, active participation of a human is thought as a necessary component of interactive art. This notion has been criticised by, for example, some of the juries of the world's most well-known interactive art festival Ars Electronica (see discussion in Huhtamo, 2007), in a bid to extend the idea of what interactive art can be, finally labelling almost all digital art as interactive. But if the user is neglected, the art functions in different areas: software algorithms, technological or mechanical innovations, or autonomous systems. The position in this research is, that the focus of interactive art should be on possibilities for interactive processes and engagement between people and technology, or between people through technology.

It is worth considering this engagement to be similar to the engagement one experiences with a design object. They are handled, used, worked with and possibly owned. One difference with the interactive art object is the context in which the interaction happens: interactive

Interactive art manifests itself through its usage.

artworks are presented most commonly in an art world context (galleries, museums, exhibitions, in public spaces, and so forth). Inside this particular context interactive art encounters can be difficult to face: we are taught to not touch art objects. Concretely and physically interacting with art requires a paradigm shift, both physically and mentally, from a passive audience member to an active user. In a way, interacting with non-art artefacts and systems designed to be interactive prepares us for interactive art experiences as well, and it might be that younger audiences are more willing to experiment with interactive art than older people (Brown & Ratzkin, 2011). However, when using HCI or Interaction design methods we can find out if the

type of interaction is good or bad, we cannot use similar methods to find out if art is good or bad (Höök et al., 2003).

Interactive art requires a paradigm shift from the artists as well: the work does not manifest without its usage (Edmonds et al., 2004; Muller, 2008). The interactive object is meaningful only in space and in time in interaction with the user (Löwgren & Stolterman, 2004). We can focus on the usage, and borrow something from John Dewey's ideas about art as an experience (1934). Instead of focusing to the art object Dewey draws attention to the experiences of the artist and the viewer. An aesthetic experience of an artwork requires a certain type of observation from the viewer. Building on this idea, the aesthetic experience of an interactive artwork requires a certain type of action from the observer. Dewey also emphasises the role of political, social, economic and cultural contexts of artworks — they are not born in a void and the aesthetic forms which the works carry are bound to these dimensions. Indeed, Dewey's texts have guided art theory discussion more towards questions like, "How does an artwork function?" This can be easily extended to questions such as, "How does an interactive artwork function?" and "How does interaction with an artwork function?" The idea of the active participant *physically* acting to complete the work extends the field of traditional art theories (Huhtamo, 2007). This idea should also be incorporated in the creative processes of interactive artists. An interactive artwork is not only an artefact, but something, which is used in a specific space and time without the presence or guidance of the artist. Thus, artists should care about what happens after the artwork is put out to display. Creating such work should support the fact that interactive art is to be interacted with, in other words making the interaction possible, feasible and logical. This has been challenged by certain interactive artists by, for example, making installations which do not always follow their own internal rules or user actions (Huhtamo, 2007). I see this as a dangerous path, although criticism of our pervasive interactive media culture can be healthy. This thesis however takes the position that if an interactive artist creates an installation, which is — deliberately or due to bad design — difficult to use, the audience will walk away annoyed and frustrated, thinking either that the installation is broken, programmed poorly, or that the fault is in the users themselves. The

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In this thesis, interactive art is understood to contain qualities of both art and design.

last thought leads to a widening of the gap between the user and the artist, putting the artist on a pedestal above the participants. This sort of philosophy forgets that interactive art does not exist without the users actively using the work, and in a way, this will always change the work and affect the roles of the artist and the user, since the user becomes a sort of performer of the work. Understood broadly, interactive art combines the skills of a designer (creating for another person in mind) and an artist (manifesting personal content and ideas).

2.4 Interaction design

IN MY RESEARCH, I REFER TO *Interaction design* as a field in which possibilities for interactions with artefacts: products, services, spaces and systems — mostly but not only digital — are created but also studied (FALLMAN, 2008; LÖWGREN, 2008). The ways in which methods and ideas from this field are used in this research is presented in more detail in the chapter 3.3 *Interaction design methods and interactive art*. Interaction design differs from other many other design paradigms in that it defines acts of intended use. It is helpful to separate functions and interactions: when interactive things do something as we use them, they function, but people — me, you and other users — interact with them (HALLNÄS, 2011). Interaction designers create relationships between functions and interactions.

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Interaction design is about studying, exploring and creating control possibilities and feedback processes for physical things, text, images, sound in space and in time.

Interaction design in this study is seen as a broader field of design, which concerns creating design, which allows interactive experiences — behaviour over time — to happen. In this thesis, this also means that the fields of, for example, audio design, programming, visual design, tactile design, and spatial design are discussed and analysed, since they affect the interactive situation. These subfields are part of Interaction design, when the designer thinks and creates choices which support (or alter) the usage of interactive things. One of these subfields is the design of interaction: simultaneous or turn-based communication or co-operation of people with man-built machines, products, objects and sys-
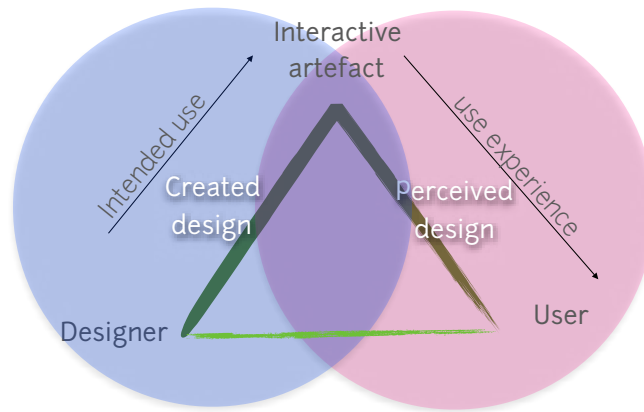
Figure 5. Intended and experienced design.

tems through or with an interface, typically a computational or programming element. The two meanings are present in this thesis: *Interaction design* refers to the whole field of research and the design of interactive artworks as a complete and complex process, and *design of interactivity* refers to the design of the turn-based interaction: creating the information architecture, designing and programming the navigation, the interface possibilities and the way the artefact gives feedback and responds to the user. In this research, the programmed computer has a vital role in this interactive loop. Spatial and physical design, graphic design and audio design, are talked about through the lens of Interaction design, i.e. how they contribute to interactivity — rather than through their respective fields.

Figure 5 displays the field of Interaction design from the points of view of the Designer, the User and the Artefact as they appear in this thesis. Intended design talks about the Designer's choices, processes and given forms related to the artefact. They are not only physical, visual or audible forms but also expressions of interaction over time: the ways of use which are intended by the designer. A different discussion and set of research tools and method is needed in the analysis of the actual use experience. The user perceives the design, tries it out by interacting with the artefact and judges it's usability: whether the artefact is effective or efficient, useful,

learnable, playful etc. — depending on the individual case (Rogers et al., 2015). Digital, programmable devices such as mobile phones and computers behave differently from many other design objects, since they represent things virtually and can have multiple use purposes or functions, the (graphical) user interface adapting to various very different tasks: paying bills, creating a birthday card, composing music, manipulating a photograph, writing a thesis. The focus of the design is no longer about the physical qualities of the object. Designing the interaction requires some software skills: programming is used to create the acts of use, and system responses to the use. Sketches, demos and different software versions are needed during the process to improve interactivity with a digital system (Löwgren, 2012). The algorithms and programs change the way an interactive digital machine behaves in time and in space. It can be argued that the logic of the design of interactivity creates expressive qualities of actual use, and that the aesthetics of interaction can be studied (Hallnäs, 2011).

The field of Interaction design often challenges commonly held assumptions about interactivity, everyday actions and behaviours (Ehn & Löwgren, 2003). Also, the core of new media art (and even hacker culture) is often to take interactions with computers or technology to new realms: hackers and artists create systems and interfaces which make new things possible or reveal new things about computing, technology, life, or even interaction itself. In contrast to experimentally difficult interfaces in interactive media art, which was criticised above, in the context of design these experiments are typically tested with users to find out if innovations in the interfaces or interaction methods actually work.

3 Research methods: from an interactive artist to an Interaction designer

In this chapter, I present my research methods and give an overview of the research process. I started my research journey with a strong commitment to contribute something to interactive art research, noting that usability and Interaction design issues had not really been popular topics in research concerning interactive art. By getting to know the field of design research my focus has shifted more to the field of Interaction design, distanced from the art world and art research. It still can be said that the written research process and the creative artwork have been influenced by both art and design research practices. It can be argued that interactive

art should be also considered to contain both fields as well: unlike in other art forms, interactive art has to be used, operated by someone else than its creators — and this brings in designerly practices.

One of the main starting points in this research is that as the artwork is manipulated or operated physically and behaves actively, creating a bond with its observers, in a way that differs profoundly from the position that traditional art theories have determined for artworks (Heinrich, 2008). Throughout this research, designerly techniques and tools have been used to collect information to illustrate how the artist can use designerly techniques to take users into account. As important has also been the discussion on how the users experience interactivity, especially in interactive art. In this constructive design research process, both of these positions will be looked at through the lens of simplicity. A Simplicity Framework will be constructed from a set of qualities. The research suggests that interactive artworks should contain these qualities for establishing a smooth interaction flow.

3.1 Constructive design research

The iterative design process: making the artwork, installing and presenting it in public — has taken place side by side with the written research. The design changes can contribute

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In constructive design research (CDR) the focus is on the construction process, which contributes new information which not only the design but also the research can utilise.

to the theory and the theoretical writing process motivates changes in the design in a cyclical process. This type of approach has been called the practice of research through design (see e.g., Zimmerman & Forlizzi, 2008). As a refinement of this practice, an even more descriptive name was given for this type of methodology: constructive design research (Koskinen et al., 2011). Both methodologies are still used today. This research addresses mostly constructive research design, in which the focus is in the construction process: a design artefact is improved and perfected as design problems are solved, producing new knowledge in the meantime. Iteration continues, and as the work evolves, new and different

design challenges arise, and the loop goes on. The construction of the artefact takes a central position: the construction process should not be seen only as a method to improve the artefact, but also as a way to construct knowledge (Koskinen et al., 2011). It can be said, that the process is not only interested in the construction of prototypes and more finished artefacts, but also in creating new theoretical models. Hypotheses and research questions can change through the discoveries made during the design phase. This type of cyclical constructive knowledge
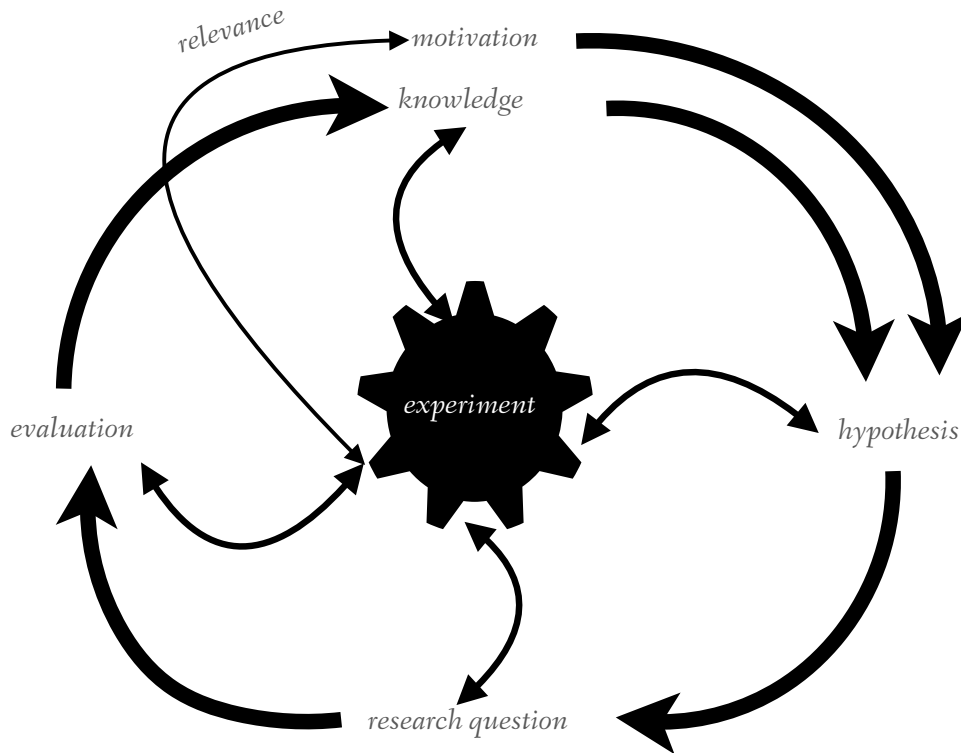
Figure 6. Experiments act as a driving wheel for constructive design research (BANG et al., 2012).

building and iterative design process suits this research perfectly: the process in which the theoretical framework has been established, iterated, improved and finally tested has happened concurrently with design sketching, prototype building, software and hardware work, presenting the work in public, and making improvements based on user observations. *Figure 6* illustrates a cyclical view of the constructive research process (Bang et al., 2012). This thesis presents a constructive design research journey, a reiterative way of working with the artefact: sketches, demo versions, released versions of the design and how they construct the theory of simplicity. Design improvements, additions, corrections, and clarifications made to *Climatable* are presented and discussed. Also, creative solutions which support the notion of simplicity in
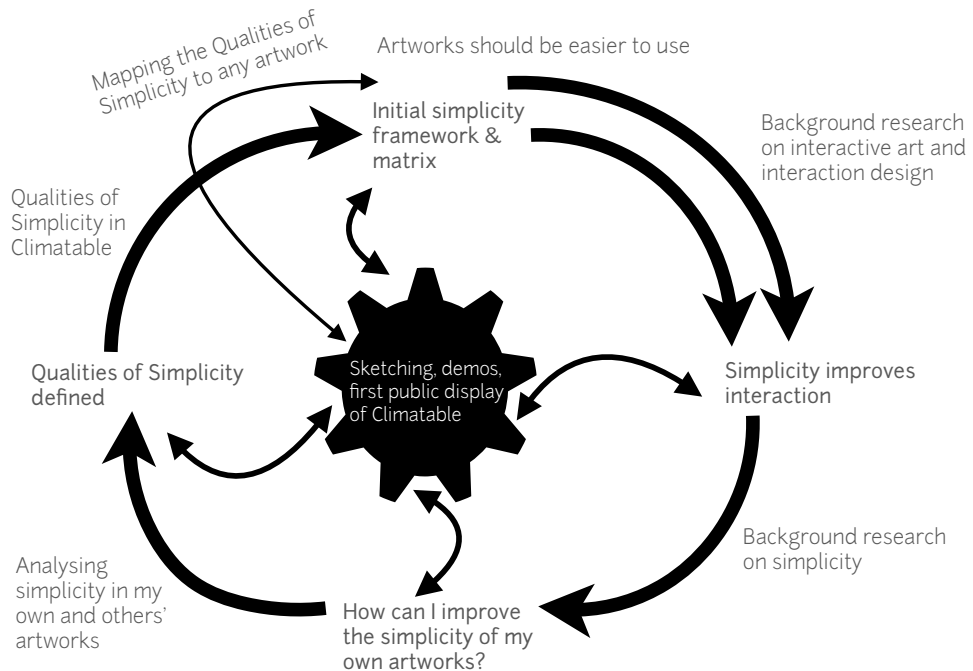
Figure 7. The first main iterative constructive design research cycle of this study.

the author's other interactive installations are discussed. The perspective of a designer continuously improving the work — in this case concurrently with written research — is complemented in this research with discussion on user experiences of other publicly displayed interactive artworks from a first-person participatory perspective. In addition, user observations, user surveys, descriptions of non-written comments and behaviours of people using interactive installations are discussed. In this study, it has become evident, that the research undertaken needs three things: the artwork creation process, the presentation and observation of the artwork in public, and the written research. They have all been focused upon many times during the cyclical, iterative design-research process, and often it is impossible to say which one follows or precedes
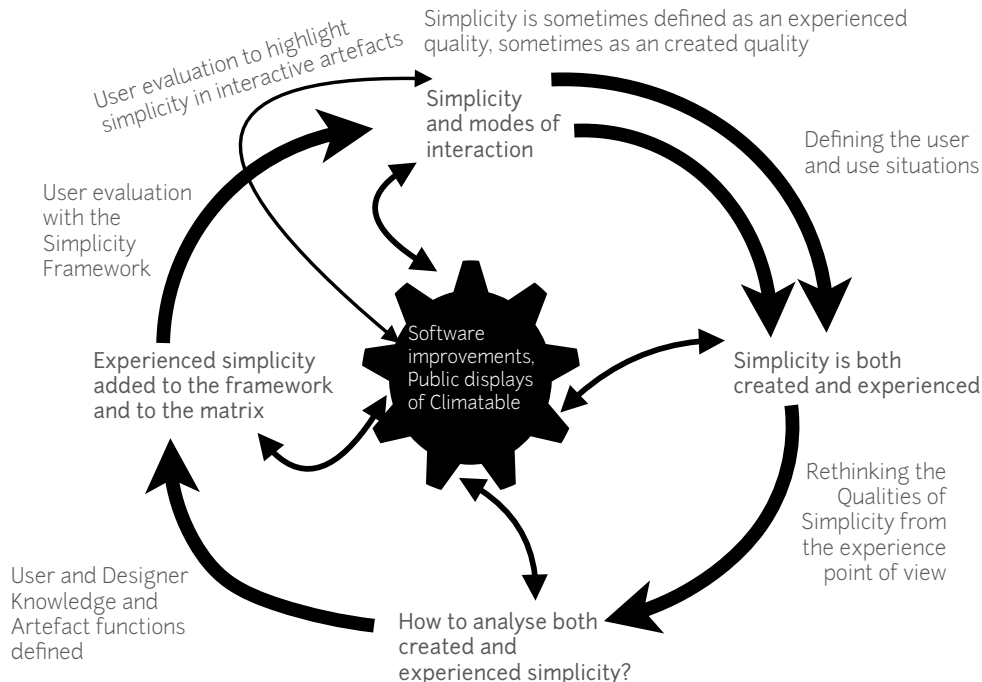
Figure 8. Later hypothesis, research question, evaluation and outcomes.

the others in time.

Figure 7 and *Figure 8* display two main phases of the constructive design process during this research: The hypotheses, research questions, and evaluations have changed and different types of insights, knowledge and relevance have been created in both rounds. These cycles are naturally generalisations and the research has led to other paths as well, including sidesteps and smaller insights which are not displayed in the figures. The motivation that interactive artworks should be easier to use has led to the initial hypothesis that simplicity improves interaction. This has been taken as a starting point for the research, and interactive sketches and programming experiments were made. The way the term simplicity is defined and used throughout the thesis adds another layer, a motivational context to the research. Along with the design experiments, background literature research on design theories and simplicity was carried out. *Climatable* was exhibited for the first time and observing its use in the wild provided discoveries about simplicity that led to changes being made to the design. Evaluation of the experiments, interviews with interactive artists, and analysis of other interactive artworks helped to Establish the Qualities of Simplicity, to build a Simplicity Framework and to create a Simplicity Matrix for *Climatable*. This cycle can be seen in *Figure 7*.

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This research has three aspects: the main body of the research material consists of interactive art, but the study itself is firmly located in the field of Interaction design, and the method used comes from constructive design research.

Starting from a new hypothesis that simplicity is not only designed but also experienced led to a second constructive design cycle where the role of the user and use contexts became more important, as simplicity was also defined as an experienced quality. Written research which was carried out based on the first loop was reviewed and for the most part rewritten. The research question also changed from a personal goal towards a more general question and the wording of it was refined more than once. The Simplicity Framework was rethought. Re-exhibiting *Climatable* on different occasions with improved design provided more detailed entries to the Simplicity Matrix. The framework was augmented with checklists for both design and user experience evaluations. This cycle can be seen to end finally with a discussion on different in-

teraction modes of interactive art installations and their relationships to the simplicity qualities. *Figure 8* illustrates the second cycle.

The main phases of the research of simplicity in relationship to the interactive art installation *Climatable* are plotted on a timeline in *Figure 9*. This timeline highlights some of the main design research milestones as well as design explorations — constructive design experiments. The simultaneous influence of exploration and research upon one another is clearly visible. There are also a few notable gaps. It is worth recalling, that this timeline displays research and exploration activities only related to the *Climatable* installation. Many aspects of this research are not visualised on the timeline. Also, during 2009–13 I attended the Elomedia research school as a status researcher (i.e. not full time), and a lot of the research tasks during that time focused on things like writing an abstract, creating a table of contents, definition of key con-
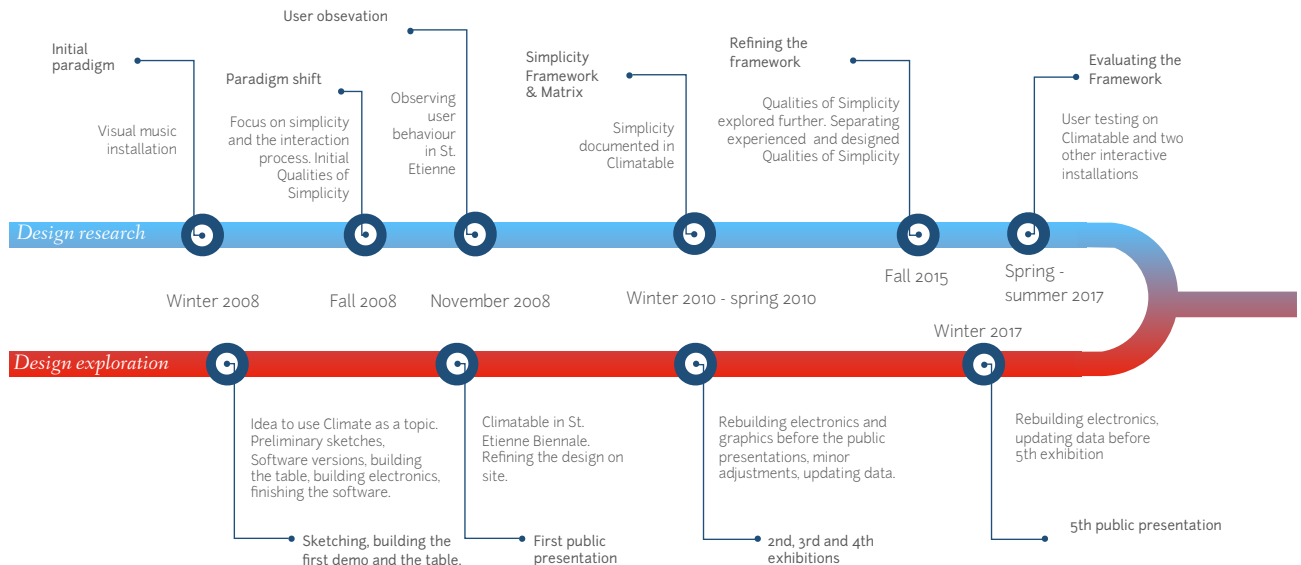
Figure 9. Design exploration and research timeline of Climatable and its simplicity.

cepts, etc. While the research moved on it did not affect the constructive design research cycle iterations so much.

It is crucial for the constructive research design process that the results of experimentation are exhibited in public. Evaluations of the experiments bring in new knowledge, and create new motivations. The whole cycle affects and changes even the foundational elements of the research itself: the hypothesis, the main research question and the research title (Bang et al., 2012). These types of foundational changes have occurred in this thesis multiple times.

3.2 User studies of interactive art

Different types of interactivity and interaction models have been documented in interactive art (Edmonds, 2011; Knight, 2017; Kwastek, 2008; Lovejoy, 2004; Schraffenberger & van der Heide, 2011). While it has been stated that hci and artistic perspectives differ greatly (Höök et al., 2003), examples of research about usage of interactive art do exist. Interactive artists have used evaluation methods or methods which take the user into consideration (Austin & Vogelsang, 2003) and evaluation methods are used by other people to study interactive art audiences (Costello et al., 2005). Candy et al. (2006) describe practice-led research strategies towards interactive art, in both studio and public display settings. In their research, data is collected about the work usage mainly through observation, interviews and questionnaires, and this data is analysed. After these results have been collected, feedback is still collected from multiple perspectives: not only from the researcher, but also from the artist, from the curator, and from the museum organisers. Höök et al. (2003) adapt hci evaluation methods for analysing interactive art. Their research also mentions that frustration arising from bad design should be differentiated from frustration, which comes from encountering artistic interaction, in this case with a machine, which can only be influenced, not controlled. However, this differentiation is not opened up in the research.

There are few examples in which the researchers have been involved in the creative process of interactive artworks themselves. It is also noted that it is not very common to find such studies (Costello et al., 2005; Höök et al., 2003; Seevinck et al., 2006). Also, many interactive artists themselves avoid Interaction design strategies and in general do not seem to care about their audience (Austin & Vogelsang, 2003; Hales, 2009). Comments document-

ing this ignorance exists: "I do not think of my audience as users any more than a painter would think of their audience in such a manner." (Simon Biggs, in Austin & Vogelsang, 2003). In my opinion, many interactive artists just miss the point.

The complexity level of the interactive installations has an interesting relationship to the time users spend with the artwork: if the work is too complex, the work cannot be used, and the users turn away. If the work is too simple, the work might be used for a while, but perhaps not too long. So, a balance is needed. Another obstacle observed by me is that for many people who encounter an interactive installation in an exhibition it is not uncommon to be very careful not to do anything which could be considered as participation, and people are satisfied just to regard the work from a distance. Public situations change the participation towards performing, and being the centre of attention is something which certain people want to avoid (Dalsgaard & Halskov, 2010). However, there are always people who are ready to try the work out immediately and see what they can do with it. Others observe what other people do and perhaps try it out after a while. Probably no one reads instructions or explanations, at least before he or she tries the interactive artwork out.

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Although user-centred design has not been the main design or research method, this thesis contributes to body of research dealing with usage of interactive art.

These general level hypotheses of audience behaviour have functioned in my own interactive art making as — sometimes subliminal — guidelines for creating artefacts with focus on user participation. One of the commitments in this thesis is opening this hidden designer knowledge to others. In order to do this, a more practical toolkit or checklist based on simplicity is created in this study.

Encouraging playful interaction can be a solution for engaging the audience better and a lot of interactive art focuses on creating experiences with participants (Costello & Edmonds, 2007). In multi-person interactive works, the work typically surrounds the people completely, leaving enough space for many people to participate simultaneously. In this case, the personal level of involvement can decrease, and it might be easier to participate since there is room for others — perhaps someone else is already using the system. This study looks at interactive art installations from multisensory aspects, not forgetting about social interactions happening in

public contexts.

3.3 Interaction design methods and interactive art

In this study, the Interaction design practice is used in the field of interactive art. The research circles around design exploration. The constructive design research in this study can be looked at through the viewpoint of an Interaction design framework with three different cornerstones: *design studies*, *design practice*, and *design exploration* (Fallman, 2008). The area of design studies focuses on academic research, using systematic inquiry to produces new theories and knowledge about artefacts. Design practice involves "industry standard" Interaction design activities undertaken as a designer, often outside academia, but with a researcher attitude. Finally design exploration allows the Interaction design researcher to seek novel possibilities outside existing paradigms for interaction. Interactive art clearly belongs to the category of design exploration, often aiming for new ways to interact, experimenting with new technologies and providing alternative views to current media phenomena. In this research, interactive art is also discussed through design studies and design practice.

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Interaction design in this research consists of design studies, design research and design exploration.

This thesis encompasses all three sides of the triangle, with discussion of simplicity as a thread stretching out through them. *Figure 10* illustrates the Interaction design framework through the various phases and implementations of this research. Firstly, beginning with design studies — this should, of course, be obvious: the research itself as a whole is producing a doctoral thesis. It revolves around discovering simplicity in interaction and creating a Simplicity Framework, with discussions with theories about simplicity and observations from interactive art and interactive artists. In addition to the Simplicity Framework and its analysis, other practices such as theoretical analysis of user interaction in different kinds of contexts, self-reflection of me both as a user and designer and interviews with other artists, have all contributed to the field of design theory. Secondly, this research deals with design exploration, which brings in discussions and practices of aesthetics from the fields of contemporary art and humanistic studies to

Design practice:

Iterative adjusting of
the design, aiming for
simplicity in design,
testing the simplicity
framework
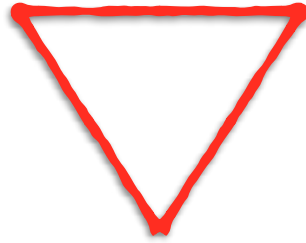
Design studies:

Generating and
analysing the framework
for simplicity

Design exploration:

Creating an emotional
experience, creating new ways
to interact with climate change
data

Figure 10. Model of Interaction design framework (based on Fallman, *2008).*

the field of design research. Under this category belong also topics with strong political or social messages: exploratory design should encourage discussion (Fallman, 2008). The topic of the interactive installation, which is part of this research, is climate change. A strong motivation behind the work is to present climate change data in a new way. Typically, climate change related databanks are numerical excel sheets, text or web pages, from which it is difficult to understand how the values are changing. Of course, the values over time are often represented as graphs, but even then, the importance of the value changes can be hard to understand. In the artwork *Climatable*, climate change data is represented with visual symbols, animation and audio layers. The data can be selected with a physical and spatial computing interface, by moving physical sliders. A multisensory installation can create powerful and emotional experiences when compared to existing scientific texts and visualisations. Having users perform the work, — to make data selections by touching and sliding — creates a connection between the people and the data. This is explorative design. Most interactive art presented in this research is explorative by nature — offering new viewpoints, novel ways of interacting with computers, new communication possibilities. Physicality, tangibility and multimodality are common in interactive art

installations as they allow unique, flexible and expressive interaction techniques (Jacucci et al., 2009; Rogers et al., 2015). In *Climatable*, up to four people can interact with the work simultaneously, and many others can see and hear what happens with the work. This introduces aspects of social collaboration and social interaction to the artwork.

Thirdly, design practice is, of course, evident as the main artwork in this research has been planned, iterated, improved and exhibited on multiple occasions. The design practice is not only about exhibiting a final work, but rather the focus should be on the iterative process. A typical Interaction design process starts with setting some sort of quality requirements, sketching many alternative versions, building prototypes, finishing the artefacts and executing evaluations with actual users in various phases of the process (Rogers et al., 2015). There are tools and methods for carrying out all of these phases. Designing the interactive installation *Climatable* began with sketches and programming tests and moved on to demo versions and semi-functional mock-up models before the work was publicly presented. Iterative design happened as the users were interpreting, participating and interacting with the work and improvements were made based on observing the use situation and interviewing the users. Also, the Simplicity Framework was tested with user studies of *Climatable* and two other interactive artworks.

As the starting point was not aimed at creating interactive products or services to support people in their everyday life interactions or communications, many of the Interaction design methods, such as user background research, designed user personas, moodboards and imagined scenarios were not found relevant. During the creative process of *Climatable*, smooth and hiccup-free aesthetics were of great concern — not only to the visual or aural design, but to the interaction as well. It was important to see how the work behaved and how it was understood. Response, feedback and delay times were adjusted, and other design decisions were made to improve the overall elegance of the interaction. In this case, the user observation and user studies guided the design, so the design practice and design studies went hand in hand. However, during this research process, there were no direct user studies which would have guided or improved the visual, audio, spatial, physical or Interaction design. The user studies conducted in the end phase of the process were conducted to test the Simplicity Framework, created earlier. Any Interaction design case is a balance between designer's knowledge, users' expectations and needs, behaviours or activities that the artefact allows, and emphasis on the way the whole artefact or the system is constructed (Saffer, 2010). Typically, each design case emphasises one of these four aspects. They are all present here in this research as well. *Climatable* was very

much designer oriented work — an artwork made mostly from individual interests. However, there were design changes which were influenced by how the users perceived and understood the work. Being able to see if the users' interaction was guided by simplicity was at the core of this research process. The creative process and the interactive artwork is discussed in the research as a holistic system, in which the design of the space, the physical design, the graphics and audio along with programming all guide the interactive experience. In this research, the actions and behaviours which the artefact allows and the way the whole system has been designed is mostly talked about together under the term *Artefact Functions*.

In this study, *simplicity* is also a term, which has been explored. The definition of simplicity has been a process between design practice and design studies. In the beginning, simplicity was thought to be a quality which aims the designer to increase the usability of an artefact. The initial design of *Climatable* reflects this idea. At the same time, research was carried out into simplicity in academic and other literature in the fields of Interaction design and HCI. The design solutions which support simplicity were analysed: the ways in which simplicity was achieved and is present in many features in the interactive artwork were mapped to a Simplicity Matrix. The selected Qualities of Simplicity were evaluated heuristically and with the help of user observations. This led to material being collected to help answer the original research question and to reiterate the design of *Climatable*. The research also displays how different design decisions have been guided by these qualities. It was realised that simplicity is a quality which can be experienced, and that the discussion needs to take this side into consideration as well. A notable amount of effort has been made to locate simplicity in various aspects of different interactive artworks, which are analysed to identify experienced simplicity in them. Also, the Simplicity Framework was evaluated with user surveys in order to find out whether it could be useful as a tool to detect simplicity. This led to the thought that simplicity can be an aesthetic characteristic of the interactive artefact itself. Finally, this thesis considers simplicity as something which helps to start and guide interaction, is experienced as increasing trust towards the interactive artefact, and allows users to explore the interaction space. I have a strong belief that the way the simplicity is mapped out and discussed also has a value for other interactive art and design creators.

4 *Research material*

The main research material is presented in this chapter. Different research material is looked through the lens of simplicity from the points of view of the designer, the user and the artefact. The research material contains a literary review of simplicity and interactive art aesthetics, but the main body of research concentrates on the analysis of interactive art installations from various points of view. Utilising Interaction design insights when analysing interactive art, and design solutions when creating interactive art has created a constructive design research cycle.

4.1 Interactive artworks in this research

The research material in this study is collected from two main angles: from the point of view of an Interaction designer and the design triangle (studies, exploration, practice), and from the point of view of the user. Each research material and method contribute differently to the

research outcome. This research focuses on interactive media artworks, and by analysing them from various perspectives the concept of simplicity in Interaction design is illustrated. The

Artworks presented \ attributes	User	Designer	Methods of analysing	Interaction design research methods	Design studies	Design exploration	Design practice
My earlier works	Me, others	Me	Observation, heuristic analysis	Descriptions in chapter 4.3.1	Finding out Qualities of Simplicity	Background for working with interactive installations	Background for design work
Other artists' interactive works	Me, others	Other artists	(Observation), heuristic analysis, interviews, user studies	Interviews (Appendix A), User research questionnaire (Appendix B)	Finding out Qualities of Simplicity, testing the Simplicity Framework	Inspiration for working with interactive installations	Finding out different working methods
Climatable	Me, others	Me	Observation, informal discussion, heuristic analysis, user study	Documents of the creative process (Ch. 4.5.1), Observation (Ch. 7.1), Questionnaire (Appendix B)	Building the Simplicity Framework, testing the Simplicity Framework	Creating new interactions, new ways to present climate change data	Improving and iterating the design, refining for simplicity

Table 1. Interactive artworks researched in this study and their relationships to Interaction design fields.

interactive artworks are analysed both from the designer's and the user's viewpoints, but also considering the Artefact Functions. Various Interaction design research methods such as observation, heuristic analysis, and questionnaires have been used to collect information. Their roles and contributions related to the Interaction design triangle presented in the previous chapter are illustrated in *Table 1*.

In this chapter after presenting a framework for knowledge in an Interaction design process, my own earlier interactive artworks will be presented. These can be argued to be examples of simple interactive art experiences. These works have been born mostly before the thesis writing and research process, but also developed further and exhibited during the time. However, they were never meant to be officially included in the research as artistic works. Also, thoughts from my colleagues are presented: I conducted email interviews with a group of young

new media artists with questions related to their relationship with their audience when they create interactive art. Different solutions relating to how they take users into consideration and make interaction easier for the end user are presented.

Secondly, a selection of interactive artworks from artists around the world is also presented. The point of view here is of a user: I have personally interacted with these works. Again, simplicity as a guiding tool towards a low threshold of interaction is presented, this time highlighted from a user experience. The works are presented in chapter *4.4.1 Simplicity in other authors' interactive artworks*.

Thirdly, my main research material consists of my interactive installation work *Climatable* and the documentation of the creative process towards simplicity as the work was created and presented on various occasions. The creative process — constructive design or design exploration — has been described and analysed from different aspects of the design; documents such as sketches and software versions are presented to support the text. First, in chapter *4.5.1 Sketches, screenshots, software versions, fine-tuning* the creative process is displayed, then in the chapter *5 Building Simplicity* I take a step back and collect all the research material and combine it with previous research on simplicity and construct my own explanation of it. After explaining what I mean by the term simplicity, various design solutions, which express it, have been found and categorised in the interactive artwork *Climatable*. This process, described in the chapter *6 Simplicity Matrix — case Climatable*, of locating and displaying simplicity in interaction is also complemented by an iterative research process with the mapped out Qualities of Simplicity — where do they manifest themselves and how they could be improved? Are they clear and easy enough to explain? If not, required changes were also made to the design.

To find out if the work was perceived to be simple, attention was always paid to how people were interacting with the interactive installation. The first time *Climatable* was exhibited, four separate user observations were conducted over three days. Notes were made about how the work was used, how people reacted to it and whether the interaction possibilities were understood. During this time, after exhibition hours, the work was slightly modified, and then later on between separate installation times and locations, bigger improvements were made to it. During the exhibitions, informal discussion with the audience also gave insights for future design improvements. Since the design-research process has been cyclical and iterative, in the chapter dealing with *Climatable* research, material (documented design decisions) and discus-

sion (how the decisions were made and altered) intertwine inseparably. In chapter *7 Evaluating Simplicity* this process is explained, and explanations of how and when simplicity occurs, how it is perceived, and how important certain qualities are for constructing an experience of simplicity are given. Also, the validity of the Simplicity Framework and the Simplicity Matrix are tested out with user surveys.

4.2 The domains of knowledge

Before the material is presented, it is worth analysing and categorising it more carefully since the material itself and methods of achieving, analysing and presenting it vary a lot. As presented above, the research material consists of many different kinds of things: reflective discussion of the author as a designer of interactive artworks; discussion of interactive artworks which the author has been a user of; other artists explaining their interactive artwork, and finally, various sketches and software versions of one interactive installation. Thus, we can talk about knowledge related to design, knowledge related to usage, and functions in the artefacts (sketches and demo versions as well as the final exhibited work). I argue that knowledge in Interaction design can be born from all three of these domains: the designer, the user and the artwork itself.

The Interaction designer iterates his or her own process, using his or her knowledge, skills and suitable tools to make the work better. Then, there is also the user the Interaction designer should learn from. However, during the design process, the artwork or artefact can reveal something perhaps unexpected to the designer, which changes the process in a direction not planned for beforehand. An example might be noticing a user interacting with the system in a way which was not intended by the designer. The user reveals something new about the interactive artefact, which can guide the design process to new directions. These can be called Artefact Functions, which are aesthetic qualities, manifested by the product itself — or in the case of interactive artworks — by the whole interaction process. Thus, even the artefact can be said to produce knowledge, which differs from the designers' original intentions and the users' experiences. The designer should be aware of the types of knowledge. They all can be studied. (*Figure 11*)

1) Designer Knowledge. This one could also be called Creator Knowledge or Profession-related Knowledge: skills, expertise, work experience, discussions in the field, communica-
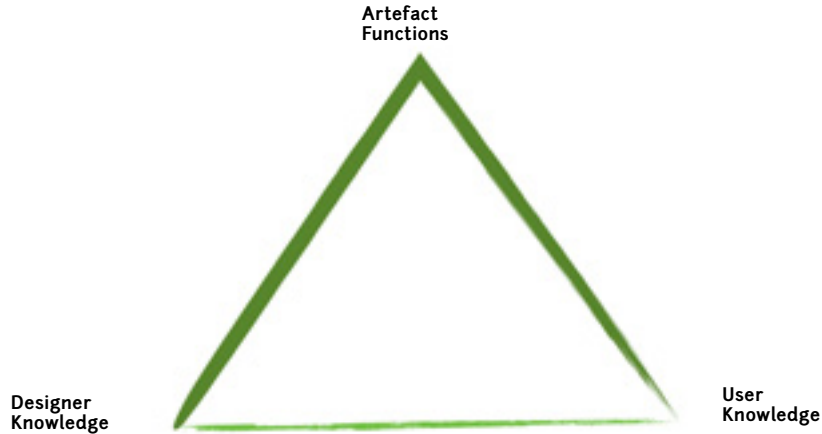
Figure 11. The domains of knowledge.

tions with colleagues all build up Designer's knowledge. 2) User Knowledge. This knowledge is use-related, and it can originate from various sources: observation of people using the work, interviews, feedback, questionnaires, user surveys, or personal experience as a user. 3) Artefact Functions. Instead of holding knowledge, the artefact can be seen as a source of knowledge. If separated from the designer and the user, this would be the most ephemeral and difficult to explain, the discussion quickly plunging into the philosophy of art and aesthetics, the hidden knowledge and the spiritual. However, one can think about this in a practical way: the Artefact is the meeting point between the designer and the user.

The designer does not often directly communicate with the user, the user does not necessarily know anything about the designer. In the figure above this is illustrated with a weaker line between User Knowledge and Designer Knowledge. In most cases, the knowledge between these two actors is mediated through the artefact. The designer tries to embed features in the artefact which he or she hopes the user will find useful. The designer builds the things as well as the acts of using them (Hallnäs, 2011). The user approaches the artefact with a mental model, a predisposition of trust, an initial understanding of the artefact based on earlier examples and experiences. The Artefact Functions are not only designed but expected, experienced

and discovered from the interactive system. We have cultural knowledge not only of what certain objects are, but also how certain are used as (Houkes, 2006). Thus the artefact acts between the user and the designer. The system is looked at as a whole, and attention is placed on the context (Saffer, 2010). Besides context, in Interaction design, the design of the action and expressiveness of use is of a high importance (Hallnäs, 2011).

It is impossible to separate knowledge produced by the artefact completely from designer knowledge or user knowledge, but for the sake of simplicity, Artefact Functions are presented as an equal third in the knowledge triangle. Between these three main attributes, an iterative cycle common to any design (or art, or research) system can be found: the creator, the audience and the work all affect each other, although the process is complex and not straightforward in many cases. In interactive art, the participants or users have a close relationship to the artwork and through that also to the creator of the system. On the other hand, the designer is more or less always the first user to test his or her own system. Thus, it is also easy to identify smaller feedback loops or cycles between any two (even all three) attributes: between the artist and the work, between the work and the audience, and between the audience and the artist. Research material can be placed in two knowledge areas as well.

4.2.1 The domains of knowledge in this research

I will continue discussion of these domains of knowledge as I present my research material related to these areas. This chapter is also a jumping board to start collecting evidence for the attribute I am principally interested in: Simplicity.

In *Figure 12*, I illustrate how these types of knowledge match the research material in this study. The main research material related to the three domains is presented in the smaller circles, and research material, which can be seen to interact between two of the three domains in the bigger circles.

Designer's Knowledge contains two types of research material: the questionnaire sent to interactive artists encouraged them to talk from their personal, creative point of view. Designer's Knowledge also contains my personal opinions of my own interactive artwork processes. User Knowledge contains the user observations which have been conducted, but also the written descriptions of user encounters and personal experiences with interactive artworks.

Artefact Functions

Documented creative process of Climatable

Climatable: a documented work with a description of the creative process and designer's (my) iterations; my own interactive artworks: looking back as a designer

Artworks for Saa Osallistua! -exhibition: an interview and artists' descriptions of the creative process and my personal user experience of them; Climatable: user observation and discussions

My own interactive artworks + questionnaire to young interactive artists

Selected interactive artworks + observations of Climatable, Simplicity Matrix questionnaire

Designer Knowledge

User Knowledge

Artworks for Saa Osallistua! — exhibition: my personal user experience; selected interactive works: my user experience

Figure 12. Three domains of knowledge in the research material.

The artefact production process is documented as well as possible in the chapter *4.5.1 Sketches, screenshots, software versions, fine-tuning*. In that chapter, the focus is on how work on the interactive artefact itself guided the design process and how the design decisions moulded the work in a certain direction without active designer knowledge.

However, there are some occasions where more than one knowledge domain is touched. When presenting *Climatable* the discussion moves back and forth between designer-made decisions and the design itself, which just seemed to happen: sometimes there were very conscious decisions, but at other times the changes cannot be traced back as such — the work just turned out to be something. Also, notions of user observation and discussions with users related to the work are mentioned, and lastly my self-user testing is discussed when *Climatable* is presented: I am always also a user of my own interactive installations. Nevertheless, I still feel the main domains of the research material are related to *Climatable* cycles between Designer's Knowledge and Artefact Functions. In the case of selected interactive artworks from other artists discussed

Methods of analysing and contributions to simplicity	Contribution to the Simplicity Framework	Perspective	In this research
Literary review	Establishing Qualities of Simplicity	Designer and user knowledge	Chapters 5.1 and 5.2
Interviews of other interactive artists (questionnaire) and analysing their artworks	Establishing Qualities of Simplicity	Designer Knowledge, user knowledge, Artefact Functions	Chapter 4.3.2
Analysing other artists interactive artworks (heuristic analysis, interviews)	Critical evaluation of Qualities of Simplicity	User Knowledge, Artefact Functions	Chapter 4.4.1
My own interactive artworks (heuristic analysis)	Critical evaluation of Qualities of Simplicity	Designer Knowledge	Chapter 4.3.1
Documents of the creative process of Climatable (Heuristic analysis of Climatable)	Evaluation of the design through Qualities of Simplicity	Designer and Artefact Functions	Chapter 4.5.1
Usage of Climatable (user observation)	Testing out experienced Qualities of Simplicity	User Knowledge	Chapter 7.1
Questionnaire for testing Simplicity Matrix	Testing the frameworks and applying Simplicity Framework other artworks	User Knowledge	Chapter 7.2

Table 2. Different research methods contributing to different areas of knowledge.

in chapter *4.4.1 Simplicity in other authors' interactive artworks*, I have no direct contact with most of the designers or their intentions, so I have my user experience (User Knowledge) and the artworks themselves (Artefact Functions) to discuss. In the case of the artworks in the *Saa Osallistua! / Please Participate!* exhibition discussed in chapter *4.3.2 Approaches of young interactive artists*, designers' descriptions of the creative processes of their interactive works complements the knowledge offered by the artefacts themselves. However, I also discuss them from my personal — in this case the user's — point of view. Thus, the discussion of this material touches all the domains of knowledge: Artefact-produced knowledge (functions), User Knowledge and Designer's knowledge.

The three knowledge domains will be also discussed from the point of view of Simplicity. Simplicity can be experienced (user), created (designer) or thought to be as an inherent or embedded quality of a system itself (artefact). *Table 2* collects the various research methods used in this study and their contributions to the Simplicity Framework and the different domains of knowledge, which have helped to create, analyse and test the Simplicity Framework.

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Knowledge in this research is looked at from three sides: designer's, user's and the artefact's point of views.

4.3 Designer Knowledge

THERE CAN BE TWO WAYS TO collect designer knowledge: firstly, "3rd person knowledge" obtained from other designers and artists either by written or oral discussions, interviews and other communications, from designer retrospectives, photographs, audio recordings, offline and online documentation. Secondly, the creative process can be written or otherwise documented from the author's auto-ethnographical "1st person" view — e.g. in this research my own work, methods, and solutions are discussed. This research emphasises the designer's role, although it is always attached to the artefact and to the user. In this research both 1st and 3rd person material are presented, in this chapter, I present 3rd person views collected with a questionnaire and verbal communication with interactive media artists. Later on in the next chapter *4.3.1 Designer Knowledge: simplicity in the author's interactive works* my personal artwork is described, in

order to support the discussion of simplicity.

The designer's knowledge is inseparably tied to the Artefact Functions. During the Interaction design work, the creator iterates his or her own design and solutions based on intuition and expertise. This two-way communication between the work and its creator can be written down from the 1st person's view but also tracked down in new media art in — for example — various sketches, different software versions of the work, and different "released" or final versions of the work. It is worth recalling that in interactive media pen and paper (i.e. sketches) cannot give a reliable picture. While traditional sketching with pen on paper has an important role, it is not always sufficient in Interaction design, which is time-based and can offer the users embodied experiences. It has been suggested to use programming to create or build prototypes with a sketching mindset instead or on top of paper sketching (LÖWGREN, 2012). Knowledge of expressions of computational things and attributes of interaction possibilities are needed — they can offer the designer a playground to explore the design space (LIM ET AL., 2007). When aiming for simplicity I have noticed it is often small details that matter, and documenting these changes is sometimes very difficult with words, still images, or even video.

The designer must also step into the shoes of a user before the work is released, and this knowledge is of course built with time and experience with existing interactive systems — not only interactive artworks but also everyday devices, controls, interactive systems, software — created by the artist or others. In other words, the designer's knowledge should contain the user's knowledge (KRIPPENDORFF, 2005). The artist can also act as an expert usability analyst and go through a heuristic checklist, asking him or herself questions like: Does it speak the users' language?; Are the possible actions clearly visible?; Do the users have enough freedom and flexibility? Heuristic methods also include such well-documented tools as scenarios, key personas and their related mood boards, which try to lead the designer to step into someone else's shoes, helping him or her to imagine what an interaction event might be like before it actually occurs.

Instead of carrying out traditional HCI surveys: studying my possible future audience, making queries, interviews and research beforehand, or co-designing with possible end users, the process of my interactive art is usually based on my previous knowledge of interactive art and Interaction design. This is a process of heuristic design, in which the designer is an actor who in the end is responsible for the final decisions over how the design turns out. The designer trusts the knowledge and the intuition which have accumulated during their career. This can be a very intuitive process or manifest itself in more or less subconscious questions which the

designer poses to the project in various phases of the process.

The creative process — constructing, designing and programming the interactive installation *Climatable* — has been a multi-phase, iterative heuristic constructive design process. It could easily be said that it has consisted of two main components, which oscillate. First, a theoretical, written component focusing on simplicity, which is defined in the chapter *5 Building Simplicity*. It is also describes how different parts of the installation follow simplicity, and cases are shown when simplicity was not feasible or did not act as the guiding line. The second round consists of comparing the solutions made with simplicity in focus, but from a user's point of view. This is carried out in a heuristic way, revealing new information about the artwork, adjusting it, making changes — to fuel the next phase of writing: helping to categorise and justify the Qualities of Simplicity presented in this research. Which of the decisions were good, which not? As one can read, these two phases did not occur in time hermetically separated from each other, rather they were mingled together, as part of the design could not have been carried out without the written research and vice versa. However, it is worth pointing out that creating something and observing something need a third wheel as well: presentation of the work. The designer creates something to discover things which would not be seen otherwise, and also encounter new problems (Koskinen et al., 2011). We can discover difficulties of use when the design is presented and people interact with it. Solving those problems through iterative design, presentation and new analysis constructs or extends designers' knowledge.

4.3.1 Simplicity in the author's interactive works

In this chapter, three interactive artworks which I have created and exhibited are presented. They do not belong to the artistic part of the thesis. Most of these examples were originally been created between 2007 and 2008, but big modifications were made when the installations were exhibited in 2008, 2010 and 2011. There is a relationship between these works and this research: the research has affected how these works have turned out and how they have been modified. In turn, the exhibition of these works has affected this research. The time span of the creation and presentation of the artworks fits the thesis writing process, which initially began in 2007. However, the focus of the research has shifted dramatically since that time, and it was not considered that the interactive artworks I was creating should be presented

in a context of the original topic — visual music. It is now evident that there is a connection of ease of use which has taken a central role in the research into the Interaction design in these works. This is why they are brought to the research as evidence of the Qualities of Simplicity detected in the chapter *5.2 Qualities of Simplicity* — as artworks where research motivation has not guided the creative process.

The first work is *Almost Famous*, which was presented as a concept or demo at Galleria Belleza y Felicidad, Buenos Aires, Argentina, in April 2007. The work in a new form was properly publicly exhibited for the first time at EMMA, The Espoo Museum of Modern Art, Finland in August 2010, and improved later on that year when it was presented in Lappeenranta. The second installation is *Wish You Were There?*, first exhibited as a prototype in St. Etienne, France in May 2008 during the final presentations of the mobilAnd workshop, where I was invited as a guest artist-teacher. The work has been exhibited at least four times since with some minor improvements each time. The third work is *Mobile Phone Flowers*, which was publicly exhibited for the first time in Rovaniemi, Finland in fall 2008, and improved for exhibition at EMMA, 2010. As mentioned, all of these works have been exhibited approximately simultaneously with writing this research and creating *Climatable* — most of them had been realised as earlier presented or demo versions, but the improvement process has been simultaneous with this research.

Almost Famous

ALMOST FAMOUS IS AN INTERACTIVE WORK in which the participant can become a famous movie character by manipulating a mask: a laminated cut-out paper head, with movie characters' names written on the backside. When a mask is chosen and picked up, one camera tracks the fiducial marker symbol on the rear side of the mask while another camera functions as a mirror, portraying the participant, but replacing the cut-out paper head on the screen with a face of a famous movie character — the same one whose name was written on the front. The character is alive, repeating a short quote, which is translated into Finnish (or English if the source is a Finnish film) in a speech bubble (*Picture 4* and *Picture 5*). The different quotes create a sort of dialogue between the characters and the participating people. Up to four people can take part at the same time, and participants can select any from over 60 different masks from a table in

Picture 4. Users selecting a mask.

Picture 5. Users viewing themselves as movie stars.

front of the projection. Still, the interaction possibilities are reduced: there are only masks in the table; and organised: each mask works in the same way — the detected symbol triggers a movie clip. The laminated paper masks were designed to be picked up by the visitors, as a natural affordance related to masks: people take them and hold them in front of their faces.

The connections between the face-shaped mask and masked out face on the screen are very tangible. Wearing a mask in the real world is transferred to the virtual world — a mapping of familiarity. Also, the written character names add familiarity since most characters are more or less famous from well-known films (Travis Bickle, Barbarella, Gilda, Don Corleone, etc.) Although the interaction possibilities are reduced, the action is repetitive, and simple once you learn it — the first time the work was exhibited not all the people realised what to do, or did not want to take the action. Although the mask affords picking up, it was not clear which way to display it to the camera, or that this was the interaction which would trigger the virtual mask. The mask was not the same size as a person's face, and the patterns, which the computer recognises are not familiar to the end users, so there was room for improvement. Also, the space was a black box gallery room, so the video mirroring did not really function when the room was empty: the screen was mostly black, not providing any visual clues about the possible interaction.

Picture 6. The simple instructions of Almost Famous.

I made some changes for the later set up of the work at the end of 2010 when it was displayed at the City Hall /Culture House of Lappeenranta as a part of the *Human | Culture — year of interactive arts —* project. As I had observed I could not trust the users' intuition of knowing what to do to in order for the work to function perfectly, I added an animated visual element which functions as a motivational element and also as instructions on the screen: a face similar to the masks which suggest coming closer, picking up a mask and trying the work

out (*Picture 6*). The location was also much lighter, so the image on the screen lured the user to move forward to see him or herself on the mirror. Unfortunately, my time was limited in Lappeenranta and I had just one night to build up the work, so I did not really see it in action, but the people I worked with have told me that the work was used quite a lot, there were no problems that they knew of, and that the reaction was positive. It is very important to be able to select the installation location and be able to design the space where the installation is built: to define how the installation is viewed for the first time, how to access it, where the table with the masks is, where the screen and cameras are located. It is also important to adjust the elements on the screen according to the physical space: how big the video mirror picture is, how big the mask images, the info image, and the fonts on the screen are. For this, I have created an easy-to-access system for the most important variable values, which can be then changed easily during the set-up process. These tools simplify my own working process with systems which can become very complex to program. Refining spatial and visual elements, and making the camera tracking as fluid as possible builds elegance into the system, and allows trust to be born between the work and its user.

Wish You Were There?

Wish You Were There? is another interactive installation I have displayed in various locations. It combines a photo and a phone-booth with virtual travelling. In the installation, the visitors stand between a camera and a green-screen and see a projection of themselves in front of them, against a black background. Text on the screen invites them to call a phone number. The call is detected by a mobile phone nearby, which is connected to a computer. A voice informs the caller that the call is received and asks him or her to look at the camera (*Picture 7*). After this, a virtual landscape appears on the screen, on a layer behind the caller and the other people possibly present. The landscape is selected from an image database by picking up the last two digits of the caller's mobile phone number (*Picture 8*). The system then takes a screenshot of the caller and the landscape and uploads the image to a website (http://koti.org/tomtom/wishyouwerethere/), where the user can see the image later on as a virtual postcard. After a while, the image of the virtual landscape fades to black and the system is ready for another virtual traveller. The landscapes are localised: some are familiar images from the surrounding area where

the work is displayed (St. Etienne, Rovaniemi, Reykjavík, Jyväskylä, Helsinki), some are more typical tourist postcard landscapes.

One of the most often asked questions when someone calls you is "Where are you?" We no longer inhabit a specific space such as home or office while talking to someone on the phone. This installation plays with the idea by placing the caller in a semi-random, not user selectable locations. However, there is a link between the chosen locations and the caller, generated by the fact that phone numbers are more or less personal ids. There is a feeling of ownership or author-ship: when the system has been on display, callers often refer to their postcard pictures having "my background" or "my landscape." The mobile phone is ubiquitous and allows instant access (at least in theory) to anyone, anywhere on the globe, any time. It has been used in interactive installations in many ways, often forcing users to upload a specially designed software to do spe-cific things for a limited range of possible phone models. In *Wish You Were There?* the options are reduced as it uses the everyday action of the phone call as the main interaction method. Thus, the interaction is simple since it is a familiar everyday action. Mobile phones afford call-ing, but in the case of this installation, what will happen when you call is not explained. Will the phone call be answered? The callers use their intuition to try the installation out and see

Picture 7. Wish You Were There? setup.

Picture 8. The resulting virtual postcard.

what happens. In the installation setting, this intuition is helped and guided by another computer, which displays the web-gallery made by past callers. The installation space and events of the interaction are organised carefully so that the viewer of the gallery becomes first the caller in front of the camera and then the creator of the latest gallery image, which is displayed just seconds after the screen capture is made.

There is enough feedback supporting intuition and building trust — although the call is not answered, the detection is signalled to the caller with an audio message. The postcard image appears, displays for a few seconds and slowly fades away, suggesting a polaroid photo being developed — in reverse. The web gallery updates as just image has faded away. All of these phases reveal familiar things: the postcard scenes and borders around the image, the photo-booth feeling, the web gallery, audio guidance — people are also asked to "Look to the camera and say cheese!" — all are things that the users recognise easily. The smooth flow of the events and successful interaction build trust, which is aided by the fact that the users can read from the screen that calling is free. Building this type of system with many changing variables required a complex hardware and software set-up. Although many things could have been programmed more easily, I searched for programs and programming languages, which would do things very quickly on the background so that the user is not disturbed, there are no wait screens or progress bars visible. The end installation uses Quartz Composer to combine the video image with the postcard, OpenGL programming inside Quartz Composer to do the Alpha channelling or green-screen masking of the video image, shell scripting for screen capturing, thumbnail creation and FTP uploading, and PHP on the website to create a dynamic gallery from the images. This seamless background processing is important for building trust: competence is again something that very small details and technical solutions can construct. Of course, this complexity is hidden from the user, and the experience remains pleasurable — transparent and simple.

Mobile Phone Flowers

This is the description of the third installation of the artwork from the small leaflet which was given out in Espoo Museum of Modern Art: "Ever wondered what your mobile phone number would look like as a flower? With *Mobile Phone Flowers* you can. The interaction is simple: call the phone number you see displayed on the screen. Five flowers are visible on the

mobile phone flowers.
call +3584050241I5
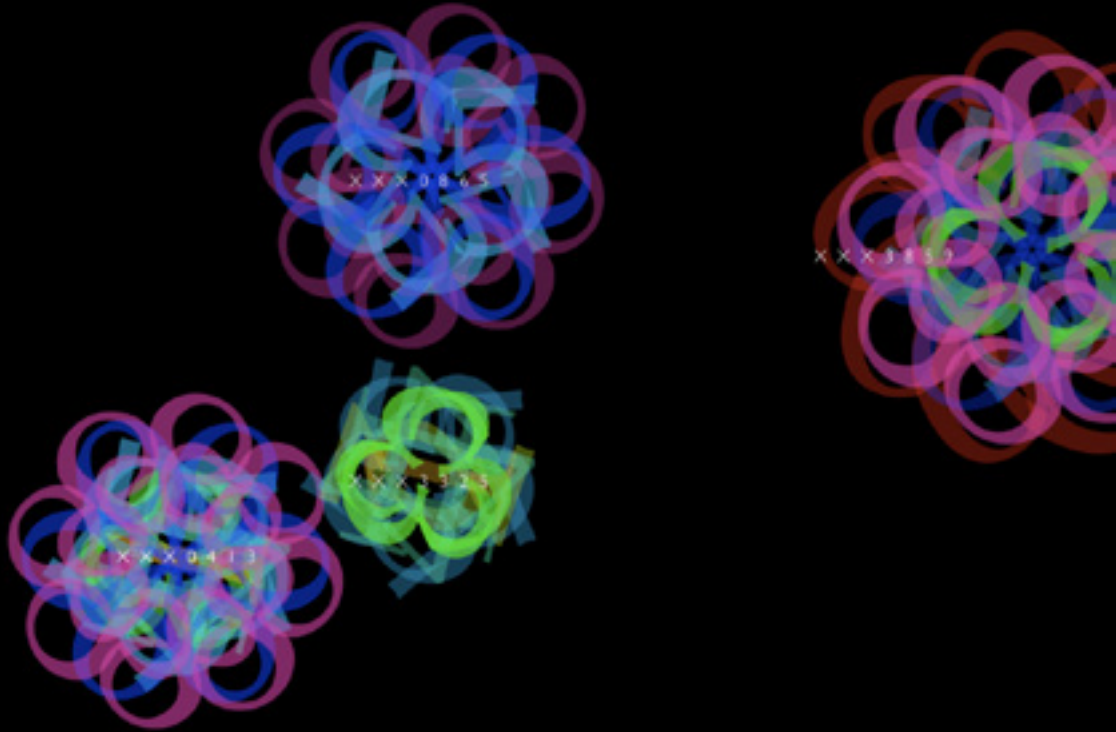
Picture 9. Screenshot from Mobile Phone Flowers.

screen, and your call will give birth to a new flower which replaces the oldest flower in the virtual garden. The flower's ingredients are embedded in the caller's phone number: the colours, size and location are all dependent on the individual digits in it." What is worth mentioning is that the installation did not require any written help text or usage guide other than the one line instruction on the screen.

Mobile Phone Flowers is an artwork about (phone) numbers, kinetic typography and visual minimalism. It also deals with visual organisation and reduction. The screen displays only flow-

er-like patterns reminding of mandalas, created from numbers or digits, which seem randomly picked, but are in fact derived from the callers' actual phone number (*Picture 9*). The complete phone number is not identifiable, but the user can recognise which of the flowers is created from his or her phone call: as the call is detected, a new flower fades into a certain position on the screen. The last four digits of the phone number are displayed on top of the flower to help identification of your own number. Phone numbers are different and usually the callers knows their own number. Again the interaction flow is organised and reduced in a similar fashion to the work *Wish You Were There?*: the flower is created by calling with a phone to a number on the screen. This is an everyday action, the result is predictable after seeing other flowers appear, but still surprising as one interacts with the work. The five flowers on the screen guide intuition with the minimal text on the screen ("call +phone number" in the first version, "call +phone number to create a flower" in the later versions) that something will happen if one calls. The user calls, hears a sound effect which signals that the call is detected, and a new flower will be shown. Audio feedback again answers predictions or fulfils the user's intuition and builds trust that the system functions. There were some problems with the last flower fading out and new one appearing — the two flowers flickered back and forth. In a sense, the visual activity on the screen caused by this programming bug helped: at least the fact that there was a change going on was noticed. More fluid options could be developed for later versions such as an old flower sinking and a new one growing from the ground when the call comes. The complexity of the programming is again hidden, the system seems stable, fluid and trustworthy.

Repeating features in these interactive works has led to a reduction of unnecessary material to the basics, using familiar actions as interaction possibilities, organisation of material in space (both physical and on the screen), and managing the time-based interaction so that events happen in the right order, feedback was given back to the user with the right timing. The improvement of the works has also been a repeated process — all of the works have been presented more than once, and improved between the times they were exhibited. All of them are also complex from the designer's or programmer's point of view, but they are put together piece by piece like a puzzle. The end users need then only to grasp the completed puzzle picture, and do not have to be aware of the complexity underneath. Some of the final changes have been very subtle, small improvements in timing: when or how fast or slow something happens, how long do certain things last, are there events which are triggered periodically; graphic design: user instructions, selection of typography, colours, animation, rhythm; audio design: which sounds

and sound effects are played, what kind of mood is created: humorous, serious, calm.

All of the works mentioned in this chapter differ from *Climatable* in one aspect: these works are more lighthearted, without much "serious" content other than the interaction itself, and the works play with the idea of the participant as a person who is somehow transformed or augmented through interaction: minimally their personal phone number is presented as an animated flower in *Mobile Phone Flowers*; their image is captured and appended to a landscape or a miniature photo to create a personalised virtual postcard in *Wish You Were There?*; and ultimately they are transformed in real-time to someone else with a virtual mask of a movie character in *Almost Famous*. This personal presence and play with interaction is absent from *Climatable*, which on the other hand might make the work more approachable — yet the experience might not be so personal or memorable.

4.3.2 Approaches of young interactive artists

In winter-spring 2011 I curated an exhibition of interactive art at Saarijärvi Museum. The exhibition was called *Saa Osallistua! / Please Participate!* and it was open from April 8th to June 5th. As a guiding line for curating the exhibition I ensured three things: 1) the artworks were interactive, 2) the artworks were made by young artists — not necessarily meaning their age but their experience with the art world and 3) the artworks were mostly Finnish (this restriction was partly due to financial reasons). All of these three ideals were fulfilled in the final exhibition. Related to the exhibition and its catalogue, I asked participating artists or artist-groups to answer four questions by email. Two questions were related to the exhibition catalogue and two to the thesis. I mentioned this and asked permission to use the answers as part of my research. The artists who answered did not know about my Qualities of Simplicity, but I did tell them that the thesis handles ease of use of interactive art and simplicity as a means to achieve it. These two questions related to the interactivity of the works were posed to the artists: "Please describe briefly how your work is used, how does the audience participate / interact" and "How does the fact that there is audience participation / interactivity in your work change your artwork or working methods?"

The complete email which I sent can be seen in the *Appendix A*. Results of this questionnaire are explained in more detail in the chapters below, as I present the collected findings and

focus on those that are related to these artists' ideas about interactivity. Particular attention has been given to notions in which the artists talk about details, which make their work simpler: easier to use and approach by the participants. These key findings help me gather material to construct the Qualities of Simplicity in the next chapter *5 Building Simplicity*. Compiled and categorised answers related to interaction methods, ideas about the work and Qualities of Simplicity, which are mentioned in the answers can be found in *Table 3*. All the artists point out to elements which can be labelled under the Qualities of Simplicity presented earlier, although they do not necessarily use exactly same terms presented here.

For most of the participating artists, the user or the participant of the work is an important element to think about before, during and also after the created work. These artists have planned things to be interactive from the beginning, and have wanted to create works which share something with the viewer, and have also observed how interactivity has been understood when the works have been presented. Interaction is often seen as a challenge as well, adding an extra element for the artist to think about when making the work. Interactivity is seen as an extra conceptual or participatory level to the work, an added possibility of communication between the artwork and its user. Based on these explanations this can be manifested in various ways: interaction creates or at least encourages playfulness, brings forth an educational component to the work, raises awareness, creates new experiences, or engages participants to the world or theme of the artwork. These powerful experiences — some artists talk about memories — could be provided by sensorial means, with which the participants are able to immerse themselves into something that is not present in their everyday experiences.

The questionnaire was short and does not really reveal the creative process behind the finished and exhibited work, but does offer some interesting thoughts and motivations from the artists involved. It is obvious that compared to traditional media artists out of which some completely neglected their audience, this is a newer generation who creates interactive works with their users in mind, with the interaction itself being a valuable additional layer or dimension in the work, which has to be designed and thought about thoroughly. The audience is asked to share or create memories in the works by Vanhala and Sipilä & group and Salminen & Jaschek; hoped to learn something in the works by Dufva brothers and Ziegler; or was even challenged to question their interactive actions in the case of Niinimäki's work. A commonly occurring theme is also that the interaction with the exhibited interactive art installations is seen as a form of playful communication between the world of the particular work and its users. Although

The artist	Interaction method of the users	Artist's creative methods / idea behind the work
Varvara Gul-jajeva	Wind, touch, listening, awareness, being present. Users are observers, using natural actions.	Complex: find a suitable interaction and realisation method. Technical and conceptual challenge. Experience by observing how interactive work has been understood.
Pauliina Salminen & Andres Jaschek	The visitor uses furniture in a normal way. Opening a drawer, rocking on a chair. Touching, moving the body	Sensory approach. Search for things which could be used as interactive furniture, part of "Granny's world"
Sebastian Ziegler	Phone calling, listening	Increases awareness of our environment.
Tomi & Mikko Dufva	Buttons and selector (potentiometer) to select, LEDs to display. Choose a year and datatype	Designed to be interactive, forces some design decisions towards simplicity (this can be good or bad). Interactive artworks are about making choices, art is often about something where the choice is not clear — requires careful approach so that the artwork does not become only a database. Spontaneity, inspiration still present.
Janne Similä & Aki Nyyssönen	Moving (or not moving) in front of a TV / Screen	Participation is a challenge to the creative process
Matti Niinimäki	Turning a crank	Raising questions about interactivity, about consequences of actions
Johanna Vanhala, Maria Sipilä & group	Visitor uses a tablet computer, headphones, chooses sounds, gives names to the works, suggests scents related to the works, mixes memories (with a physical interface with potentiometers), lifting up a pillow.	Creating a shared memory with the visitor. Design and produce an environment, where the visitor could interact & participate as much as possible. Tablet computer creates a private moment for the visitor.

Table 3. Results from the interviews with interactive artists.

Role of interactivity in the work	Qualities of Simplicity mentioned (and observed)
Adds additional dimension, conceptual value. Coherent with the concept of the work. Behaviour of an artwork, Installations as communicating, living things.	Audience-friendliness, instructions not needed (intuitiveness).
Reveals something hidden, personal about the imaginary habitant. Surpasses the intimidating technological side of interactive devices. Sensorial experience. Relates visitors to something which might be out of their usual life circles. Activity makes participators feel included to the artwork's theme.	Familiar objects, everyday actions, (tangibility).
Playful extension of education. Raising consciousness.	(Familiar everyday action). Ringtone corresponds to the information poster on site (organisation). Bird voices as ringtones (tangibility, familiarity)
Simple, encourages playfulness. Allows exploring of lake state changes throughout the years. Participation can create a sound or vivid experience.	Simple physical interface (intuition, tangibility). Understandability (familiarity) and meaningful (tangibility). Represent the best knowledge on water quality and be aesthetically interesting (reduction, organisation)
The work changes from state to another when movement occurs (or has stopped). Audience movement an essential part of the work.	Moving (Familiarity, intuitiveness)
A dead robot becomes alive, but only for a short time	Simple physical actions, understanding interaction (reduction, familiarity, tangibility)
Creates a moment of remembering in interaction with the visitor. Content and aim determined the interactive form.	Physical actions: touching, mixing (tangibility), environmental interactive experience (organisation, tangibility)

design was not mentioned in the questions, many artists describe designerly activities: they talk about designing an interactive space or interactive work, others talk about Interaction design methods such as observing how users behave, to improve interaction later on. These methods could very well be considered design exploration, one of the three fields of Interaction design, but most artists presented here have worked outside design research and academia, and the exploration is not backed up by research or everyday design practice. It is important, however, that the art audience is considered active, and their participation is essential for the experience of the work. The artwork is not complete without the audience trying it out, being active, complementing or augmenting the work with their actions, experiences, memories and comments.

4.4 User Knowledge

This research does not claim interactive artists should become usability engineering specialists, undertaking extensive target group scanning, audience surveys or user testing, although there are some artists who carry out even this type of research (Austin & Vogelsang, 2003). However, in interactive art, the participant simply cannot be ignored. It is left to the artist to define the level in which the users of the work are considered. Basically, information about the users can be gathered in three different phases of the creative process: First of all before the creative process has even begun, such as in user-centred design, where the potential users are researched, assumptions are made about possible users, and identified future users are interviewed to know what kinds of devices, services or other things they would like to have or use, or how existing ones could be improved. In User-centred design people other than designers or artists participate in the creation process from the beginning, even acting as co-designers. The second phase of collecting information and feedback from the users happens during the design process with user testing, observation, user-generated comments (oral or written) and surveys. In the third case, using similar methods as above, the information is collected after the work is finished — to improve the work before it is presented next time or to avoid repeating the same mistakes with future artefacts. Without any user studies or surveys, the Interaction designer is left without some crucial information, which possibly could make his or her work better. Thinking about the user is necessary for the interactive artist as well.

In this research and the artwork related to it, I have used user research methods in at least

two different ways. First, I have written from the user's point of view from personal experiences with certain interactive artworks. This text is by nature qualitative and subjective since it focuses on personally experienced simplicity, with interactive works of art I have selected. The descriptions help understand how an artist or designer can expand their knowledge and learn from other works — not necessarily copying interaction or interface styles or behaviours, but using certain methods to achieve and create a similar experience of naturalness, flow, simplicity in their own work. Secondly, I have gathered user data using observations and discussions as a way to find out if the interaction has been simple enough when the work is released. I have observed and also discussed the installation with some people when the work has been displayed, but have not asked users specific questions or made them complete certain tasks or collected surveys afterwards. When my interactive artwork *Climatable* was presented the first time in St. Etienne Biennale I tracked down how long users tried out my work and how many unique interactive locations they tried out, to find out whether a low threshold for interaction was achieved or not. I also marked how they behaved when they used the work — whether they talked about it with their friends or took photographs for example. Further discussions with users of the work have pointed out various smaller details about the design solutions and the work has been improved on the later installation occasions. This is documented in the chapter *6 Simplicity Matrix — case Climatable*.

One thing to remember is that the results of user surveys and observations are context specific: if the information is gathered in a home or an office context, the results would be different from a survey, or observation, which was carried out in, for example, a science centre or a gallery. In one extreme there are interactive artworks, which can only happen in a certain context (KWASTEK, 2013). The work has been displayed in various different contexts and discussions about it are context-dependent. This display context has affected the way users think about my work, changing the expectations they have towards it and the meanings they give to it although the content of the work does not change. The context even changes expectations and the behaviour of the participants towards the work — the willingness to interact with the work depends on the location and the way the work is set up. Certain contexts guide people to start interacting: users are more willing to participate if the work is shown in, for example, a science museum exhibition context with a lot of other interactive, hands-on things around them than in a posh white cube gallery, where it is normal practice still to not touch anything. So context is a design criterion which must be taken into account as well as the choice of a font, or a colour,

or a sound. This is also the reason the user surveys in this research have been conducted in the wild, in the actual locations where the interactive installations have been set up.

4.4.1 Simplicity in other authors' interactive artworks

With simplicity in interaction in mind, three artist-made interactive artworks are presented. I have interacted and tried out — experienced — them myself, so this section is written from a user's point of view. The works vary from screen-based software programs with graphical / mouse and touchscreen-based user interfaces to interactive installations both in gallery contexts and outside it. The interface may be the door, window, map, visit card and brochure to the interactive work, but it is also the steering wheel, the door handle, and the eye, the ear and the mouth of the work. Many kinds of interfaces do exist in the context of interactive art: natural, innovative, playful, and powerful, even interfaces, which are easy to understand.

The works not only contribute to user knowledge but analysing them gives additional support for the Qualities of Simplicity: searching for repeating features or patterns of simplicity in interactive artefacts has helped to build the Simplicity Framework and the Simplicity Matrix. Although the works are made by artists other than me, it is worth noting that I, of course, experience them as an artist or Interaction designer colleague, who has a long knowledge of the field and is able to analyse many things ranging from technical execution to spatial and physical design decisions in the artworks. Through analysis of these works it is possible to come up with new things to consider as an Interaction designer — things such as how to create new experiences, how to make things fun, or how to time interactivity in a way that it seems to flow perfectly. Analysing the works from the user point of view extends the designer knowledge. So, in a sense my designer knowledge affects the analysis at least in the background, but the user knowledge and experience should be in focus.

Heidi Tikka: Mother, child

A great example of an interface which cannot be separated from its content can be seen in the interactive installation *Mother, Child* (Tikka, 2000). I tried it when it was exhibited at

*Picture 10. Heidi Tikka, Mother, Child.
Photo © Heidi Tikka*

the F2F — *New Media Art from Finland* — exhibition at The New Wight Gallery in Los Angeles. In the installation, the participant sits down in a chair, holds a white fabric on his or her lap, after which an image of a newborn baby is projected on the cloth, the baby's noises surrounding the sitter. A camera motion detection system tracks the movement of the participant sitting — if he or she keeps still or rocks the fabric gently back and forth, the baby sleeps or calms down, but if the participant is moving very rapidly, the baby gets nervous and starts to cry. The fabric, the chair, the projection, the soundscape, the natural rocking actions to soothe the baby are all familiar actions and create a natural interaction method while also being part of the content of the work. The work is not a simulation of how to be a mother or a father. It is not a game, or just an experiment in interface design or programming research about video tracking. To be fair, the work does contain all of these elements, but above all the work is an interactive art installation, and interactive art like this can provide insightful ideas for Interaction design research (Edmonds et al., 2004).

The spatial design in the installation is very minimal, all the unnecessary elements are taken away. There is a chair, which allows for sitting down — an often used example when talked about affordances. The fabric affords picking up, holding it in your lap, but also waving it around in the air. The tangibility of the cloth material and the virtual baby create an interesting duality for the work. Familiarity, yes, but alienated. The familiar objects and the behaviour of the baby flirts with the users' intuition, steering the interactive process forward — perhaps to

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test the system by moving too rapidly, or trying to find soothing actions, rocking the baby back to sleep. Overall, the work is predictable: it functions as expected and the experience is emotional and powerful. Trust is born between the user and the work.

Golan Levin: Yellowtail

Interactive artist Golan Levin's Yellowtail is a software application, which is used by drawing a white line or a curve on a black background with a mouse (or with a finger as in the currently available iPad and iPhone versions). I have tried the downloadable Java application version and the version for Processing software. Even after reducing the users' possible actions to a simple line-drawing task, a surprisingly intriguing interactive application is born. The work begins with an empty, black screen, and intuitively one moves the mouse, clicks and draws something. The gesture with which the line is drawn turns into an animation: the line becomes alive and its appearance and animation direction, path, speed and time get their parameters from the way the user drew the line — although the action is mirrored and the drawing starts to move from the original starting point, but backwards in time and space. The users' drawing action affords the line to loop around the screen slowly or quickly, with sharp or low angles, or by rolling around — with all of this being reversed in time and dislocated in space. It is easy to populate the screen quickly with similar or different kinds of lines, to create fast or slow abstract animations. (*Figure 13*)

Drawing a line on the screen with either the mouse or the finger is an action we have become very familiar with. There is a small surprise element when the line becomes alive since it starts to grow from the point first drawn and shrink from the point where the mouse was released, reversing the drawn path from end to beginning, yet still producing the same form. However, the methods in which moving lines are born and created are easy to understand and this tangibility opens up possibilities to play with the screen space, test different line behaviour, different speeds, rhythms, styles, shapes. The user really becomes the animator, and the work behaves differently each time the work is used, and of course with each user. As the work functions well and creates these moving patterns, which can be recognised as very unique, it can
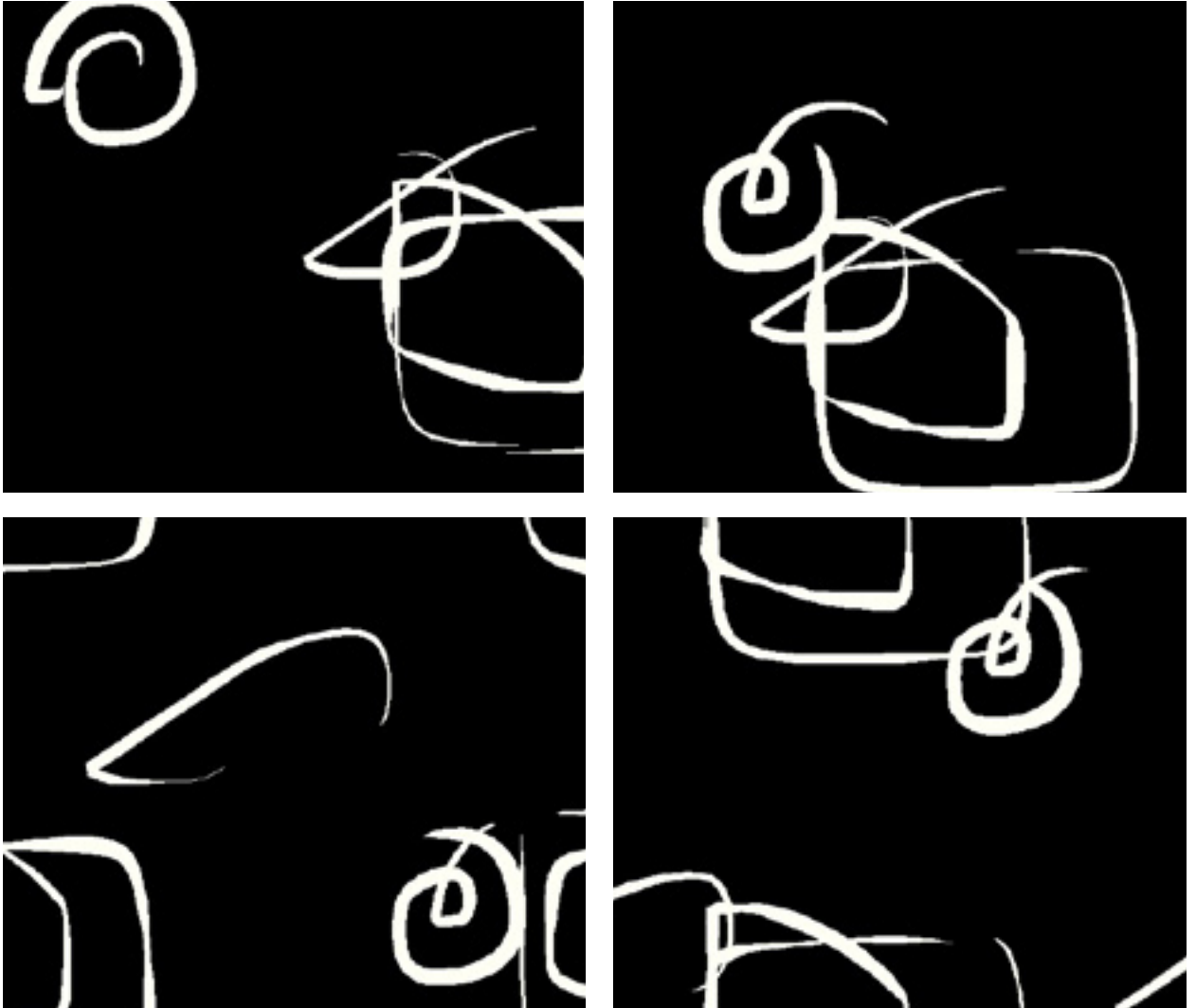
Figure 13. Golan Levin: Yellowtail.

be trusted by the user, and thus returning to the work and trying out different things becomes pleasurable.

Paul De Marinis in collaboration with Rebecca Cummins: A Light Rain

This installation was exhibited in front of Kiasma museum in Helsinki, in 2004 during the isea 2004 Symposium of Electronic Art. It is based on Paul De Marinis' work *Rain-Dance / Musica Acuatica* (1998), in which "Twenty falling streams of water, modulated with audio signals, create music and sound when intercepted by visitors' umbrellas" (DeMarinis, 2004). In other words, the umbrellas become audio speakers: the water stream is encoded with sound information. The falling water has been manipulated using a magnetic field, thus causing different kinds of sounds, notes and melodies. When the water hits the umbrella, which acts as a resonator, music is heard — the falling water stream itself does not make any sounds. In the version exhibited in front of Kiasma, there was also a rainbow visible during sunlight, created with water mist, which invited users to walk into the installation.

The installation sounds technically complex, but for the participant it was extremely simple: to experience it, one needed to use only a regular umbrella. There were umbrellas to borrow next to the installation if you did not happen to carry one with you. The interactive installation clearly plays with our intuition, familiar things and affordances: when there are umbrellas which can be borrowed and a rain & rainbow machine, we want to try it out and do what is natural: open the umbrella and walk under the rain(bow). Again, the user interface (the umbrella) is a crucial element of the artwork. Perhaps in a situation where there was no one around and only the water streaming system was seen it would not be possible to understand what to do, but to see other people try it out was all the instruction one needed. Modulated water behaves differently than the random sound of water drops in nature. One could detect organised patterns: the umbrella's surface affords modulated water to be heard as melodies: notes, noises and even drum beats, and songs can be heard (the installation played the song "Singing in the Rain", naturally). The umbrella could be moved, which produced changes to the sound but kept the melody identifiable. But the surprising and fun effect of *Aquatic Music* and *A Light Rain*

Picture 11. A user trying out A Light Rain.

is the feeling that you are the one (with your umbrella) who creates the music, and this hooks the user to the work (*Picture 11*). Simple interaction can make people believe in what seems like magic: a water stream under a rainbow turns your umbrella into a musical instrument. One has to experience it to accept that it really works.

The three interactive artworks presented here are very different in execution and content, providing very different user experiences. Yet all share the same regard towards the end user: the interaction is simple, yet powerful enough to make the user enjoy the work. It is also important once again to point out, that without the user there would be no baby to take care

of in *Mother, Child*; no lines to animate in *Yellowtail*, no music to be heard in *A Light Rain*. The users and their actions are deeply woven into the works. All of the works presented also share the element of minimalism: the possibilities for interaction are reduced to very few basic actions in all of the cases. Yet they leave a stronger emotional experience than a simple mechanical action or interaction with a common everyday object (a door, a light switch, riding a bike). Whereas design often wants to get out of the way, these works give us surprises, let us see, hear and experience familiar things and behavioural patterns in a new way — for many, this is the most important purpose of art. And it was me, as the user of the work, who caused the magic to happen!

4.5 Artefact Functions

THE THIRD MODE OF KNOWLEDGE IS related to the functions of the designed system, artwork or artefact. As mentioned before, the artefact is typically the only meeting point between the user and the designer. The designer tries to envision what the user is like, and builds the artefact according to this. The user tries to understand the designer's implications, the world-view, the story, using only the artefact as a guiding point. Although good Interaction design should be easy to understand and follow, the artefact always contains other connotations in addition to those originally intended; it affords alternative realities, truths and ways of use. The artefact manifests itself always differently to the user, in ways that diverge from the designer's original thought. The interactive experience is different between users and even different for the same user in diverse contexts of use since user expectations and motivations vary over time. The Artefact Functions manifest differently based on the predisposition of trust, and the physical, mental and cultural contexts. On the other hand, several people can observe and discover common aesthetic qualities in the visual, aural, spatial, and Interaction design of an object — especially when users share the same cultural and social context.

Countless designers, painters, and musicians have talked about how the creative process, the painting or the music itself guides what to do, what happens next, and what the end result is. There is something in a creative process that cannot be predicted or written in advance. Of course, there is always something about a designed system or an artwork that cannot be verbalised at all. This has been called hidden or tacit knowledge, distinct knowledge not accessible by

traditional models of enquiry (National Research Council, 2003; Young, 2003). Discussions about aesthetics in art often revolve around this issue. The hidden knowledge does not manifest itself in the finished artefact only, but the creative artwork itself can be seen guiding the creative process: the artefact takes forms and shapes and colours and sounds and interaction methods which seem to belong to it. This is also the basis of practice-based research or practice as research (Pakes, 2004). If we could explain all the creative decisions we have made in creating the artwork with a practical reasoning process, or create artworks according to accepted models, the works of art would not generate original art, nor provide us with new insight (Pakes, 2004). The finished artwork or artefact can also be analysed to reveal at least some of this knowledge.

Formalism or formal analysis is a branch of art philosophy, which at its most extreme claims that all the essential information needed to comprehend an artwork, or state its value, is visible or audible in the work of art itself: its style, colours, shapes, even musical relationships together produce a sum of it its meaning. When talking about interactive art this we should also consider the aesthetics of interaction: the work cannot be measured by its perceptible qualities alone. The artwork is not finished: when it is presented to the audience, the audience interaction activates the aesthetic experience (Kwastek, 2013). There are typically no set tasks to achieve with interactive art, rather the works are typically playful, exploratory, open — terms often associated with experience and game design. Although interactive artefacts trigger emotions: pleasure, curiosity, happiness or sadness, sometimes anger or fear, we should also be able to separate interaction forms and their related expressions, which refer to actual artefacts, not only to the users' experiences (Landin, 2009). Expressions can be targeted by the design towards different types of connoisseurship: from novice to advanced users and everything in between. This inherently means that the Artefact Functions produce different types of aesthetic appreciation. Thus the user experience can never be totally controlled by the designer. This thesis discusses both designed and experienced interaction, which manifest themselves in the interactive Artefact Functions. The interactive installation is seen as a designed environment, an entity and container of certain qualities, a place for possible interactive and even performative events.

For the Interaction designer, working with the artefact itself affects the design decision making: different problems emerge during the design process. Design choices are made by the designer, and because of those decisions, some options arise, and some options are closed. Due

to certain changes in the design, something unplanned might happen, but the designer tries to make changes as they improve the design. This knowledge is based on the experience of the designer and often linked to it by intuition (Raami, 2015). However, the intuition is not something superstitious but rather born after years of practice and experience on the field. In other words, the designer trusts (gut) feelings.

Although Artefact Functions is an entity which can be discussed on its own, it is always connected to either the designer's described knowledge, or the user's observed knowledge. In everyday practice, we talk of, for example, beautiful, simple, easy to use or frustrating products or systems — not so much how we experience something to be beautiful or how a designer has managed to create a service which is really understandable and fluent. Not only we know how certain objects behave or are used, but we also judge, compare and even rate products, systems and services based on our experiences, preferences and context: culture, language, age, skills, religious and political beliefs, etc. Similarly, with person-related knowledge (designer or user), Artefact Functions are inherently tied to cultural circumstances, to personal taste, to the context in which the artefact is encountered. But sometimes company brands, products, services, systems or even operating systems seem to be universally accepted to be of high quality, to be better than others, or to be major disasters. In other words, we have a predisposition to trust and attach our beliefs to artefacts, expecting them to contain certain qualities, and even though they do not always answer our yearnings we still refuse to stop believing in them. Thus, knowledge related to artefacts is also tied to branding and brand management, though this topic goes beyond the remit of this research. Nevertheless, artefacts seem to contain qualities which are bound to them without us observing or experiencing them or without designers consciously adding these qualities.

Aesthetics of designed artefacts or artworks can be interpreted in various ways and mean many things to different people, and this is true with the design of interactive things as well (Hallnäs & Redström, 2002). Interaction by itself can express something: "Interaction is expressed in a design" states Landin (2009, p. 46). Again the simplest cause for this is that people have different experiences, backgrounds, expectations and attitudes toward interfaces and interacting with media. We expect interactive artefacts to contain qualities we have become used to when interacting with them. In addition, interfaces can surprise, trigger up imagination, cause a thrill, anxiety or many other emotions. Interfaces and technology can be not only misunderstood but also misused, so they hold in themselves the potential for transformation, with

implicit or possible functions not intended by their creators. It can be argued that all artefacts: systems, services, software, hardware all contain qualities which have not been designed to be used at all, or at least in the way which has become the de facto standard in everyday life. Perhaps this can be thought of as tacit artefact-produced knowledge, which has been discovered and adopted by users in our global neo-nomadic culture, not unlike the way in which traditional knowledge is created and maintained.

As I have argued before, in interactive art, agency is transferred at least somewhat from the designer to the user. Physical actions of the user create a different connection between the user and the work than in traditional art. Participation creates a sense of authorship, in a proportion related to the freedom of movement embedded into the artefact by the designer. However, the interactive artefact itself is an open system, allowing the users to take control. The world contained by the artefact and its interactive possibilities remain unrevealed if the interaction is obstructed. The interaction should be simple and guide the user in order for this communion to happen. There should be no need for artists, designers or staff — and no set of instruction notes posted on the wall — explaining what to do with an interactive artwork.

4.5.1 Sketches, screenshots, software versions, fine-tuning

I will review the design process of my interactive installation *Climatable* in the chapter *6 Simplicity Matrix — case Climatable* more thoroughly, mainly from the designer's point of view. In this subchapter, I present some documented media material: sketches, software versions and written notes with ideas, improvement suggestions, observed problems which were undertaken during the creative phases of the constructive design research process. The material should illustrate some design solutions when working on the interactive audiovisual installation. Working alone, using an iterative heuristic design as my process, there were times when the designer's conscious knowledge had no role, as intuition guided by the design itself took over. It seemed that the process, the elements, the selections and design choices made dictated what to do next. Also, as I later mapped out Qualities of Simplicity for the various components of the interactive installation during my written research, I was able to reiterate on the design from the

artefact's point of view, revealing new things about Qualities of Simplicity and their occurrence and importance during an Interaction design cycle, which I had not thought of consciously when designing. Typically, this refining process happened iteratively between the times the work was exhibited: before the exhibition, there was time to adjust small details, graphical elements, audio, and interaction to improve the simplicity of the work and to make sure it suits the current physical environment. The work was displayed in public five times, and the written research process — especially mapping of the simplicity criteria with the installation — was also fine adjusted side by side with design improvements for the work. *Table 6* in chapter 6 displays an approximate timeline of the design and research process.

Reviewing the sketches and early versions now after the work itself has been finished helps me clarify and point out the Qualities of Simplicity in my work and in my approach to working. There are major differences between the initial demos and the final version. Later on, the differences between software versions became very small, but nevertheless important since the changes were performed so as to create a more tangible, more intuitive, and in the end more trustworthy system. Thus, the whole re-iterating design process consists of sketches, demo versions, released versions and improvements to the released versions. Here they help to understand the design process and point out afterwards were simplicity-related design decisions have been made. They Also, I hope they help to demonstrate how the artefact itself directs the creative process, how one design action which was taken closed down other possibilities or how by aiming towards simplicity there were no other options for the end result — and all this being achieved more or less subconsciously.

The creative work started with some ideas in my mind, which I sketched down with a pen and paper. Probably the first idea about the work was to create physical and spatial audio-visual, or even musical interaction with tangible objects. As mentioned at the beginning of the research, I had a completely different starting point, and in this chapter, I focus mostly on the phase after initial steps and ideas. So the idea of a visual musical instrument was soon abandoned and replaced by an interactive artwork about climate change. Pretty soon it was decided that the work should be constructed as a round table with a projection from the ceiling, and the

Figure 14. Sketches and documentation for Climatable.
Top left: first ideas about possible interaction components; top right: visual and interaction ideas; bottom left: more visual ideas; bottom right: notes and technical design issues 1–2 days before the first public exhibition.

CLIMATE

audio
video Climate

Climate

sää ~ aurinko /
pilvi

Äljhanitlaet

poronsarvi / poro

Valumaoorin
sisällä
jotain?

Tuto?

Climate llo. 7   top view

info
asi alpa

Pentagonawsiil
tagekline?

siimmihiopiste

visualisointeja:

holes for
ice

viivat

C=O=C
CO2

(ferhosia) muita
(ulkomaisia?) eläimiä

partly / nostaa

---

kutsuvorato technical specs A.S.A.P!

- 3 muuta työtä kesken samaan tiassa

4x
pridget pistet

4x pitkät pistet

$a^2 + b^2 = c^2$

$a^2 + b^2 = 6.31^2$

interaction would be designed as an embedded part of the table. I can admit that the physical form of the installation was decided first, and it did not rise from the content, or from the way the interaction was imagined as functioning. Perhaps intuition guided me in deciding that a round table would work as a collaborative interaction surface. But now, later on, I do see, that the work could have been developed form the content and interaction onwards: what kind of interaction would I like to see, how would I like to present the content, how would the collaboration or even discussion around the theme work be good starting points? Nevertheless, I do see this as a sort of design exploration: by choosing the round table, I restrict myself to a certain physical setting: what does it allow me to do as an artist or Interaction designer? Which options are not usable in this context?

Ideas about circular projection and a circular table produced a lot of visual ideas and also the interaction around the table was sketched out. These sketches were mostly made before the physical, software, audio, graphical, and interaction construction phase, and I did not really use them later on, in any direct sense. The drawings served as a means of expressing ideas and "thinking by drawing." On the other hand, sketching also acted as problem-solving — writing down and drawing a problem can be used to solve it simultaneously as well (*Figure 14*).

The sketches were a necessary means to brainstorm ideas, one visual idea leads to the next, but when the software and hardware design processes began, they happened more or less autonomously, or automatically, without thinking or writing down verbally long descriptions or looking at the sketches — the artefact moulding itself. More complex and complicated ideas were easy to abandon already at the sketching stage. I also used sketches to note down ideas for future development, document physical and electronic design details and to illustrate the physical structure — even the construction — of the table, a sketch which finally ended up being a technical drawing for the carpenter helping to build the table.

The graphical design was then mostly executed in Adobe Photoshop and Apple Quartz Composer, which is also the visual programming environment on top of which *Climatable* has been programmed and runs. Ideas about noise and ice bricks or ice sheets and a "temperature blob" were sketched out, and some ideas for the execution for other graphical elements can be found in the sketches. Some of the graphical elements were created directly in Photoshop without any sketching, and some elements were further manipulated in Quartz Composer — especially when the elements were changing according to different values. The layout, final colouring and proportions, as well as the animation of the objects, was designed in Quartz Composer,

except for one of the four areas.

The screenshots of unused or outdated files tell the story of a typical design workflow: ideas and designs are improved, manipulated, abandoned and re-introduced. The first projection tests were carried out with only three hotspots, later on, a fourth was also added. In the beginning, the idea was to test out the three basic primary additive colours: red, green and blue. This functioned well, but I was not happy with the physical design and the feel of interaction with only three hotspots, so yellow was added. Yellow seemed a natural choice, since we are perhaps even more familiar with the red-yellow-blue subtractive colour model, and in this case, green would be an extra colour. Red circles present in the first version were abandoned not to be confused with graphic elements that point out the interactive spots, and replaced with a colour changing and expanding or shrinking blob. Yellow roundish Pollock-inspired graphical elements were replaced with dingbats (which were present in the sketches) to make them more distinct from other material, the lace background image (the original idea for it was to act as a virtual tablecloth) was taken away to clear clutter, and colours and fonts are changed to clarify separate areas. Selecting one set of graphic materials and deciding on the design of one particular hotspot and its graphics really dictated what the others could and could not be: their shape, size, colour, amount, and style had to be different and work both independently and together with other elements. Slowly the work took on its graphical form. The first and last exhibited versions contain only small differences: a few more visual clues over how and where to interact and a change in typography are most evident in the visual outlook. Changes in software have also occurred, mostly related to animation and interaction feedback times (*Figure 15*). The changes may seem small, though I found them necessary to the fine adjustment of the interaction flow, which helps create trust, a type of benevolence, towards the system. Intuition and visual clues must be matched by reactions: what happens and how fast, and how long will the action last.

Several small software snippets were made to test out different things. Different visualisation possibilities for the datasets were tried out (*Figure 16*). Along with graphical style, the number of possible (visual, aural, data) layers was locked to four. In the end, three different data visualisation (software) methods were used, since the yellow and blue layer use the same method, with only different graphical elements, and slightly different animation values. However, all the layers appear and function in more or less the same manner: bigger values in data produce more graphics, more animation, more noise. Finding the smallest and highest values from the

World temperature
1957
−0.023 °C below normal temperature

2008
0.246 °C above normal temperature
2003
Global glacier volume change −270.43 km³
2007
Annual Mean CO₂ level in Mauna Loa 383.72

1985
Global glacier volume change −113.52 Mkm³
Norhern hemisphere
1985
Seasonal sea ice extent in the Northern Hemisphere 12.43 million km²

Murmansk, Rus...
1995
0.476 °C above normal temperature
1998
Annual sea level (revised local reference) in Murmansk 7083
...ments in Murmansk
CO₂ measurements...

data was crucial since they defined what the work looked and sounded like when the values were at their lowest or highest. Also, testing out all layers together as a collage was important: if all four layers are triggered at high or maximum levels, what kind of audiovisual chaos emerges?

Initially there were also ideas to present the table with a map of the Earth, and making a more complex interface with about 4–5 locations all containing 3–4 similar datasets but this proved to be first of all impossible since there are not enough locations on the planet which would have the same 3–4 datasets for long enough periods. One solution would have been to select different locations and to use one or more datasets from each location. More than one dataset per location would have also resulted in a messy — complex — interface, which was not desired in this case. In the end, the installation's subject guided the selection process: rather than trying to map the four corners of the world (north, west, south, east) I turned to data in which I thought climate change would be most noticeable. Also, the map of the Earth as an interface metaphor and a graphical element is over-used and would have turned the work towards a science centre exhibition object, not to mention that it is impossible to present the globe as a 2-dimensional round surface. Now I feel the visual outlook is more interesting, and if one wants to see the Earth in it, I have nothing against that. The data is partly location-based (CO_2-levels in Mauna Loa and Sea Ice level in Murmansk) and partly global (global glacier mass balance and annual mean temperature). It is also easy to update or even change the data and datasets, in the final version replacing one (XML format) text file and updating one graphical element is all that is needed.

It was also important to test the sensors and sensor interface since I was working with them for the first time. There are two sensors built for each dataset. The first idea for the interaction was to control or change a dataset by using a hovering hand, moving up and down on top of a light sensor embedded in the table. This idea was soon abandoned since the control was unstable and not very precise, plus it was impossible to lock the data in one place. In the first released version, the light sensors only triggered an action when a hand was placed over them, but even this feature was removed in the later versions because it merely caused a surprise element — the users seemed to wonder why this thing triggered even though they had not touched

Figure 15. Changes to Climatable graphical interface.
Top left: first tests with three spots and a tablecloth pattern; top right: test with three layers, bottom left: first exhibited version; bottom right: final exhibited version.
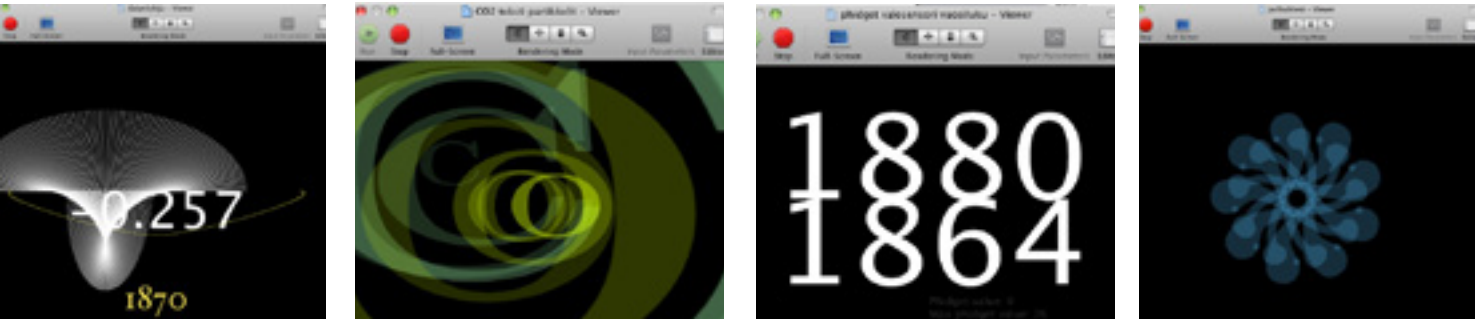
Figure 16. Small software snippets created for testing out different things.
From left: visualising data values by drawing line patterns; using a particle emitter with CO_2 values; testing the sensor interface; layout and animation test for graphical elements.

the slider yet. The sensors were also technically unreliable due to my limited electronic design skills at that time and seemed to be triggered whenever they felt like it, even without user presence. The placement of the sensors came about naturally, but the actions had to be planned in more detail. Once again, natural actions were thought of: what kind of actions would the table afford? What would be functional, intuitive and natural? In the end, a chronological dataset was selected: the user chooses with the slider a year, and for this purpose, the linear physical sensor was really the best possible option, since we are used to reading timelines, which go from left (earliest date) to the right (the last date). The nature of the linear sliders really helped to push this decision. The sensor system was changed between the versions (from Phidgets, to Leobodnar HID, to Arduino), although the behaviour and final interaction style remain more or less the same. This was more of an improvement for the ease of construction and programming. Also, test software for the "home screen" animation was made: helping to discern what goes on when the work is inactive. The circles with texts describing the data were animated to guide the attention of the visitors to the interactive hotspots inside them, to display the text completely and also to show by a movement that the work is alive. A circular movement made sense since the shapes were hollow circles. Later on, arrows were introduced to point out where the interactive sliders were placed. As interaction is not only a physical but also a temporal happening, timing was fine-tuned many times when the work was presented: triggering the work had to

be instant so as not to cause frustration or confusion, while shutting down was planned to be smooth, the work staying alive for a few seconds after users' actions stopped, before the graphics and audio faded out. This small delay was needed for the user to understand the effect of his or her action, and to allow time to become familiar with the content. It was also important that the work did not seem to shut down too abruptly. These adjustments with time values were undertaken by relying on a gut feeling and "listening" to the work: how does the work behave when actions are stopped? How long should a sound be heard and a graphic element be visible? Should they fade out simultaneously or separately?

There are a few documents and other examples of the sound design process: although sound design is not my speciality, somehow the chosen sounds and the way I decided to manipulate them according to climate change data fell in place very quickly. The more or less ready graphic materials and visual outlook, together with selected data-sets guided the sound selection process. For example, for the global glacier mass balance dataset, with sharp-cornered light blue graphics, the sound of ice carving was selected. Only a few other sounds were tested which were not used, and only a little testing with different filters or effects was needed to achieve results, which pleased me. A separate software was also made for testing out the sound-interaction combination (so as to understand when sound should start and stop when something is triggered by the user), and making sure data (midi to be exact) signals move from one software to another, since the audio is played and manipulated by Ableton Live. This sketch software does not have a visual output.

There are some phases which can be considered specific to Interaction design. These include the need to experiment early with final interaction methods: in this case how interacting with the linear sensors changes the audio-visual appearance of the work was tested out quickly after graphic elements or sound design was completed. The programmed interaction guided the audiovisual elements and also the selection and design of the information, not vice versa. Building and testing interactive prototypes is necessary in explorative Interaction design (Löwgren, 2012).

Another consideration relates to the refining of the material, which of course happens with other art and design artefacts as well, but here the refinement was undertaken so as to ensure interaction with the installation works. The graphic material and audio design has not been changed too much since the early prototypes — the refinement which has happened with the work has really been focused on simplicity of using or interacting with the work based on

designer's gut feelings, observations of and discussions with the users, and the overall feeling that everything falls in place in the installation. Traditional design perhaps aims at elegance or ease of use. In *Climatable* I wanted to create a strong emotional connection with the users and the installation, so elegance was not really the path to take — controversy or confrontation was perhaps more adequate. Neither was the main focus was on understandability, since I was not creating an educational or demonstrative piece about climate change, in which case the physical, audiovisual and interaction form would have been dictated by the information. I wanted the users to understand immediately what the work was about and experiment with it, and a keyword which I have found for my method of doing this and also for the method for users to jump into the world of the installation is *simplicity*. It would be difficult to illustrate how simplicity has guided the creative process by using this sketching material alone, but when brought into context with the complete design process in chapter *6 Simplicity Matrix - case Climatable* illustrative points about decisions supporting simplicity can be made. These improved graphics files, software versions, and neglected audio clips reveal something which is often very unconscious or intuitive for a designer. Close attention to detail might seem trivial, but it might also be the crucial thing necessary to create a sense of flow, as the work appears organised, familiar, intuitive enough: in other words to improve its simplicity.

5 Building simplicity

In this chapter, the concept of simplicity will be deconstructed, reconstructed and defined. In doing this it will be broken down into certain key elements, which I call *Qualities of Simplicity*, with each of them being analysed thoroughly in their own right. I also show examples of how the term and its different qualities have been used in Interaction design and design in general. In the end, simplicity and its antonym, complexity, will be discussed. In chapter 3 above, I have already used these qualities when describing other works of interactive art, together with how interactive artists have used these qualities when describing their works, and have illustrated in detail how these qualities can be found in my personal works. All of these findings will help construct the Simplicity Framework (*Table 5, p. 126*). In the following chapter *6 Simplicity Matrix — case Climatable* the Qualities of Simplicity will be mapped onto a Simplicity Matrix by conducting a thorough design case analysis of my interactive installation *Climatable*. The Simplicity Matrix will be filled with both observational (User Knowledge) data and heuristic analysis of the design process (Designer Knowledge and Artefact Functions), providing information both for experienced and constructed simplicity. After this in chapter

7 Evaluating Simplicity, the viability of the framework and the matrix will be reviewed based on a user survey, which was conducted on *Climatable* and two other interactive installations.

5.1 Scoping simplicity

Simplicity seems like a good remedy against interactive art which is challenging or impossible to use. It is not an easy term to define, and although simplicity can be seen as one of the design goals or golden rules of design (See e.g. Jenson, 2002; Maeda, 2006; Nielsen, 1999), it has been discussed in Interaction design or interface design relatively little — there is no consensus on what this term actually means. According to the Merriam-Webster dictionary, synonyms for simplicity include: uncomplicated, natural, clearness, plainness, but also naivety. Simple things are undemanding, understandable, straightforward and easy. Everyone understands the term, but there is no common understanding of how simplicity is constructed, what are its key elements, and how it could be used, especially in the field of design. Norman (1998) claims it is one of the main goals to aim for when designing information appliances, yet merely explains it as an opposite to complexity. Lewis (2007) points out that simplicity is not a unified concept and the level of simplicity varies with the capabilities of different users. Kim & Lee (2009) use the term simplicity to describe a transparent, disappearing and minimal presence interface, in a ubiquitous computing setting. Chang et al. (2007) document an exercise in creating tangible interfaces in which simplicity was achieved by minimising input and output options. The simplicity definitions are either larger than life, hard to understand lifestyle qualities or concentrate on some small details. This chapter discusses one way to define simplicity-based tools for a designer and also describe how they can be experienced from the users' perspective. Again, this is not the only possible answer to the question "what is simplicity?", but one possible collection of qualities, which I have found fruitful when discussing both the design and the experience of certain interactive artworks, including my own work.

In the fields of graphic design, industrial design, interface design and Interaction design simplicity is often a popular rule — typically expressed with the acronym kis(s): keep it simple (stupid!), and in design manuals, books and lectures it is expressed via various different terms e.g. intuitiveness, usability and legibility. The other vital quality of design is its functionality: design should improve the world and be useful, and regarding how well the usefulness is

executed we talk about how the designed system is impractical or functional. Most design work plays with these ideas: a chair can be designed to be simple in many ways (structure is reduced to the bare essentials, we can clearly recognise this is a chair, it clearly allows for sitting) and functional (feels good, easy to stack, move around, etc.). Other options for designing a chair might be a very simple but impractical chair (e.g. hard to sit on, heavy to move around — perhaps it is not meant to be moved after installation), a chair which is very functional and comfortable for sitting on, but very complex in design, or a chair with which the designer breaks all the rules: complex, ugly, dysfunctional, hard to sit on. Simplicity and functionality can be achieved in many ways, though these elements are not always the aim of good design. Designers have a field of possibilities to work with, and sometimes breaking the rules or boundaries creates new, innovative, even revolutionary design. In this research, this idea is referred to as the simplicity-functionality diagram. (*Figure 17*). In this study, simplicity is mostly seen as a value operating on a different layer or axis than functionality. It could be argued that the functionality axis is where art and design differ: e.g. *Climatable* is an easy interactive work to use, but is an impractical work about climate change if you look at it from its informational value since it was not designed for a functional purpose. Then again, the design of *Climatable* does utilise a lot of functional solutions: the sliders are functional rather than impractical, the material, physical and spatial design are all designed to be functional. In this diagram what is meant is the overall functionality or impracticality (and simplicity versus complexity) of the artefact.

Figure 17. Simplicity — functionality diagram.

The simplicity axis begins from the very simple and gradually grows towards the more complex or even tortuous. Yet the question remains: what are the qualities which construct this simplicity? Which are the ones that are beneficial for discussing interactive artworks, and which can be left out?

There are some other concepts and design practices which have mostly been neglected during the process of defining simplicity. Some terms, which are related to the chosen Qualities
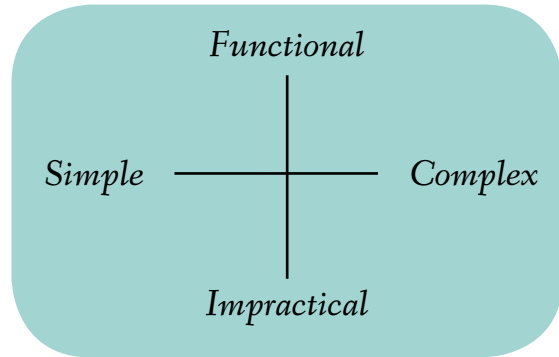
of Simplicity are discussed below, but it is worth mentioning already, that certain things, which take time to build, have been omitted from this research. Values like emotions, pleasurability and even learnability build up between the interactive artwork and the user, if the initial design has been successful (simple) enough and only after a certain period of time has passed. These would be important if the research area was experience design or service design.

The interactive works presented in this thesis should be understood as art objects, with artist-centred subjective perceptions and qualities rather than design objects, which are created for certain purposes, situations or audiences. The creation of the interactive art installation *Climatable* from the sketches to the first exhibited version was undertaken quickly and intuitively, with design processes remaining in the background. After initial installation and between various exhibited versions the design and the process were researched: the theoretical part has been improved and iterated, user data has been collected and key terminology related to the research has been crystallised. The keywords or qualities mentioned below in this chapter did not make it to my Qualities of Simplicity list for various reasons — although often they can be found in the work and all the works presented in this thesis certainly could be discussed using most of these terms as well. Instead of these, I have sought to use terms which more precisely describe what I mean by simplicity in the field of Interaction design and in the context of my interactive art.

It can be argued that an artwork does not have to have a functional use in the same sense as, for example, a tool, a service, a piece of clothing or a building all have, although it might have an educational or aesthetic use (Fishwick, 2008). However, as mentioned before, many design features in the interactive artwork discussed later on are clearly intended to be more functional than impractical. In one sense, functional design choices have been made to make the design easier to use but they are not always necessarily simple. Functionality can be seen as a complementary entity to simplicity and is therefore mostly outside the focus of this research. Informativeness can be found in the work *Climatable*, but the installation is not really comparable to a book, article, scientific poster with information graphics, or even a science centre exhibition component. One starting point for the installation was to create an emotional experience more than a learning experience. Emotions and experiences are both very relevant in Interaction design, and using them as goals can lead to intriguing interactive artworks. While it can be argued that simplicity can lead to powerful experiences and positive emotions, in this research the focus is on constructing simplicity, not constructing experiences. Simplicity is very important

in the users' initial bonding with the work — strong feelings, emotions and experiences can only be achieved after some interaction with the work (unless you count frustration from an impossible-to-use interface as a strong feeling). Do simple things provide powerful emotions or experiences? Perhaps if the simplicity is felt to be pleasurable repeatedly. Yet if this is the case, they cannot be Qualities of Simplicity, but rather the opposite, and worth further future research. This research focuses on the designer and the interaction situation — taking into account a certain place and location, and a specific user.

Minimal as a term is left out in this study since it has a strong connection to an art or design style, *minimalism*, and as such has a strong connection to the designer's chosen style, not to the designer's method or the end user's approach. Instead, the term *reduction* will be used as a necessary means to achieve simplicity. *Transparency* and *natural* are also terms associated with design (Dunne & Raby, 2013). When our main actions or goals are not disrupted, when the layer between us and the content is transparent, natural, easy to penetrate, simplicity is talked about. However, transparency was not chosen as one of the Qualities of Simplicity in this research since it is a difficult term to use, with many more qualities residing underneath it. It is also a term which can be associated with many other fields of science and has been defined in many other ways, e.g. as a programming algorithm which makes automatic selections from the user's browsing history (Swearingen & Sinha, 2002). In this paper, one can see qualities associated with transparency in the terms *intuitiveness*, *familiarity*, *affordance* and even *tangibility*. It is worth reminding also, that many design decisions in the creative process of this study aim for the opposite: making sure the interaction possibilities are visible, understood, and graspable. It has been argued, that interacting with the machine becomes more aesthetic, when communication is deliberately not transparent (Dunne, 2008).

The feeling of elegance can be understood to be born from the interactive experience, the fluidity of the interface and its movements, and the pleasure gained from using an interface that works (Rogers et al., 2015). However, it is still easy to relate the term too much towards visual and physical appearance or style, material selection and qualities, and can perhaps be considered as a longer-term goal after initial simplicity. Elegance also contains many other ingredients, such as reduction, clarity, organisation and also again tangibility, most of which I have used to construct my definition of simplicity. Well-designed, elegant objects also possess an aura of luxury, and it is often related to the quality of the material, the brightness of the screen, the quality of the audio, the responsiveness of the system. Another widespread usage of the
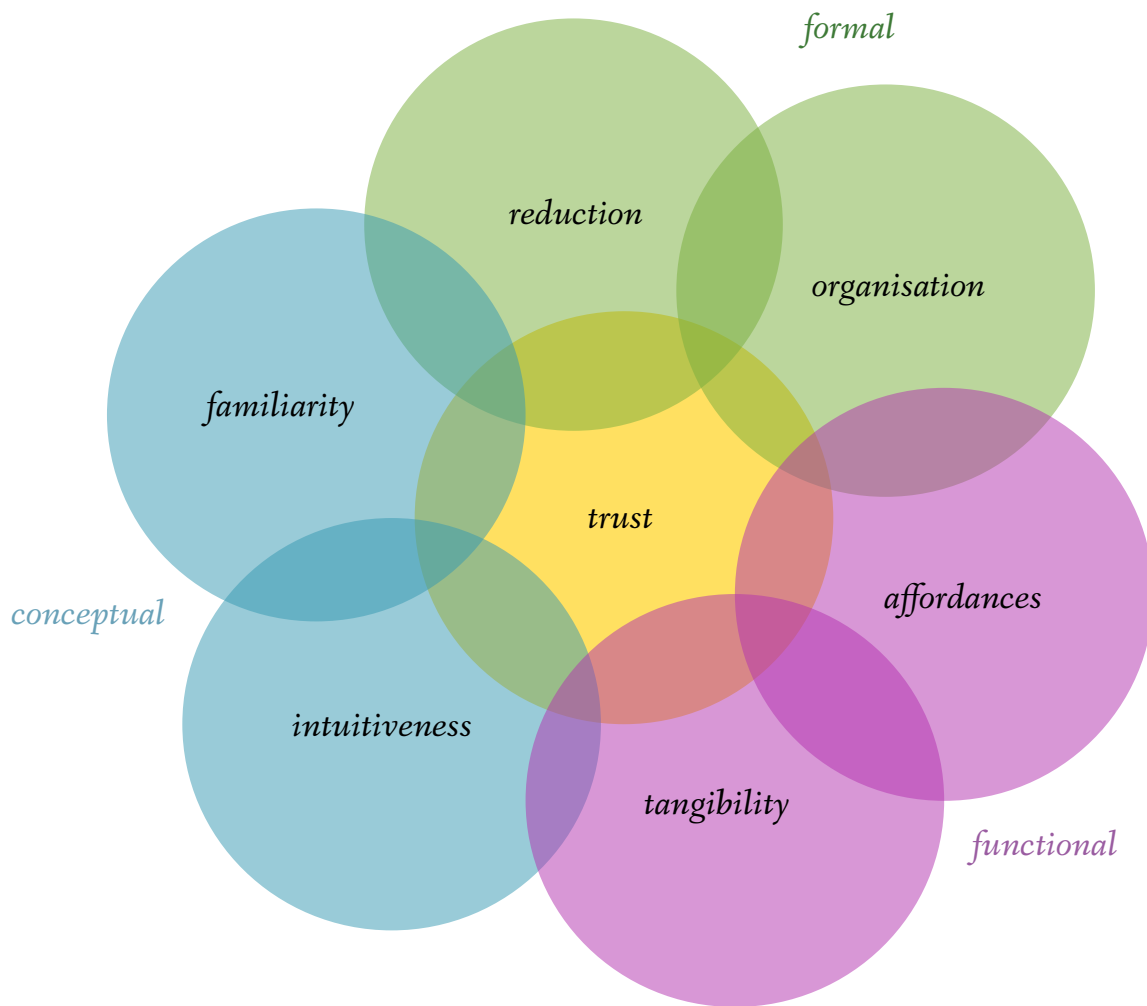
Figure 18. Qualities of Simplicity.

word elegance seems also to situate it as a top-level term: elegance — especially in machines and technology — is born when power and simplicity are combined (Gelernter, 1998; Löwgren & Stolterman, 2004). Earlier I also mentioned elegance was not a goal of the installation — I feel that an artwork can and should create discussion, mixed emotions, perhaps even anger or frustration as well as a feeling of elegance, comfort, or luxury.

5.2 Qualities of Simplicity

After ruling things out, reducing unnecessary qualities and organising what is left, a set of six plus one different qualities is presented. All of these have been used in earlier chapters in the analysis of both my own and other artists' interactive artworks. Again, it would be foolish to claim these are the only possible Qualities of Simplicity from which design, art, Interaction design or interactive art is constructed, but these qualities have guided the research process, the Interaction design and interactive art creation for the thesis. In this study, simplicity consists of six qualities in three categories. Formal: simplicity by reduction and by organisation; functional: simplicity of affordances and of tangibility, and conceptual: simplicity of intuitiveness and of familiarity (*Figure 18*). At the heart of Qualities of Simplicity trust is also included. For a long time it was considered as one of the Qualities of Simplicity. However, trust seems more complex and not on the same level as the other qualities, a construct with observable and designable qualities which is embedded in users beforehand. It is related to acceptance of technology and building trust is a longer time-based challenge in Interaction design (Sousa et al., 2014). These qualities have been gathered together during a design research process, incorporating both practical work and a literary review. Most terms are familiar to anyone who has undertaken any Interaction design, design research, or who knows something about usability. A very important eye-opener for choosing simplicity as the research focus was John Maeda's book *The Laws of Simplicity* (2006). Although it can be argued that the book is not very well organised or simple — it displays 10 laws plus three bonus laws, which are not all equal in any way, it provides many fruitful ideas and explains many things which were more or less unconscious decisions in my work beforehand. After its publication, the book caused quite a lot of discussion and even controversy about simplicity and complexity. There were dozens of blog posts (see e.g. Brown, 2009), articles and even books which were written to support simplicity or abandon

it for complexity (see e.g. Norman 2010a), as if they were choices which ruled each other out. Maeda's book states clearly that complexity is needed as well and I agree with this, as long as we understood complexity correctly. Another book with an interesting discussion on simplicity is Scott Jenson's *The Simplicity Shift — Innovative Design Tactics in a Corporate World* (2002). Although this book focuses on designing innovative consumer products for the consumer electronics market, most of the examples actually talk about Interaction design. Simplicity, however, is not defined very clearly in the book — it is seen mostly as streamlining, reducing complexity and making sure core tasks function well (Jenson, 2002). A lot of Jenson's arguments for simplicity are also targeted at designers, who combat against product or feature requirements coming from the engineering or marketing departments in corporate environments. A shift towards simplicity arguably needs to take place in company culture.

Two of the most recurring Qualities of Simplicity in Interaction design related literature seem to be organisation and reduction (see e.g. Jenson, 2002; Maeda, 2006; Norman, 1998; Obendorf, 2009). Two qualities — affordances and familiarity — have been introduced to Interaction design mostly by Donald Norman (1986b) and they reappear in various texts later on. Tangibility as a novel physical way to interact with computers has been tracked down in various texts from the mit Tangible Media Group by Ishii and partners (e.g., Ishii, 2008; Ishii & Ullmer, 1997; Ullmer & Ishii, 2005). Many people have talked about intuitiveness as an important quality of an interface, referring to the ease of use on the first time an interface is encountered (Laakkonen, 2006). On the other hand, it also has been reviewed as a skill designers can develop and apply (Raami, 2015). Finally, I will take a look at trust as a designable relationship between the work and the user, and especially how it is related to simplicity (Landin, 2009; Maeda, 2006). The selected qualities have been grouped into three groups: formal, functional and conceptual. The first one — formal qualities — relates to design questions linked to form: reducing and organising content. It is not really relevant whether these

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Qualities of Simplicity in this research are: reduction, organisation, affordances, tangibility, intuitiveness and familiarity. If these qualities are present, trust is formed between the artefact and the user over the interactions process.

Qualities of Simplicity	Formal: reduction, organisation	Functional: affordances, tangibility	Conceptual: intuitiveness, familiarity
The designer…	Clears cutter, organises content	Creates possible and understandable actions using established conventions	Steps into users' shoes, aims for recognisable and intuitive interaction options
The user…	Experiences clarity, elegance	Is able to interact the way it is supposed to	Recognises the interaction conventions and is able to use the work without thinking
The artefact…	Appears coherent and consistent	Provides feedback, behaves consistently, guides usage	Is efficient to use wivth a transparent interface

Table 4. Qualities of Simplicity from the points of view of the designer, the user and the artefact.

affect the audiovisual material, spatial and physical design or interaction possibilities. The formal qualities are often the ones which design guide books explore, and are consequently part of most designers' toolkits. They are also easiest to observe: lack of order, messiness or too many options can easily be judged as bad design selections. The second — functional qualities — refer to actions: affordances are related to artefacts providing possibilities of use, tangibility is the act of grasping, understanding and touching; kinetic or embodied knowledge in other words. These can and should be designed, and they do not exist in the art world in the same sense: traditionally art objects do not need to be used, sat upon, thrown — handled as everyday objects, or even understood. The last set — conceptual qualities — is related to mental processes: non-rational and rational thinking, recognition and emotions, and thus they have been labelled as conceptual.

Familiarity and intuitiveness require that the designer knows or understands something about their users: what is familiar to them and what kinds of design solutions would help them to use the work. Designing for these elements is not often easy, and detecting these in a designed artefact is often very difficult. Interpretation of what constitutes them also varies from design case to design case, from designer to designer and from user to user. Creating them or designing towards them is a fine balancing act, and can in some cases be helped by user-centred design: users can provide input on what is familiar to them. However, in some cases, it is best that the designer trusts his or her own instincts and knowledge about possible users and their

cultures of interacting with devices. Designers have learned from their own and others' previous successes and failures: what kinds of things are most likely to be trusted here and now, in this context, using this material, or with this way of presenting it. *Table 4* collects the simplicity quality categories through the eyes of the designer, the user and the artefact.

This categorisation is used from the users' point of view in chapter *6.3 Experienced simplicity* as perceived Qualities of Simplicity relating to my installation work *Climatable* are located. The chosen qualities are by no means equal, they overlap in places and cannot possibly tell the whole story about simplicity. But they can help reveal things in this research about design decisions undertaken in interactive art, as well as simplicity which can be experienced when using interactive artworks. The six qualities have guided the design process in this research — the design was reiterated through the qualities and improved, and the qualities were clarified after analysing the design decisions. But there remains perhaps only one more question to ask and answer, and we return to usability once more.

Why simplicity, not usability?

There are possibly hundreds of different usability qualities, and no real consensus on the standardised metrics which matter most, or how usability could be measured or observed (McGee et al., 2004). While some of these characteristics such as organisation, familiarity or intuitiveness can be seen in the qualities I have chosen, there are many which are not discussed in this thesis. For the sake of simplicity, usability qualities, which relate to longer interaction processes and systems are more or less ruled out. Even many of the core usability quality components: e.g. consistency, learnability, efficiency, memorability, errors and satisfaction, (see e.g. McGee et al., 2004; Nielsen, 1993) relate more or less to systems, which are to be used many times, and might require a big learning curve. These values and criteria become more relevant when more complex longer-term design and interaction processes are evaluated, especially during user testing. Typical usage surveys measure physiological usability, usage patterns, learnability, satisfaction, comprehension and perceptions of outcome and task difficulty (Hornbæk, 2006). Thus, while usability is regarded as an important design goal, it seems to relate more to complex systems, which are built for accomplishing certain tasks. Probably all of the core usability metrics and measures can be further split into smaller components. In this re-

search, I am splitting simplicity into values which I see relevant for my Interaction design work.

5.2.1 Reduction

Reducing things is perhaps the easiest way to gain simplicity (Maeda, 2006). Some go even so far as to claim that reduction or minimalism equals simplicity (Obendorf, 2009). Design processes start out with hundreds of possibilities, tens of tried out solutions, ending with one crystallised product. In Interaction design, reducing everything to bare essentials is necessary to give room to content. Sorting noise from data is a process of reduction, clearing the clutter. The maintenance of clarity is an often used benchmark, and can be seen as an alternative term for reduction. In this thesis, the term reduction is preferred, since clarity also hints at organisation, and for me keeping reduction and organisation apart is important since their role in the design process is different. However, clarity is a useful term for experienced simplicity: well organised and reduced design expresses clarity. Reduction has also been discussed in Interaction design from a psychological point of view: the memory load of a person cannot handle too much information at a given time. However, it takes designer knowledge to know what to take out and what to leave. There are now excellent examples and success stories of products and services with reduced, minimalistic design. It is also good to remember, that the simple search field of Google was not a success only because of the ease of interaction, but also because of the hidden power (fast processing) and an ingenious way to rate data according to the backlinks created by people. There were only a few search engines with similar, simple interfaces before Google, many were powerful with big databases, but with complex search features, and messy front pages with content categories. Google was one of the first ones to combine powerful search, relevant results for the user, and simplicity of interaction on one site. The interface and touchscreen of the iPhone may be hard to distinguish nowadays from its competitors, but the fluid way the interface behaves, or rather interacts with usage, the way new software, music and other media material can be purchased or downloaded set the Apple device apart from the

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> Reducing elements clears clutter and together with organisation provides clarity.

competition in the smartphone market when it first appeared. There is no extra clutter in both the physical and the graphical interface, there are no other buttons needed for use. Many competitors suffered from the combination of two kinds of interaction method: buttons need to be used for some operations, touch operations for other kinds of operations. By now it is clear (and a debated matter in many lawsuits) that the touch-based interaction actions popularised by the Apple iPhone have been copied to other smartphone operating systems in the market.

Reducing things in design is always a compromise: when something is taken away, something is left out for good. Sometimes this can create elegance, as the iPhone demonstrates. But there are negative sides of reduction as well: the buttonless touch-screen-based iPhone or iPod is difficult or almost impossible to use without looking at it. Changing the next track via haptic feedback of older iPods or mobile phones was easy, yet this is no longer the case — if you are blind, this device is not really for you, even with voice-over speech to help you out.

5.2.2 Organisation

Organising content when designing interactive systems is widely regarded as one of the key elements in making complex things less complex when creating interactive systems, no matter whether they are websites, DVD menus or virtual worlds (Löwgren & Stolterman, 2004). The term information design is also commonly used when talking about organising data

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A well-organised system is experienced as coherent and logical.

(Murray, 2012). Information design is often also related to the field of graphic design (Kang & Satterfield, 2012). In this research, information design covers the organisation of elements, but also the design of the textual content: organisation of data into understandable units and text. However, organisation is related to many fields other than text: e.g. audio signals can be organised — to simplify a bit, even music could be thought of as organising different notes for different instruments in different groups over time.

By organising information, graphic material, sounds and physical objects and their arrangement in space we can make sense of the world. Instead of having to remember a list filled with hundreds of objects in random order, we can sort things into categories and their subcat-

egories, label these and remember those labels. We can sort elements based on, for example: magnitude, alphabetical order, time, geographical location, frequency, or popularity. Visually, when observing things, our sense of vision creates groups of things of similar colours, sizes, shapes, close proximity. One can claim that spatial design and architecture is all about organising physical space and material in a manner which is coherent for human beings — if and when we are the inhabitants of that space. When designing interactive systems, organisation is also crucial: knowing when to introduce new elements, when to jump to the next level, etc. Therefore, interaction is organised on a timeline as well, starting from the initial steps: what is the first contact with the system, how does the system behave when someone begins to use it, how does it stop, and so forth. Organisation is also about prioritising certain features over others (Jenson, 2002). Certain elements take priority over others. Connections between different elements, entities and structures — categories and possible sub-categories — make sense. Perhaps a rhythm or pattern is recognised. Visual or aural elements do not collide with each other. The selection of colour, shape, layout, typography, as well as sound design, follows a certain aesthetic pattern or style. Even the interaction timing and feedback feels right.

5.2.3 Affordances

Familiar things afford us to do familiar — and unfamiliar — things. A table affords people to put things on top of it, gather around it, dance on it, hide under it in the case of small children, but also chop it into pieces for firewood, or carve an ice-fishing hole in the middle of it. A chair affords sitting, but also moving it around, or even throwing it. There can be millions of different uses for a sheet of A4 paper. Affordances in their original sense are a complex relationship between the person and the object, but on the other hand, they function in an intuitive way without much cultural mediation or learning (Bill Buxton interviewed in Moggridge, 2006). Affordances can be seen as implicit communication between designers and end users (Norman, 2007). Perhaps the designer wanted a certain thing to be done with the product, and this was built in, and thus the device affords this thing to be done with the product. The end users, however, might find other purposes or hacks for the product: they might improve the design to fit their needs or use it in a completely new way. In this way they create new affordances or exploit those not intended by the designer, sometimes to an extreme degree, as for

example in the Mobile Phone Throwing Championships (http://www.mobilephonethrowing.fi, n.d.), held annually in Finland. The designers often become aware of these new uses, hacks and redesigns, and can use them to improve the products or services.

The standard method of using a computer is via basic control devices such as the keyboard and the mouse. More advanced input technologies such as voice commands with a microphone and gestures with the video camera exist, but they are only slowly becoming more common. Operating systems and software have been standardised, and hold common features, affording certain things to be done with them, and hoping the software does not afford exploitations of security failures or other malicious actions. Patterns and behaviours related to graphical user interfaces have been standardised and documented at least ever since the Macintosh Human Interface Guidelines, the first drafts of which date to 1978, and which is still updated online (Apple, 1992, 2017). Throughout computing history, artists, engineers, and other specialists and companies have created a multitude of different kinds of software, devices and systems which afford various innovative or new ways to control a computer. The development of custom physical interfaces and even programming is nowadays very easy and cheap, requiring only minor software skills, a few readily available components and microprocessors which plug in between the computer and the real world. A vast number of projects all around the world by people of all levels and backgrounds are creating exciting new affordances, new natural ways to use computers and smartphones. The development of new interaction models, such as gestures, does not come without problems, and it does not

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Designing for affordances in this research means trying to put the users' focus to the preferred methods of interaction, by creating physical and spatial, graphical and audio design, which supports the desired interaction.

replace established Interaction design principles such as feedback, conceptual models, even graphical elements such as menus or icons (Norman, 2010b). Nevertheless, the list of possible actions with systems, services, software and devices is expanding, and some best practices become new de facto standards, affording us the opportunity to use artefacts in new ways. In this way our cultural habits are changing in respect to how and what (primarily and secondarily) to do with artefacts.

While the main affordances of simple objects such as tools and furniture are easy to understand, affordances of digital devices can be more complex. As mentioned before, a smartphone is a phone and dozens other things. A smartphone — or any other computer — is basically a universal machine, customisable for gazillions of tasks through programming. Programs are instructions to the computer in the form of abstracted instructions and rules: algorithms. Thus, the computer is a procedural medium (Murray, 2012). Computers can count, compare, act based on conditions, manipulate lists, etc. Digitisation has made it possible for a computer to store more information than all previous media combined. Thus, the computer is also an encyclopaedic medium (Murray, 2012). Databases and metadata offer access to information globally in a way never before possible. Perhaps most relevant for this study, however, is to see the computer as a participatory system (Murray, 2012). Participation is the key element in interactivity and requires an understanding of both machinery and people from an Interaction designer. New interfaces afford us to participate in novel ways. Complex systems, devices and their operation might require learning and manuals, but in an ideal world, these systems themselves would also guide users in how they are supposed to be used, without separate instructions. The interactive artefacts should guide or explicitly tell us how they are supposed to be utilised — the *correct* affordances guiding the user, brought forth by the designer or the artist. In digital systems, there are already certain Interaction design features which for us are transparent and do not need an introduction from the designer: links are underlined, thumbnails can be clicked to see a bigger picture, buttons can be pressed. Interactive art can introduce novel interaction methods, and if it is understood, it can enrich the knowledge of the users.

Computers also afford spatial design. Spatiality here does not mean maps, representations of landscapes or even 3-D worlds via a computer, although they can act as inspiration. Virtual, simulated and mental spaces are created by the designer, represented by the computer and accessed by the user. Space-related terms are utilised by designers and users: navigation, sites, visiting, moving backwards and forward, are all spatial references, even though we might be simply reading and clicking through text on a flat screen. Spatial metaphors function as a sort of a mind-map, which affords us to navigate in the terrain of the interactive artefact.

When designing with affordances, certain design elements or components are chosen instead of other ones, because they facilitate desired actions more efficiently. For the user, the designed affordances manifest themselves as the ways the design artefact should be interacted with and also interpreted. The user should understand how to interact, what are the possibilities, in

which order the interaction should happen and what to do next, and also what the outcome of the interaction should be. Well-designed affordances provide consistency to the artefact.

5.2.4 Tangibility

There are many subdomains and categories, terms and descriptions of interaction which takes one step away from the screen, keyboard and mouse. Physical computing and embodied interaction, even in their titles both contain the human body and also the surrounding environment as an essential component in interaction. A lot of attention has also been placed on embodied cognition in the context of Interaction design — a notion that our body and the way we use it is an active way to think and to extend our brain into the real world (Klemmer et al., 2006). Physicality and embodiment are complex keywords with debatable meanings, and as such do not fit inside simplicity. So a concept related to this field makes more sense: tangibility. The usage of the term tangible in this thesis is twofold: on one hand, it can mean something which can be touched, grasped with a hand, as explained above. On the other hand, tangible things are also clear, understandable, or graspable by our cognition. The words *tangible* and *graspable* both embody a bodily knowledge which is often forgotten. There are tons of different skills what we can accomplish with our bodies — hands and fingers especially are expert in many kinds of tasks such as tying shoelaces, knitting, eating with chopsticks or playing an instrument. Grasping something uses or extends your bodily memory and embodies cognition and physical skills, but it is also a way to operate in the world, interact with your body with the outside world in order to be creative, to think and to understand something. An even better word than *graspable* for a Quality of Simplicity is *tangible*: tangible things can be touched, and tangible ideas are real, clear and definite — graspable to the point where you can almost feel them.

It is often forgotten, that even the most common ways we give commands to a computer are carried out with gestures: they are undertaken with hand and finger movements employing the mouse, by touching, rolling or manipulating a touchpad, pointer stick, trackball and by pressing keyboard buttons. These input devices are indirect and not always easy to use, accurate or ergonomic, often preventing the use of more natural gestures we perform in everyday communication. Alternative devices to keyboards and mice for telling the computer to do some-

thing have long been developed. Various manufacturers also try to improve traditional devices by either adding buttons or removing them, making the surfaces bigger, adding touchpad features to a mouse (the Apple mighty mouse, for example, can be petted like a cat). Developments in pen-like interfaces, multi-touch interfaces, different types of musical keyboard-like input devices and mouse alternatives have come and gone, some different interaction behaviours have stayed, some are forgotten. At the moment, there is clearly a boom in new kinds of interaction devices for human-computing interaction, e.g. gyroscopic sensors and tilt sensors and accelerometers, camera and laser-tracking systems can be found not only in interactive art installations or in hacklab and makerspace workshops, but also in consumer products, such as computer and gaming input devices where your hands and fingers, or even your whole body is the controlling system. Nintendo Wii, PlayStation Move, Microsoft Kinect and the Leap Motion Controller, are some examples of these type of devices, which are already on the commercial market. A recent boom in health and well-being self-monitoring also has brought forward all sorts of devices ranging from smart pillows to socially connected wristbands and watches to brain activity scanners. Tangible, gesture-based interfaces for computer interfaces can function very well when information can be mapped to the physical input method. Though using facial or hands or arms-based gestures as an input source for a computer can create problems from physical exhaustion to confusion to noise. Exhaustion happens when you hold your hands up for a too long time — a Minority Report style interface would be a flop: holding one's hands up all day is very fatiguing. Confusion occurs when there are no agreed global or even cultural mappings between gestures and their actions: What should shaking a hand or a finger represent — change, stop, back, forward, no, or more? Another example: Shaking or bowing one's head has different meanings in different cultures. As such, how can we use these as neutral gestures? Noise happens when our everyday movements are interpreted as control commands — stretching hands, moving about, yawning, eating can all be interpreted as gesture commands if the system has been designed poorly. So gestures have their problems, but tangibility and natural user interfaces, however, both consist of more than just gestures — in fact, tangibility is a specially reserved word when we touch something, real-world objects or physical representations of these.

Tangible user interfaces and tangible computing as I understand it is are terms used when a suitable physical form is given to devices with which we access digital information (See a comprehensive survey from Shaer & Hornecker, 2010). Manipulating these augmented physical objects causes things not only in the real world (a knob is turned, an object is picked,

a certain shaped object was placed in front of a camera, etc.) but also affect digital data. The digital (numeric) values (e.g. an electronic value, a distance value, a speed value or a chemical value measured by a sensor) which are changed by using, manipulating, or handling of the input device are fed to a processor and this allows interaction with the computer (Ishii, 2008). In computing systems physically manipulated everyday objects are referred to as tangible user interfaces. Getting rid of the wimp metaphor (Window, Icons, Menus, Pointing device) provides possibilities for intuitive interfaces based on users' pre-existing knowledge of the everyday, non-digital world (Jacob et al., 2008). Simply put: tangible computing connects affordances of physical objects to digital, virtual things. (Ishii, 2008) What makes tangible user interfaces different from graphical user interfaces is that the physical forms are unique, suitable, moulded to the task and to the digital information. While even the mouse and the keyboard are touched and manipulated, they are general input devices with which a multitude of actions are possible. Tangible interfaces are often very specific, embodying the key aspects of the digital system.

Devices with touch screens have gained huge popularity in the last ten years. Manipulating the interface with your hands without physical buttons in between — or rather somewhere else than the interactive place is — literally puts the content under your fingertips. The input is direct, and this helps to build a feeling of naturalness, effortlessness and even transparency. Touchscreens, however, present the same problem as a keyboard or mouse does: it is a ubiquitous surface capable of presenting anything. Also, the current flat surfaces restrict actions to be taken typically with one or two fingertips of one

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Tangible design is constructed in a way which makes sense, and is easy to understand.

hand, sliding or tapping only along 2 axes. By getting rid of buttons on the phone new problems have also come about: it is nearly impossible to answer a phone call with a smartphone without looking at it — in older phones this was easy due to tactile memory in which the hand and fingers automatically pondered the shape, size, orientation and weight of the phone and its buttoned interface, making it possible to figure out which was the button to answer the call. So, tangible computing interfaces can offer much more than current era smartphone interfaces afford us. In this thesis tangibility often appears as simple "walk up and use" interfaces or parts of interfaces, but it of course could be developed in a much more complex way — especially for

those whose hands perform dexterous skills such as surgeons, musicians, and jewellers. We as humans get pleasure from touching different kinds of surfaces, especially when the materials are well selected. There is a haptic feedback loop with tactile objects which is independent of the digital, computer-based feedback loop (Ishii, 2008). Tactile feedback can also be felt without sound or graphics, in total darkness or silent places. One goal for me when working with interactive installations is to create sensations of intimacy and feelings of connectedness to the artefact. I argue that this sensation is strong when touching something is mapped to the outcome of that act of touching. Interactive artworks function by creating a desire for collaborative exchange with the public, exploring experiences and new insights (Lovejoy, 2011). Collaboration between people and even a feeling of ownership ("this is mine!") is born. There is a strong bond to something, which is situated in the real world, compared to virtual or simulated environments (Klemmer et al., 2006).

In this research, the term tangibility is also used when it refers to understanding something. The user should not only understand the real objects and the possible actions they enable but the actual, hopefully well-defined content represented by the objects. The connections between the information, the graphics, the audio, the spatial and physical design and the user interface should be understood. Through this tangibility and this understanding, the user also gets connected to, or builds a relationship with, the interactive artefact.

In digital media, the graphical user screen can represent many kinds of content, and the system with which we access material (mouse: pointer, keyboard: text input, or direct input devices such as drawing tablets with screens or touchscreens) can be programmed to control just about anything, which is both a blessing and a curse. This complexity or entropy of possibilities — affordances — ensures there is something for everyone, while on the other hand too complex interfaces might not be learned. Tangible objects usually perform a limited set of functions — functions which the objects afford us. There is a one-to-one match between the task we are performing (using our hands to bend something for example) and the programmed system of the computer. We should immediately understand the relationship between the physical object and digital data — this is where tangible interfaces differ from other interfaces. It would be perfectly possible (and an often repeated mistake in Interaction design) to use a tangible object and program it to do something which the object really does not afford, something which is not familiar or expected. If we bend, let's say a plastic tube to change a size of a 3-d ball on the screen, should the ball get smaller or bigger the more bent the tube is? Which way should we

bend it? Sometimes this can create an interesting experience, e.g. in a fun-to-use interactive art piece, where one can try out various things with unexpected results but this does not really add to the simplicity. This notion of tangibility (direct contact with the physical and virtual) leaves it outside the world of indirect graphical user interfaces. Even with touchscreen-based inter-action we are only dragging, tapping or moving our fingers on the screen, and these methods do not afford all the functions possible in the virtual realm — there are still a lot of buttons to click on the screen, new actions to learn (sliding your finger to the left or to the right takes you to the next navigation page, etc.). On the other hand, not all things have a representation in the physical world.

Design is a very tangible process, with a hands-on-clay attitude. Sketches on paper, tests with different materials and prototypes serve not only to help out creating early functional demos but also to practically work through different solutions through iteration. Digital and non-digital intermediate versions help the designer to foster tacit knowledge and come even up with surprising results (Klemmer et al., 2006). Easier access to sensors and electronics, which are connected to programmable micro-controllers are making digital Interaction design of smaller and task-specific devices ubiquitous. The Internet of Things (iot) is about creating new connections between devices, machines, the real world, and humans, and with modern tools, designers have new ways to think through prototyping with hands-on interactive tools. Many of the iot devices emerging to the market are prime examples of simplification: a button which can be re-configured easily to do many things, but only one thing at once, a sensor which connects with your mobile phone app displaying use of home electricity, key values of heating, water usage, etc., or a keychain with gps, visible on any map application.

5.2.5 Intuitiveness

When we encounter a new interactive system for the first time, we do not just stare at the new thing in confusion. Something picks up our attention, and guides us to start the interaction process — the first signals which raise the curiosity of a user act on a subconscious level. We anticipate what happens if we start interacting, and our intuition guides us to start experiment-ing and going forward with the system, trying to be one step ahead (Löwgren, 2002). Design-ing for experimentation is designing for intuition. Experimenting with the artefact makes us

braver, and further exploration makes the interface seem more transparent, and guides the way for familiarity. At its best, intuitive interfaces create a state of flow, where interaction is pleasurable, not too challenging, but interesting enough. This is more or less a subconscious process happening quickly, knowledge or understanding is reached without a reasoning process. In the case of physical, novel interfaces which are common in interactive art, intuition plays a strong role. Interactive artefacts not only allow but require the users to handle the work. Touching and interacting have even become the most important feature of interactive art (Huhtamo, 2007). Intuition guides us to touch and to interact.

Discussion on the relationships between intuition, learning and familiarity is needed. Learnable things have been said to be intuitive (Raskin, 1994). It has also been stated that familiar things can be applied to an interface to make it intuitive (Blackler et al., 2010). An important difference between the words here is that the familiarity, or prior knowledge, can come from many different domains. The artwork can utilise, for example, physical sliders, which the user may not have tried out in an interactive installation before, but may in any case know how they behave from earlier experience. These sliders in this case are not familiar in this particular domain, and intuition is needed to try them out to see if they function in the way we expect. Intuition guides the interaction process forward, letting users try out new things and learn from their behaviour, integrating sensory information to the user's mental interaction model. Information also need not be conscious in order to trigger behaviour (Blackler et al., 2010). This kind of subconscious information can hardly be called familiar or learned.

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Intuitiveness can be used when designing, but also as a design goal. Intuitive artefacts are perceived to be simple.

When wrong feedback and odd behaviours of a given artefact are noticed, it feels our intuition has guided us to the wrong place. This leads to disappointment, but it is possible to learn from such errors, and to try out something new. If we cannot trust our intuition, we feel that we end up making mistakes all the time and get frustrated, often unnecessarily blaming ourselves for being *stupid*. The relationship between the user and the interactive artefact has also been challenged. Artist Ken Feingold has used unconventional interaction decisions, such as randomness, incorrect or surprising feedback, delay times and unclear goals in his

work The Surprising Spiral (1991). These hindrances are supposed to restrict the desire of the user to get something out of the interactive artwork and prevent the control or mastery of the participants over the artwork (Feingold, 1995). No trust between the user and artefact can be born. The position of this research is that obstructions like these fail to make the participants question their relationship to interactive artefacts. Rather they blame themselves that they don't understand and walk away from yet another frustrating interactive art experience as a souvenir. Taken to an extreme, it could be stated, that an artist who uses such practices also raises himself above the users by creating something which is deliberately difficult to use. He expresses his dominance over technology and mastery over users who don't understand his field. However, the intention is not to condemn The Surprising Spiral as a failure — rather the work can be taken as an important milestone in interactive art. The installation has many layers and possibilities, with meditative qualities and interesting commentary on feelings which arise during travel (Feingold, 2002).

Intuition needs to be designed for interactive artefacts. Machines do not contain such intuition — they are limited in their skills to predict what the users are trying to do — they just fulfil the instructions which the users give them — instructions which designers have built into them (Norman, 2007). This notion might be argued by artificial intelligence developers — perhaps if we create a subtle enough system which learns from a large user group and changes its behaviours accordingly, we can experience a computer system which feels intuitive, and this might be good enough for most users. Designing with intuition, whether expertise or everyday life based, is an interesting topic, which has attracted significant research (Raami, 2015). This type of intuitiveness, or trusting the right feeling, is not something supernatural, but a skill which can be developed and used (Löwgren & Stolterman, 2004). While in this thesis intuitive design choices related to the installation *Climatable* are presented, the main use of intuition here is that designers should design for the users' intuition. The designer should operate in the same way as a user when building intuitive things: being aware of existing systems, supporting their positive features and by trusting his or her own knowledge — and also the user's knowledge (Colborne, 2009). It should also be remembered that even if the designer's knowledge contains user's knowledge the opposite is not true. The mental image of the system is very different between users and designers.

Designing for intuitiveness can be very fruitful in physical or embodied interaction situations (Antle et al., 2009). While intuition should guide the user to things which are

experienced as familiar, I see it also as a close companion to tangibility: our physical actions or reactions often precede mental, cognitive thought processes. As users, we might know exactly what to do without too much thinking. It is beneficial to incorporate or to allow possibilities for this hidden knowledge in Interaction design as well. We have behavioural patterns, ways to operate in the world, and embodied schemata, and using them to create interaction models can be a powerful design tool (ANTLE ET AL., 2009).

5.2.6 Familiarity

AS THE INTERACTIVE SITUATION BEGINS, PRECONCEPTIONS towards the artefact and intuitive choices which have been made to trigger the work should be investigated. We compare the system with other interactive systems we have experienced, seen, heard or read about, noting familiarities in the graphics, organisation, layout, soundscape, etc. We have a mental model of the system, based on other systems, which exists already before the interaction begins. As the interaction proceeds this model is either supported or challenged.

The list of familiar, everyday things and actions related to them is endless: picking up (and even throwing) objects, holding things in one's hands, arranging objects, using the mouse / keyboard, pressing on a touchscreen (not dragging), looking at a camera and playing with your mirror image or shadow, using headphones, watching moving things, calling with a phone, putting things in various places, and so forth. These all can be starting points for Interaction design. Things which happen in the world naturally are familiar to us: we are excellent at picking up different kinds of audio signals, we know the meaning of hundreds of different signs and signals, both natural and man-made. We (at least in Finland) know what to wear when the temperature gets below zero. We react to natural events. We grow up learning these things, picking them up by observing the world and the people around us. We interpret new situations based on what is familiar and we can act and do things based on situations we have faced earlier (YLIRISKU, 2013). As noted earlier, intuition guides the process, when everyday actions

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Designing for familiarity is designing with identifiable elements, behaviours and patterns.

are implemented in novel interfaces for Interaction design. When encountering new things, systems and technologies, it is also often social influences which help us learn, use and adapt to new technologies (McMillan, 2006). Thus, cultural and social contexts are crucial when designing for familiarity.

Familiarity is one quality we can embed in our interactive artefacts by using everyday actions, circumstances and objects as our design principle, but it can be used in the context of media material too: text, graphics, audio and user interfaces are typically built around existing things. The look and feel should be somehow recognisable and easy to contextualise. Scientific data, text and tables are popularised — made more familiar — to reach wider audiences outside the scientific communities. Difficult terms are replaced with common ones, small details are ignored and overall ideas or results are emphasised. Familiar shapes, basic colours, familiar imagery can be used to support visual messages. Natural sounds, familiar music or instruments can be brought in to help make simple, clear audio footprints for interactive artworks as well. Graphical user interfaces are typically built with familiar things such as common symbols, icons, underlined text for navigation, certain positions for lists, links and logos. In interactive art, there are already fairly many common practices which the interactive artist can use, such as: using the mouse/keyboard, pressing on a touchscreen (not dragging), looking at a camera and playing with your mirror image or shadow, using headphones, watching moving things, calling with a phone. But we can also incorporate things from real life into the digital domain: instead of pointing and clicking with a mouse, actions can be executed naturally, or rather natural actions can be incorporated as part of our everyday interactions with new media. Ubiquitous computing and artificial intelligence are bringing a paradigm shift to the way we think about — and use — computers. Computing will profoundly change in the future: instead of moving our hand and a mouse, or fingers on a touchscreen and choosing things with our fingertips, we will use gestures, speech, real-world physical objects together with their digital representations — even our brains — to be able to interact more creatively or naturally with the people and technology that surrounds us. Interaction moves more and more to the physical space and will also be physical in itself (Dourish, 2004).

5.2.7 Trust

Trustworthy devices are also ones which we gladly return to. When we have decided that we trust a device or system — it will be comfortable to operate, it will not crash, it can do a task we assign it to do — it relieves our physical and/or mental burden, offering an experience of relaxation and simplicity (Maeda, 2006.). Trust can also be born when we know we can alter the system, modifying it so that it better fits our needs. Having many options and possibilities to do a certain thing can simplify complex tasks especially when you are an experienced user.

An exercise that I have used for teaching vector graphic drawing requires creating a triangle in ten different ways. Not all the ways are simple or even make sense. Some , such as using the triangle tool, are too simple. The idea is to teach the student how different tools are or can be used to build skills and thus confidence to do more complicated things, use tools creatively, and in the end to be able to pick up the most suitable tool — or at least personal favourite — for the task at hand.

Trust for an interactive system or device is only born after some time during the interaction process. It is generated from various sources: there needs to be proper feedback from the device, mappings need to be correct, and the user experience must be fluid or elegant — the system answers the promises it has afforded. This user experience can be created by developing artefacts, which satisfy users' aesthetic and functional needs while remaining easy to use (Norman, 1998). Positive user experience adds up to simplicity and we trust systems which are simple to use (Maeda, 2006). Besides simplicity and ease of use, there are other important factors contributing to trust (or distrust). The social and cultural context of the interactive experience has a profound impact on trust towards the computer system (Sousa et al, 2014).

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Trust between a human and a machine is a complicated social and cultural bond. Trust towards an interactive artefact increases by fulfilling the initial user intuition, by allowing the interaction behaviours to be understood and contextualised and by creating a technically and aesthetically pleasing system.

The designers should trust not only their own skills and knowledge but also the users'. It can be argued that complexity cannot be eliminated, but only reduced or dislocated — perhaps to the users' domain (Colborne, 2009). There is a lot of research on interpersonal trust in social contexts, some research on interpersonal trust applied to electronic commerce and online social interaction, but not a lot of research about trust between humans and machines, especially with humans and interactive systems. However, there is some research, from which designers and artists can learn. Constantine (2006) builds a model for Interaction designers with four qualities: predictability, transparency, competence and benevolence. Building on this work and others, Sousa et al. (2014) present seven observable trust qualities in the social and technical environment: motivation and willingness (taking into consideration user's expectations), competence and predictability (user's rational perceptions), and reciprocity, benevolence and honesty (user's emotional perceptions). Their model consists of perceived trust — values which humans see as trustworthy. The model has been tested on online social collaboration and co-creation, and brings forth the importance of trust in human-computer interaction. However, it says little of designing trust or locating trust qualities in interactive artefacts.

Trust slowly grows (if all is well) when an interaction cycle is going on. Enabling or creating trust is not a random design process, but can and should be designed with trust-enabling qualities (Sousa et al., 2014). In the beginning, users have a predisposition to trust towards interactive systems, which varies due to cultural and social contexts and prior experiences. We start using interactive systems based on our mental models of them — and with a certain level of trust (or if we are grumpy — distrust) towards them (Constantine, 2006). Early phases of interaction especially need to communicate trust-warranting, contextual properties, such as social, temporal and institutional embeddedness (Riegelsberger et al., 2005). Qualities of Simplicity in this research operate on this signalling level, and contribute to the initial phase of an interactive encounter. Interaction happens in a certain social and cultural place, in a certain time, and is affected by institutional trust, such as trust in technological, cultural and organisational platforms. If trust is born between the user and the artefact, we need to know about the user and use our best skills when designing the artefact. It is more difficult to design for users with no level of trust or even distrust towards interactive art installations, for example. Easier to use systems are also more trusted (Riegelsberger et al., 2005). This is yet another reason why simplicity is needed.

Out of my selected Qualities of Simplicity trust is closely related to familiarity and intu-

ition, although all of the qualities when designed well seem to improve trust. Intuition should be understood as a notion that we can trust the right feeling, even though we are facing a new or unpredictable situation (Löwgren & Stolterman, 2004). Familiar things are easier to trust and aesthetically pleasing too — organisation and reduction are thus needed as well. The functional qualities: affordances and tangibility are the touching points with which the predisposition of trust is tested: does the work behave in the expected way , does it offer ways of usage, which are understandable, is the behaviour graspable and logical? Although I have placed trust in the middle of the Qualities of Simplicity in *Figure 18*, trust towards an interactive artefact is a much more complex phenomenon.

5.3 The Simplicity Framework

Table 5 presents a framework for simplicity by combining the Qualities of Simplicity presented in this chapter with checklists for both designed and experienced simplicity. It collects the main features to take in consideration when designing for simplicity, along with a design checklist of things to heuristically evaluate related to the six different qualities. It also includes main features which should be inspected related to experienced simplicity and suggestions for questions which can be used in observations and user surveys about simplicity. Some of the questions were used in the surveys presented in chapter *7.2 Evaluating the Simplicity Framework*. The framework as a whole has been used to create a Simplicity Matrix (*Table 6, p. 155*) for *Climatable* in the following chapter.

5.4 Simplicity and complexity

Simplicity needs complexity — as an antidote, as something to refer against — but also as a next step, outside from the very small boundaries allowed by simplicity, which can become boring quickly. Also, it is good to remember that artefacts which are perceived to be simple can involve very complex technology and/or programming, and are most likely products of long and complex design processes. In this thesis, the focus is mostly on simplicity, since it was considered interesting to know how an interactive event loop is triggered at the beginning of

Qualities of Simplcity checklist	Simplicity by reduction	Simplicity by organisation	Simplicity of affordances	Simplicity of tangibility	Simplicity of intuitiveness	Simplicity of familiarity
Designed simplicity	Leave only important things	Organise in meaningful categories	Guide the interaction properly	Use understandable language. provide understandable ways of interaction	Create an intuitive interaction flow	Use recognisable elements and interaction methods
Design checklist	Are there only important things left to the artefact?	Are the categories meaningful and balanced? Is the content ordered in a suitable way?	Does the design guide the interaction properly? Are the preferred interaction methods obvious?	Is the artefact understandable? Are the interaction methods graspable?	Is there an intuitive interaction flow?	Is the content, media material and interaction familiar?
Experienced simplicity	Information was detectable from noise	The work appeared coherent	The work behaved as expected	It was easy to understand what to do	The usgae of the work created a flow-like experience	The work was familiar and reminded of earlier works
Usage checklist	Were there unnecessary elements?	Was the work organised well?	Did the work behave as expected? Was using it effortless?	Did the users understand what to do? Did they understand what the artefact was about?	Could the users use the work without thinking?	Did the work remind of an earlier work? Was it familiar?

Table 5. The Simplicity Framework.

the interaction circle. The thesis does not fight against complexity, on the contrary, it is claimed that the role of complexity must step in after the system is used for some time. Again it is good to remember that we can also think about locating all designed systems, artefacts and products on a vector between simple to chaotic, with complicated and complex systems somewhere in between. More complex systems and content have to be learned, and complexity then allows a lot more information, a lot more choices, a lot more time to be spent with the system, allowing emotions to flourish and experiences to be born.

Complex systems can be broken down into smaller and simpler pieces. In computational thinking, this process is called decomposition, and it is the first of the four key parts or techniques related to programming. If these simple pieces do not fit together, confusion or chaos is created. Complex processes, e.g. picking up new physical skills or learning something, require certain logical step-by-step actions and even mental processes where familiar patterns are recognised and combined together, which help us to understand new information and learn new skills. But when the complexity is a result of careless design, the systems or artefacts become too complicated, confusing, incomprehensible, unusable, illogical (Norman, 2010a). Thus, there are at least two sorts of discussion and understanding of the word *complex* around us: it makes sense to note the difference between *fuzzy* (difficult, confusing or chaotic) complexity and *puzzle* (logical or complicated) complexity.

Fuzzy complexity is noisy and messy, consisting of various simultaneous competing or random signals. It is worth remembering in this case the other antonym for simplicity besides complexity: difficulty. Typical systems like these are poorly designed operating system interfaces in computers or advanced smartphones, which also contain other applications which have their own interfaces which might even be located within other interfaces such as in web browsers, creating a complicated multilayered virtual or mental navigational space which may be impossible to make sense of. On top of this, the computer or the smartphone is operated by physical actions, such as hand or finger movements, special clicks, swipes, and gestures, which also need to be learned at some point. The human logic relating to the use and handling of such systems is built from previous encounters with various kinds of interfaces. If the interface and its various ways of operating do not make sense, messy and fuzzy complexity is felt. Fuzzy complex systems can be learned piece by piece, but they never really make sense, comments like "why is this button here?" or "why does this function do that?" can

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Simplicity is a solution for complexity arising from confusion. On the other hand, puzzle-like complexity is often needed for artefacts with a lot of content and different types of interaction methods. In this case simplicity can guide the process of learning how to interact with the artefact.

still be heard every day from people who do not like the way their mobile phones or computers work. Systems remain chaotic and illogical.

The other kind of complexity is also born from vast amounts of data, interactive possibilities, visual, aural or textual information or content in a system which is meant to be used for many kinds of things, perhaps by many kinds of people, but somehow organised in such a way that we know what to do and why. I call it *puzzle complexity*, since it can be broken down into many pieces that fit together as the user learns to operate the system. We talk about complicated systems. This acknowledges that some learning is to be done to understand how a bigger picture is formed from all the intricate parts. Other words might be *learnable*, *reasonable*, *rational*, *logical* or *orderly*.

An example of this type of system is the interface we need to operate to drive a car: it has various switches, physical controls and electronic buttons, but we can learn even one by one the correct use of the foot pedals, the steering wheel, the stick shift and the turning signals, adding other things on top of the basic driving skills, such as handling the windshield wipers, the radio, the lights, the air conditioning, the controls for opening the windows, etc., to finally be able to manoeuvre a car in traffic. In a sense, the operation of a car is a complex interaction system but can be broken down into separate parts by reducing them to the basic necessary elements, organising the control possibilities into groups, and using familiar controllers (from other cars and vehicles familiar from childhood on). Still, driving a car requires the training of new kinds of muscle motor functions, body movements, observation skills, knowledge of traffic rules and behaviours and a lot more, all of which help us interact with the car and other cars, drivers and traffic.

It is commonly agreed that driving a car requires such complex sensory-motor and observation skills that we need to be over a certain age and certain skill level to be allowed to do it. You also need to prove that you manage it by passing a test or tests and hold a driving licence to be allowed to drive a car — but the car and the way it is operated can be taught to most people. When learning to drive, the most important skills in handling the car are learned first: turning the steering wheel, using the pedals for acceleration, for breaking and for changing gears. After this, other things, such as switching on the windshield wipers, handling the lights and so forth are picked up. The complexity of the driving system — the interface of the car — also constantly grows, since we keep adding new "intelligent" digital features to the driving experience, such as semi-automatic maintenance warnings, measurements of current fuel usage or mileage and

various combinations of these two, advanced controlling of the car music and entertainment systems, cruise control, navigation tools, etc. Many of these are used with various types of buttons and switches and menus which seem to date from the time of the first digital watches with two or three buttons on their sides. On top of this, the information is displayed on various screen displays, which distract our driving. So a new type of fuzzy complexity has entered our cars in the last 10–15 years or so, while the driving itself has gotten easier and smoother due to enhancements in ergonomics, motor design, and other driving mechanisms. Simplicity is as an antidote to fuzzy complexity: it should act as a cure for illogical behaviour, difficulty of use, messy organisation, unfamiliar or incomprehensible content. I also do elaborate on the limits of simplicity — why and when we need more complex systems, which can be seen as a puzzle, consisting of simpler pieces.

6 Simplicity Matrix — case Climatable

IN THIS CHAPTER AND FOLLOWING SUBCHAPTERS, my interactive art installation *Climatable* (*Picture 2, Picture 3* and *Picture 12)* is presented. This installation accompanies my research but has also been officially accepted as an artistic part of the research project. The artwork has been improved and presented on multiple occasions, simultaneously with research writing. The exhibition history is presented in *Table 7* in chapter *7.1 Observations of Climatable in the wild*. The constructive design research process of *Climatable* was illustrated in a timeline in *Figure 9* in chapter *3.1 Constructive design research*. The work is analysed focusing on the Qualities of Simplicity presented in the previous chapter. Also, a Simplicity Matrix is presented (*Table 6, p. 155*). It collects all the main simplicity principles designed for *Climatable* and also those qualities, which are experienced when the work is used. In another words, the Simplicity Matrix is the Simplicity Framework put into practical use.

6.1 Climatable

Climatable is an interactive table with 4 separate hotspots for 4 different datasets which have been collected from various online scientific research databases. Used data documents climate change via the following data: CO_2 levels in Mauna Loa in 1959–2007 (Tans, 2007); Annual global mean temperature change between 1850 and 2008 (Met Office Hadley Centre, 2008); Seasonal sea ice extent in the Northern hemisphere from 1870 to 2007 (University of Illinois, 2008); and Glacier mass balance change in km^3 per year between 1961 and 2003 (National Snow and Ice Data Centre, 2003).

The software used for handling the data, compiling it to a visual output and manipulating it with the physical sensor interface was created in Quartz Composer -software, with Phidget sensors, which were later replaced by a USB HID -sensor board, and then with an Arduino micro-controller. Information for the sound behaviour was channelled from Quartz Composer via midi to Ableton Live -software and manipulated using that program's built-in effects.

The creative work which was premiered in the installation at the St. Etienne Biennale, November 2008 started slowly during spring 2008. I started out to create a politically somewhat neutral audio-visual interactive instrument, but as I noticed my area of knowledge is closer to the field of Interaction design rather than to that of my original interest: abstract visual music, the work and the viewpoints in this thesis slowly changed towards Interaction design especially from the viewpoint of simplicity. At the same time, instead of searching the connections between abstract visuals and music, the topic of the work shifted towards an ecological viewpoint. Finally, after seeing the movie *An Inconvenient Truth* (Bender, Burns, & Guggenheim, 2006) I decided to create an interactive piece on the topic of global warming, especially in the Northern Hemisphere and the Arctic areas in general. I became interested in finding out what climate change sounds like, if the data was turned into sound through sonification, and what kind of possibilities would there be to visualise the warming Arctic in a different way, instead of via typical scientific data visualisations. Would the changes in recent years be drastic? Overall the main design goal was to offer the participant a new way to understand and experience the rapidly changing climate.

In the end, I wanted to create an emotional experience of climate change data for the

Picture 12. A user trying out Climatable in the corridor of University of Lapland.

participant. The idea was to make to create an artwork, which raises curiosity with a distinct audiovisual presence. This invites the participant to see, listen, make sense and feel in a way that is not experienced when reading articles on climate change, scientific papers or news. One aim was to offer an experience of creating new insights and associations about climate change — sort of putting the participant in the place of the researcher who discovers something. Interactive art installations hold the potential for not only understanding meanings, but also creating new ones and communicating them. I have experienced the feeling of becoming the author or creator when using good interactive art created by others, and I wanted to offer this feeling to others hoping an emotional bond which is born between the user and the work will help deliver my message. Art can also leave some things unanswered, open, unexplained or uncovered, to create emotions and experiences in the audience. So, *Climatable* turned out as an interactive artwork which enables new ways to experience and understand data and information related to climate change. With digital technology, it was possible to link actual climate change data (peer-reviewed measurements made by scientists around the world) to create the connection between the information, graphics and sound. More importantly, I wanted to see how this link can be controlled by intuitive, simple interaction. Again, adding the interactive component for me was important: the users must act or take action to reveal the information. Experimentally exploring the work can provide forms of knowledge — either critical reflection or self-awareness, self-experience or self-expression (Kwastek, 2013).

During the building of *Climatable*, there were a lot of things which had to be taken into consideration, as the interaction as a whole is built up from many factors. The creative process raised questions and problems with many possible solutions. Questions in physical and spatial design and technological construction: How big and high should the table be? How does one enter the installation? What kind of materials, sizes and shapes should I use for the interactive elements? What kind of video projector is needed? How do the electronics and sensors work with the software? Where do I hide the cables? Questions in selecting and organising the data: which data can I use and have access to? Will the data be consistent with the other datasets in terms of time periods, measurement accuracy and relationship to global warming? Should the data be from a certain narrow place, the Northern Hemisphere or around the whole globe? Questions in visualisation: will the graphics be abstract, representative of the phenomenon, a mixture of these or something else? Should the graphics occupy the whole projected area or the area near the hotspot? What colour should they be? Questions in audio and sound design: will I

turn data into music by e.g. FM synthesis or should I use natural sounds? How will the sounds/ music change according to data amount — change in pitch, tempo, volume, colour, harmony? Should I try some other, not so well-known form of sound manipulation such as granular synthesis? How does the audio help to create an atmosphere, and affect emotions or feelings? Questions about interaction: will the participant be able to select a location, a dataset, a time or all of these? Will they be able to manipulate the graphics and/or the sound by their actions regardless of the data? Will a group interaction situation affect the system? How does the interaction begin and end? Which programming and presentation environment should I use?

Design problems are not solvable in the same way as, for example, with mathematics — with one correct solution (Löwgren & Stolterman, 2004). There are many possible answers for these kinds of questions that help to illustrate what kinds of questions or problems arise during a creative design process. In the next chapter, the design processes of the five main building blocks of *Climatable* (data and information design, audio design, graphics design, technical and physical construction and design of interactivity) are presented. The way in which the different Qualities of Simplicity in this thesis are used to guide the design will be elaborated. In reviewing the finished product, the ways in which Qualities of Simplicity are located in the design are also collected at the end of this chapter in relation to the Simplicity Matrix (*Table 6, p. 155*). To complement the table, the perceived Qualities of Simplicity — i.e. the users' experience of simplicity — are represented.

6.2 Overall design and its improvements

The interactive installation Climatable has been exhibited five times (*Table 7* in chapter *7.1 Observations of Climatable in the wild*). The installation time periods *Climatable* have ranged from one day to almost one year. For each installation, some changes have been made to the software, hardware, physical and spatial design. At the premiere event, there were some problems with the set-up of the installation — the projector image was too small and did not match the surface of the table and the light sensors behaved very fuzzily. I decided to get rid of the light sensors, reducing possibilities for interaction. The second time the work was installed for one day in Kirkenäs at the Arctic Calling — Barents Spektakel 2010 art fair — and presented during a seminar "Visionary Arctic." The projection now matched the table, but only when

I lowered the table to about knee-height, making physical interaction with the work a little difficult — and adding an unintentional feeling of humbleness as one either had to bow or kneel down before the installation. The graphic design was refined too. Also, some minor changes were done to the way the work comes to an end after the interaction has finished.

The first proper installation — where the projection matched the physical size of the table as intended — of the work was presented at the foyer of the Faculty of Art and Design building of the University of Lapland, Rovaniemi, for one week in March 2010. I received support from the Northern Periphery Programme-funded project Clim-ATIC, which allowed me to acquire a short-throw video projector, with which the mapping of the projected image and the table could be realised in the way I intended. Now it was possible to fine adjust the graphical elements, the circles around the hotspots, their size, rotation and colour. The fourth time the installation has been exhibited was as part of the *Ilmastonmuutos — Climate Change* exhibition at Levi Summit exhibition venue, March 2010 - February 2011. The exhibition was an informative, text-and illustration-heavy science exhibition, designed mainly with posters, and with much less focus on hands-on interactive displays than is commonly seen in a science centre exhibition today. My work was installed in a separate room, which I think suited it well since my work had quite a different take on the subject than the rest of the exhibition. The fifth and so far the last installation was in February - March 2017 in Edinburgh, in the *Arctic Exhibition: Wayfarers* at the Basement Gallery, Summerhall, organised by Highlight Arts.

All five exhibition settings have been very different. In a small gallery with four media artworks in a huge design biennial; in a hotel meeting room as an example of an artwork, as part of a public and very local seminar in a cultural festival; in a public space where artworks are exhibited from time to time at the university I work in; as an exhibition component in a scientifically focused themed exhibition; and as part of an art exhibition with video art, installations and performances. Although in each location I have watched user behaviour and talked with people who are using the work, I have carried out proper, documented user observation only in one location (the biennial), and thus cannot gauge clearly how the context affects the user's behaviour or their opinions or understandings of the content. Still, I have gathered important details about usage from all locations, which has helped me improve the interface and create a more powerful experience. In so doing the following questions have been asked, leading to improvements: which elements could be visualised better, how loud should the volume be, should the colours be adjusted, is the text big enough, how long should it last when the work shuts down?

The amount of fine-tuning carried out on the interface can be infinite — even though on first impressions the first running demo version and the last presentation version might look, sound and feel quite similar.

There are differences in the way users behave in different contexts. There are situations where the common practice is that exhibition objects are not meant to be touched, such as galleries and biennials, and other contexts where interaction is encouraged — such as science centres. In St. Etienne, some suggestions were to hide the textual information — values and their related years — completely. At the seminar in Kirkenes, I presented the work, talking about its content, explaining how it works and asking the audience to interact and try it out, clearly lowering their interaction threshold. In Levi, I talked with some of the people checking at the exhibition and they found the artwork perhaps a bit out of line with the otherwise very informative exhibition, longing for more precise scientific information.

6.2.1 Designing the physical table

Initially, I started out with the idea of building an audiovisual instrument, which could be played by perhaps 2–3 persons. These ideas developed into an interactive, circular table, on which a circular image, which fills the table's surface 100%, would be projected from above. Although interactive round tables are perhaps not the most typical interactive media installations, many precedents for *Climatable* can be found. Timetable (Hoberman, 1999) revolves around the concept of time and the clock, allowing many people to gather together to find out different things. Another cooperative interactive system is a multiuser game, which was displayed at the *In Future* -exhibition at the Science Museum of London (Casson Mann, 2010). Also, the *ReacTable* system (Music Technology Group, 2005; Jordà et al., 2007), aimed at visual music production for novices and experts, is based on a round table, this time projected from below. In a sense, I wanted to contribute to this form, which can be seen as a recurring pattern in media art, and take the form as a pre-given starting point.

To add everyday feel to the design, I also wanted the table to have a tablecloth. This combination clearly supports simplicity of familiarity, and tables carry interesting everyday meanings and conventions: coffee table, round table, living room table are all places to gather around and discuss issues, from multiple points of view and often with different opinions. *Climatable*
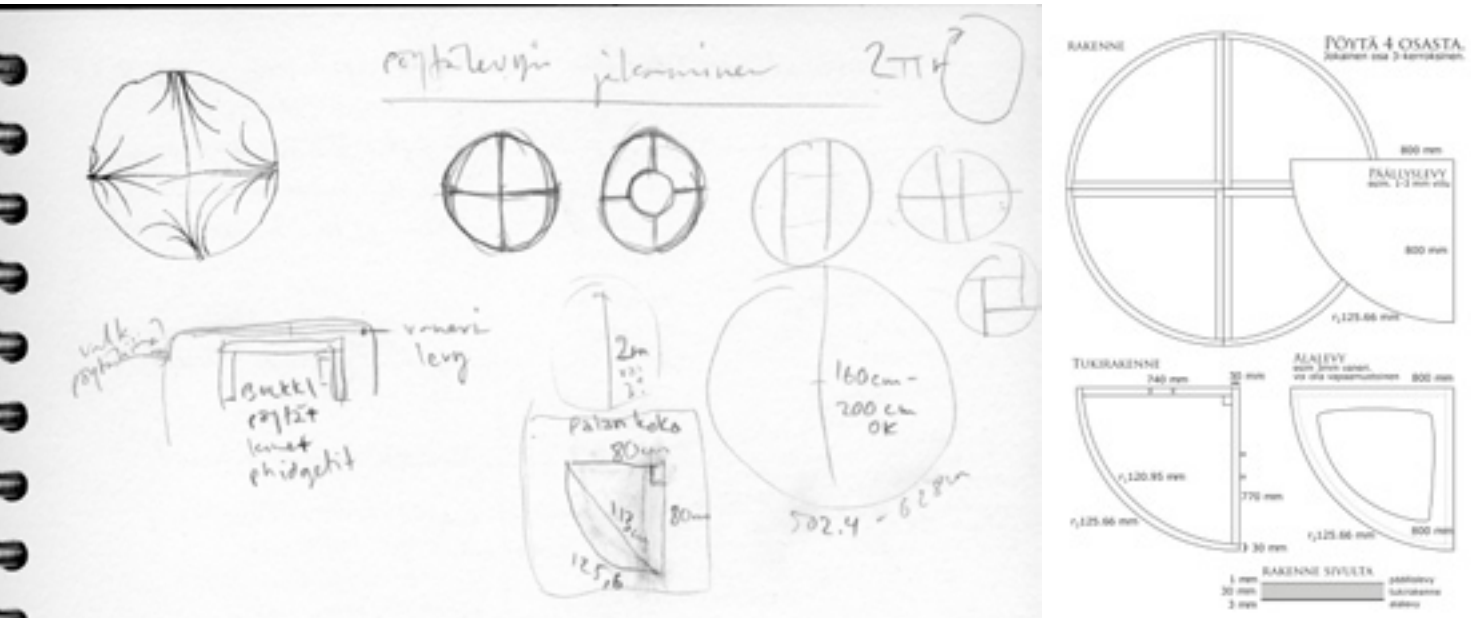
Figure 19. Designing the physical table.
Left: Early sketches of the table and the way to divide it; right: Technical drawings for the construction of the tabletop.

affords walking around it since it is a circular table, each position around it gives an equal view to the table. A circle is easy to divide into any number of slices, and I ended up with four sectors — simplicity of organisation is natural to circular forms (*Figure 19*). The size of the table is also designed with multiple person interaction in mind, one person cannot use every interactive spot simultaneously, so tables also allow for gathering together (Jordà et al., 2007). With the final diameter, there is enough space for four users and people who want to watch the work side by side with someone else using it, perhaps discussing what they see, hear and experience. Thus, the implanted physical measurements and the affordances embedded in a table allow people to be social. As a bonus, the table and its tablecloth also allowed objects to be hidden under it, so the computer, electronics speakers and most of the cords did not create any clutter. The round

form itself is very symbolic, a perfect shape which has been attributed to divinities, the sun and the moon, perfection, eternity and unity. The roundness of the disk also relates to the Earth, and to the map of the globe. This simplicity by familiarity and a sense of predisposition of trust — interpretations, interactions and conversations from daily life is something I wanted to bring in, with a quite an obvious ecological and almost political standpoint as a discussion trigger.

The tangible interface was designed as minimal, yet functional: the users are guided around the table by four equally distributed active areas in the vicinity of the table, with the physical design related to the space in which the table was installed made as accessible, recognisable and easy to approach as possible. The active areas around the table are marked by physical linear sliders similar to those found in electronic devices. The knowledge needed to grasp and use the sliders is intuitive. For simplicity's sake, I also decided to reduce the number of active places around the table to four — it is easy to recall where the interactive spots are and remember what the content associated with each was. Another, very practical, reason was that I had to design the table in pieces to be able to take it with me in the aeroplane to St. Etienne. A light-weight, dismountable system would be useful in future. The pieces could not be too big, there could not be too many, and four pie-shaped pieces of about 80 cm length on each side seemed perfect. With the final diameter, there could have been maybe one or two more users, but that would have left out space for people who wanted to watch the work side by side with another user. The number of possible users and active spots was an issue which was not resolved solely in relation to the physical design of the table: the incorporation of four real-time animated visualisations and sonifications controlled by sensors, was pretty much at the limit of the computing power of the Macintosh Mini computer I was using. The cpu and graphics cards handled four real-time simultaneous interaction events well enough, but more layers would have been more problematic. Finally, a set of four is very suitable as a metaphor: the four corners of the world; east, west, north, south; earth, wind, water, fire; winter, summer, spring, fall; moist, dry, cool, warm, are just some examples of the number "four" in relation to the planet Earth. This all adds to the simplicity of familiarity.

A physical object is always placed in a certain space, and in this research, the spatial design is considered part of the physical design, although it is important to consider it as an individual and unique category. In setting up *Climatable*, when it was possible I tried to influence the selection of the space where it was installed, although in some cases this was not possible. However, I always made adjustments to the way the work was seen and heard for the first time,

including aspects such as: the way the work was entered; how much room there was between the walls of the space; the positioning of the interactive spots so that they would be towards the space's entrance; how the lighting of the place was arranged; and even the height of the table.

6.2.2 Information design

In order to tell something about a complex thing or phenomenon, the data needs to be understandable to the listener. The data which is used needs to be consistent and well organised. The viewer should understand the context to which it is related. In the case of *Climatable*, I have used data related to the various measured effects of climate change. As I decided to build an interactive table with four active areas I chose to use four sets of data. Although this seems like a natural thing to do I did consider other options: there could have been many user-selecta-

Figure 20. Data is visualised by text and graphics.

ble options built into each hotspot or the active dataset could have been changed over a certain period of time, e.g. every 10 minutes, every hour, or every day. In the end, I decided to clear some clutter: this was not a piece that communicates everything about climate change. *Climatable* presents a rather small fraction of data related to climate change, but I realised that four different, carefully selected, datasets can demonstrate the results of the changing climate just as well as eight, twelve or even twenty would. This reduction was also conceived so as to keep the work consistent: it turned out to be difficult to find more datasets which were organised in the same way. For most participants, the selected phenomena are familiar, since it is easy to find climate change-related topics as they appear constantly in the news and other media. I preferred to use data which the users probably had preconceptions of already.

I also aimed for simplicity by organisation: the selected dataset have an average numerical value per year and the thus the value changes in a dataset are easy to follow and to understand. Together with reduction, organisation and familiarity, consistency guided my selection process. Searching and selecting the data proved to open some possibilities by excluding certain options. It was not possible to obtain many kinds of data from a certain place or even a country. Some data was in a format which was not suitable for my work, e.g. covering a large geographical area in a 2D grid. Some of the retrieved data was inconsistent, with values missing from certain years, so those were left out. Some of the datasets were from a too short time period compared to other datasets, or had not been updated in many years or even decades. In the end, data with an annual average displayed by only one value could be found in various different measurements and afforded a simple and consistent structure. Originally the idea was to concentrate on Arctic area data measurements, but as simplicity guided the data selection process, I decided to use more easily understandable values from the whole globe, and the constraint of one dataset per one hotspot allowed me to select four distinct enough datasets. When the underlying structure is evident, the data becomes believable and trust is also built (Constantine, 2006).

Even though the selected datasets contain very different kinds of data and even measurements (e.g. deviations from the annual mean temperature or concrete amount of glacier which has melted per year in thousands of cubic kilometres) the data is represented with human-readable numbers. I found out that consistency of units or values or scales is not necessarily needed throughout the whole system. For consistency's sake, it is enough when the displayed year and the displayed numerical value behave the same way in each of the four active areas. Some data is also easier to understand as an absolute value rather than a deviation from average and vice

versa. So, the information design is quite complex: the datasets are not equal by numbers, units, values or even time periods. However, their presentation and organisation are consistent and all the data share a linear, year-by-year time scale. There are no gaps or made-up values in the data. The values can still be confusing and difficult to understand without some knowledge of natural science: how should we read the CO_2 value of 315.97 ppm (mole fraction in dry air, micromol/mol)? Is it a low or high, a good or bad value, and compared to what? What is the baseline or value that we compare these values to? By conscious choice, this information is not present in *Climatable*. During the information design process, at least rudimentary comprehension needed to be developed for the data values, their scales and fluctuations.

The information design stays true to the value scales, and an audiovisual representation of the selected value in the dataset is automatically generated based on its relationship to the two important values — the highest and lowest values of the data. These were the only values, which were defined by what they look and sound like. The numerical data of the user's selected year will create the visual and audio output: changing the year changes the visual output and the sound, as each year holds a unique value. The work is much quieter and more tranquil, when the data is low — typically in the earlier years of the dataset — and gets louder and busier as the datasets have higher values, typically closer to our times. Each hotspot presents values in a way which is to be felt rather than understood. The real-timeness of the audiovisual presentation of the data adds to the pleasurability of interacting with the work, and can lead to the experience of awe or confusion. This for me is what contributes to the fact that *Climatable* is an interactive artwork in its own right. The nature of the installation is dynamic and interactive, and was not intended to create a final stabilised image or sonic footprint. The audiovisual presence of the work was designed to trigger curiosity by having a sense of novelty, partial exposure, complexity and uncertainty (on curiosity principles see Tieben et al., 2011). Curiosity creates an interest in exploring the work and, subsequently, emotions to be experienced by the user. This installation was not designed to be explorable for longer periods of time: there are no new levels or methods of operation which are revealed over time. However, the emotions experienced included even terror, as one person who was interacting with *Climatable* explained to me: the observed effect of climate change is terrifying.

There is a sort of bounding box which I have set as a designer: I have made decisions about what the maximum and minimum values of each dataset should look and sound like. How the graphics are displayed or what kind of sound is heard at a certain yearly value point is then de-

pendent on these extreme values (*Figure* 20). Tangibility has been the guiding line here: when values are low, information is scarce, sounds are normal. When values are high or off the scale, this is also visible and audible. Working in a digital environment affords programming how numerical values affect the visual and audio output. Computers understand numerical values: the same number can represent, even simultaneously, a point in a movie timeline, the number of graphical elements displayed on the screen, a certain colour, the intensity of a blur effect, a transparency value, the loudness of a sound, the pitch of an instrument or sound, the strength of an audio effect, to name a few. Digital, automatic, synaesthesia is born when the same value controls both the audio and the visual. The connection between the two is tangible for the user.

One of the presented ideas about information design is that more can be more — many times the data cannot be reduced or simplified without losing unnecessary information. Any set of data has many ways to be turned into information, but any unnecessary information in the display will become noise, cluttering the end result (see e.g. Tufte, 1983, 1990). I have kept these ideas in mind when creating the visualisations and the sonifications: there is nothing unnecessary displayed on the table surface, everything you can see and hear is born from the values of the data. However, there is an element of artistic expression or design exploration: again the graphical elements and the audio of one single dataset work together as a unified entity, supporting the information content, but there is not any clear consistency between the four layers, and instead of trying to understand the textual and numerical information, the changes in the values of the datasets are presented as an interactive, real-time audiovisual experience.

6.2.3 Designing the graphics

The graphical design process began with a lot of different sketches of different visual styles and ideas. From early on an idea of mapping guided the visualisation of data: the visualisation of the data should be more important than displaying the numerical value as text. The graphic is changed and even animated based on values derived from the data itself. The visual output and the animation follow algorithms, allowing an emergent visual canvas to form. The data for one dataset creates one *layer* of graphics, and it was necessary to create a unique *feel* for the layer, not an exact physical appearance (*Figure* 21). In the beginning, I tested the system with two datasets simultaneously to be able to see how one graphical set effects and goes togeth-
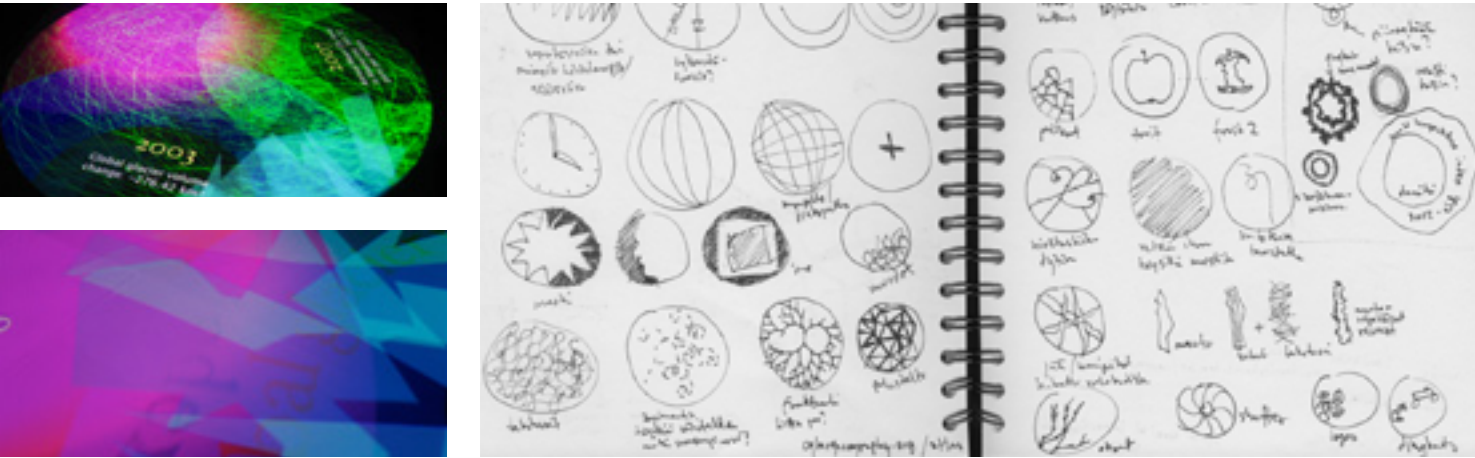
Figure 21. Sketching on paper, on the computer and by programming.
Right: Early sketches for Climatable graphics; top left: Early Climatable prototype; bottom left: Detail of global warming and sea ice layers.

er with another set. Then adding the third and fourth set was simpler, as I could see what kinds of things worked together visually. Sketching was first carried out on paper, with graphical elements created partly in Adobe Photoshop, partly with my main visualisation/ programming/ presentation software Quartz Composer and tested with the latter program.

By creating test versions, using different kinds of graphic material, testing various shapes, colours, sizes and transparencies I ended up with four sets of animated graphical material. The visual output is a very flat, texture-like living surface for the table. As most of the measured phenomena are quite unrepresentable by natural images, the image material is also mostly abstract, with some possible references to the impression given by the dataset — the glacier mass balance is visualised with ice or crystal-like blue polygons, global warming is represented by a vapour cloud which varies from blue (colder years) to red (warmer years). Since there are no agreed ways how to visualise, for example, CO_2 or its change, there was a lot of creative freedom. The visual look is kept organised by using basic colours (red, blue, green, yellow), separating each layer visually from each other, and using easily recognisable shapes (polygon shapes, typograph-

ical ornaments, lava-like particle blobs and messy lines) — each easily recognisable as a member of one group. In fact, individual layers can be easily identified, and the graphical collage creates the work as a distinctive visual presence, which doesn't hide important information — as such, trust is generated (Constantine, 2006). Also, the location where the graphics appear is near the interaction spots so as to let the participant identify the dataset she or he is manipulating. There is also some relationship between visual material and their respective data values, but not 1:1 relationship — 383.72 ppm CO_2 does not yield 384 images on the screen. Instead the data values are inspected and the lowest and highest amount are stored as memory. I decided what these points look like: how many objects are represented; how far the video loops; how big the particles are; what colour to use and the intensity of the colour; and maximum and minimum positions. The end result for the participant is that the system is more tangible: it is easier to understand the changes between the two extremes of the values.

Forgetting scientific charts and tables also made visual compositing much easier for me to create and for the user to understand. When the lowest value is present, visual output is matched to the values: the visuals get fewer and are smaller, move less, they are more transparent, and not so bright. With the highest value, the graphic material nearly fills the screen, moving rapidly, and is more saturated and opaque in colour. The data values and their related years are also presented above the sliders visually by numerals. In the feedback from Dr. Chris Hales, who was my opponent in the artistic part of this research as the work was presented in public for the first time, I was advised to consider leaving out the numerical value displaying the data and even the year value. This could have perhaps better supported the emotional experience provided by the audio and the animated graphics. However, I wanted the work to have credibility — displaying the data values as text confirms that the values don't come out of the blue. Also, the work has a chance to be informative and educational as well — there is a clear right-minded, moral or even political message in the work. So, the numerals which are displayed make it easier to understand the appearance of the graphical element. Later on, I made a derivative work called *Sound of Climate Change* (2014, 2015), a linear video piece, which uses the same audio and same annual mean temperature data from 1850 to 2009 (in a later version 2014), without presenting the values as textual information, or even graphics, just the sound and the year number.

When *Climatable* was not in use each active spot was marked by an animated circle rotating around the linear slider, guiding the people together with the sliders to access the interac-

tive spots. The animation was also designed to give information about the state of the system: it is obvious that the work functions when the circles are animated. As the sliders were touched, there was visual feedback: the circles expanded, reacting to interaction. When the slider movement ended, there was a small delay before the images shrank. This elegance adds trust between the participant and the work. A later addition to the graphical interface of *Climatable* was undertaken in order to aid participants' intuition: animated arrows were added inside the circles, next to the sliders to raise curiosity and to point out explicitly the interactive points from which the work could be used.

6.2.4 Designing the audio

I began the creative work with a Zen-like question in mind: "What is the sound of climate change?" Luckily, with modern technology, at least glimpses of what we can call indicators of global warming can be made audible, sonified. Again, mappings guide the sonification of data: changes in data create changes in sound. However, there is not really one sound we can relate to global annual mean temperature or the sea ice level in the Northern Hemisphere, so creative solutions were needed. The sound was tested out in Ableton Live, which allows connections to other programs through midi, and also easy real-time manipulation of a sound with different effects, filters, etc. (*Figure* 22). Basic workflow included finding an interesting enough sound, an effect which would transform it, and defining the limits of this effect, then mapping these values to the highest and lowest values of the dataset. In the end, the participant hears the changes appearing in time by going through the dataset with the linear slider. The effect is powerful: even for me, it was surprising, that, one can hear climate change in a sonic form, and in fact, the effect is rather powerful and even scary in some cases.

There were many options for sound creation for *Climatable*. As I was using a simple set of numbers for each dataset, it would have been possible to convert them into musical instruments with different notes, volumes, even chords or sine-waves with different pitches, frequencies, wave-shapes. Each dataset could then have become a synthesised musical instrument which the user could control. I ended up not using the dataset values and the hotspot as a virtual instrument or a software synthesizer. There were many reasons for this: As the dataset does not output constantly growing or shrinking values — they change year to year to lower or higher

Figure 22. Audio design.
Left: Sketching how the audio is layered and how effects have been assigned; right: A view of the real-time audio program Ableton Live in action.

values — it would have been perhaps too confusing for the participant to try to play the instrument as the slider's behaviour would have sounded erratic. Also, as the graphical material was very flat, and not representational, music created by simulated instruments perhaps would not have functioned together with the imagery. The instruments' connotations might also guide the listeners to think about situations where such instruments are played or heard — concerts, recordings, garage jam sessions.

As these options would have made the work sound more unorganised and confusing, I decided on a simpler organisation and different kind of familiarity in audio design: use and manipulation of recorded sounds. Looped natural sounds which were loosely representative of the datasets were chosen: ice carving, birdsong, water dropping, humming. The sounds are related to the geographical measurements presented by the related data, although the relationship is somewhat distanced from scientific data. Using one identifiable sound loop with each measured dataset was a successful solution. These recognisable and even familiar sounds strengthen the experience of the participant, giving hints of events happening in the real world. The installation has an identifiable sonic presence, the relationship between the sound and the data is trans-

parent. This type of soundscape builds trust: it supports the imagery, making the installation more spatial and geographical, adding reliability and clarity to the work (Constantine, 2006). The four sound layers are all manipulated using values derived from the data, similarly to the graphics. Basic, simple audio editing parameters such as delay, flanger and envelope are used to manipulate the sound. Thus, the audio could be described as interactive musique concrète or interactive sound collage.

Rather than trying to provide a clear display of scientific data I aimed for a more emotional atmosphere: the imagery and sounds convey connotations of nature: water, fire, gas, birdsong in a forest. Soundscapes and sound events can create powerful emotions, and our relationship with sonic environments is studied in the field of acoustic ecology (Drossos et al., 2012). The sound proved to be an essential triggering signal in the installation context, not only providing an atmosphere but also attracting users to approach the work, letting them know that the work functions. The sounds give direct feedback, reacting to the movement of the sliders, rewarding the intuition of the user. The sounds convey perhaps the strongest emotions of the piece: the last 10 years of each dataset sounded very different from earlier data, making the story of climate change truly heard and felt. This again increases the novelty of the work: the sound is based on data values, but conveys information quite differently compared to text or graphs.

6.2.5 Designing interactivity

While I see every chapter previously mentioned to belong to the realm of Interaction design, in this chapter I discuss the ways the user manipulates the work and the ways the work reacts. In other words, how the element of interactivity is programmed. This mainly means thinking and designing the interactive spots, their physical sensor design and software design: what happens when the work is activated, how fast does the work react, what happens when the values are changed, and for how long the work give audible or visible feedback. I do see the process of interaction beginning at the instance when the user has perceived (basically heard or seen) the work, and decided to try it out. As such, it is necessary to remember things which happen before the actual interaction: how the work is approached, how the user is guided towards interactive areas, and how the participant is lured to interact in the first place. Designing physical space and objects, what the measurements are and how the table is situated in
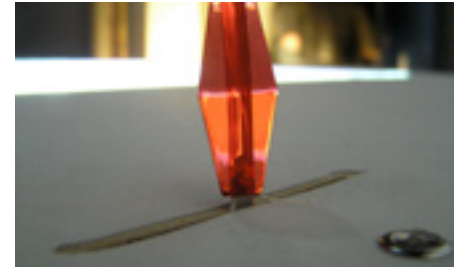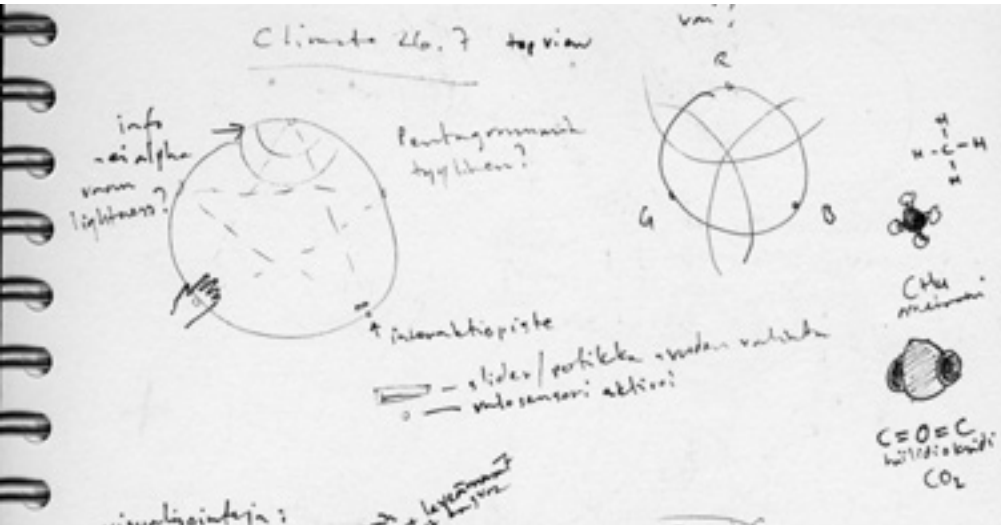
Figure 23. Iterating the interaction.
Left: Interaction ideas sketched out; right top: Testing out the physical sliders; right bottom: A jewel-like controller on the slider and the light sensor next to it.

the space to allow people gather around it; arrows which present the place for interaction; or audio which attracts potential users' attention must be seen as part of the interaction process, which happens in space and time. As most of this has already been talked about in the previous subchapters about the physical design, graphics design and audio design, I mention these only when necessary, only when new information is brought forth and concentrate instead mostly on the physical interaction itself, and the mental interaction which follows the first interactive steps.

Each hotspot, i.e. place where the work can be controlled from, consisted originally of two sensors: one light sensor and one linear slider, both mounted on the surface of the table. *Climatable* is interacted with by moving a physical slider to select a certain year from the dataset, which changes the graphics and sound accordingly. In interface design, it is often difficult to match the physical to the digital information (Chang et al., 2007). The linear sliders give nice

tactile feedback and a tangible feel to the work and map perfectly with the linearity of the time-line of each dataset, using typical western left-right mapping to select an earlier (move left) or later (move right) year. Controlling a system by sliding is also a familiar action from cars, stereo systems and some home appliances. The initial movement of the slider triggers the selected interactive spot, giving instant visual and haptic feedback: the position of the slider in relation to the scale is immediately graspable. It is often even virtually emulated in user interfaces, (e.g. as a volume control) which further helps understand its physical origin's usage in a computer-based installation. All four hotspots can be activated at the same time, but this requires more than one participant, allowing the work to be used collaboratively.

The way the light sensor was meant to be used was by using one's hand to control the amount of light coming to the sensor: the closer the hand to the sensor, the darker the shadow. One option was to use the light sensor alone to trigger a certain year. It sounds like a good idea, but I abandoned it because it would have been difficult to select a certain year and stay in that selection. The light sensor could be a very nice tool to track down hand, arm or leg movements — not unlike playing the theremin — a feature I will certainly put in to use in my later work — but it is not ideal for selecting very specific numbers. The light sensor is also unpredictable: the electronic values which are turned into mathematical values for the software are not constant but fluctuate constantly, and the amount of light in the room changes all the time because the different graphical elements which are displayed emit light differently. In the end, I decided to use it as an on-off trigger switch only — placing a hand over the sensor would start the work automatically. After a few days of testing with this system, I decided to abandon this too since it caused confusion around how the work was supposed to be used and, accordingly, I decided to reduce the interactive elements to the sliders alone (*Figure 23*).

On the software side, simplification by organisation and reduction happened hand in hand with data selection and graphical and audio design. Key aspects of software design were to offer intuitiveness and tangibility: the interaction should be mapped to the presented data, and the work should give feedback that it is functioning, increasing trust towards the system. When the table is not used, a small animation guides the users and tells them that the work is live. After the slider is activated, graphics and sound are awakened. Moving the slider immediately triggers the work. When the slider is stopped and the user lifts his or her fingers from it, the work remains active for a few seconds before fading out — this was built into the system since otherwise the work would have been starting and stopping all the time when the slider was not

used or was used very slowly, thereby eliminating clutter and confusing messages. Building for predictability and consistency is arguably the most important single factor in creating trust in interaction (Constantine, 2006).

6.3 Experienced simplicity

In the chapter above, I have documented the design decisions which were made in order to simplify the usage of the installation. In this chapter, I try to focus on the user's experience of simplicity in *Climatable*, as perceived during the interaction event. Instead of looking at the different design categories (physical, graphic, audio, information and Interaction design), I discuss the different Qualities of Simplicity, as I have grouped them earlier in *Figure 18* to three different groups: formal, functional and conceptual simplicity.

Formal simplicity can be experienced when the design has been organised in the best possible way and unnecessary information has been left out (Maeda, 2006). Reduction and organisation help identify different datasets and their text, graphics and audio layers in *Climatable*, and allows users to remember which dataset belongs to which side of the table. The physical design and Interaction design allow users to start using the work from any interactive point they choose (or whichever point is unoccupied). As states, there is space enough for four users around the table and also some space for others who can observe the work being used. The way information is framed, reduced and organised helps users understand connections between data values and their related years, and the way information is accessed explains how to navigate between the yearly values.

To experience the functional simplicity values, users start using the work, try it out and understand what the information is about. Affordances can be understood as features, which allow things to be done, and tangibility can be understood as a physical-mental activity. The work invites usage by physical, visual and aural presence. The materiality and the set-up of the table and the sliders, together with the placement of the interactive sliders around the table guides the users around the table, thereby creating a conversational experience. It is easy to understand where to stand, where to move next, how to touch and how to keep using the work. The connection of the work to climate change is grasped and a bond between the work and the user is born through interacting with it. Combining physical, bodily operations with sense-based perception

creates a special level of experience and a sense of immediacy (Paton, 2008). The relationship between the graphical elements and animations, sound and data values are understood.

The last set of experienced simplicity values is more conceptual: familiar and intuitive things which help make connections between newly encountered features and the users' previous knowledge. The physical design and spatial design are familiar and it is intuitive to move close to the table and to the interactive spots. Personal memories of tables are triggered. Previous encounters with sliders make interaction familiar, although the user might not have tried out a slider with an interactive installation before. Using the work behaves in the way it was intended: moving the slider triggers a year number and related value, graphic, animation and sound, which all change as the slider is moved again, and fade out as the work is not used for a few seconds. The work gives feedback as it is used, so intuition is answered and familiarity is confirmed. The graphical sets and audio layers are recognised and identified, and their relationship with the content understood (e.g. blue blocks graphics — ice carving sounds — glacier mass change data). The timescale is familiar and grows from left to right, as behaviour to the slider movement unfolds as expected. All in all the work is tied to users' personal lives, increasing and perhaps deepening the sense of climate change, with possibilities to, for example, see how the annual mean temperature has changed since the individual user's birth year.

When the design — i.e. its intended use and everything which helps it — and actual use match, trust is born between the users and the work. We trust systems that do what we expect (Constantine, 2006). This requires consistency from the design, and adjusting small details to make the experience feel natural, smooth and effortless. Trust does take some time to build — repeated encounters or repeated usage of the work allow the user to rely on the functions and mechanics of the work.

6.4 The Simplicity Matrix of Climatable

In order to gain knowledge about Interaction design and my interactive artwork, I set out to find answers to many questions. I have tracked down decisions I have made which simplify the work for the user in information, visual, aural, physical and technical, and designing interactivity. The original intention for creating *Climatable* was not to represent the climate change data as clearly as possible: there are scientific diagrams, maps and visualisations which try to

popularise the science of global warming. The main target of simplification here was getting people to interact with the work and to offer a fluid interaction experience, meanwhile producing an alternative way to experience (see, hear and feel) the climate change.

Table 6, the Simplicity Matrix, is based on the Simplicity Framework (*Table 5* in chapter *5.3 The Simplicity Framework*). The Simplicity Matrix documents the various perceived and designed Qualities of Simplicity (see *Figure 18 in chapter 5*) and how they are manifested in *Climatable*. Some of the qualities have been thought about early on, as design starting points, some have appeared and found their place during the creative design phase of the work. And there are some which have been noticed or added after the work was presented and its use was observed and discussed. It does not always necessarily make sense to distinguish all the qualities and all the design elements, but I argue that the chart illustrates the way puzzle-like simplicity can be constructed. While interacting, the user is in the space and sees and hears things at the same time. The term visibility grows to contain physical, graphical, interaction and information design. Thus, the elements overlap and must be also planned simultaneously — changing one affects the others as well. The experience is multisensory: physical, visual, aural and tactile while the information is processed and understood.

It is also notable how it is necessary to take all aspects of the design into consideration in order to analyse the interaction experience. Interaction design does not concern only the graphical, audio and information aspects of design and ways of interacting with them. The physical design and the surroundings are an important ingredient not to be forgotten when mapping the whole experience of using the system. The whole aesthetics of the interaction is built on the elegance of execution, the fluidity of interaction and suitable mapping of the content (Fallman, 2008). The lowest row in *Table 6* refers to programming and design of the sliders and their use, but the whole chart should be understood in a way that every element is constructed to support the interactive experience.

Climatable was planned and designed as an information system, which is capable of producing emotions, even powerful ones. A difficult task was to keep a balance between the

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Qualities of Simplicity in Climatable were illustrated both from the designer's and the user's viewpoints in Table 6, Simplicity Matrix.

	Simplicity by reduction	Simplicity by organisation	Simplicity of affordances	Simplicity of tangibility	Simplicity of intuitiveness	Simplicity of familiarity	Simplicity and trust
Physical and spatial design	**Designed:** 4 interactive locations distributed around the table **Experienced:** 4 points of access easy to see, understand and remember	**Designed:** 4 sliders distributed equally **Experienced:** Structure in space and in the visual presentation.	**Designed:** Right size, height, and positioning of elements. Tablecloth hides cords and speakers. **Experienced:** Conversation happens around the table. Knowing where to stand and what to touch. Waiting around and observing.	**Designed:** Placement of the sliders accessible, guides users around the table **Experienced:** Touching the sliders triggers the work. Tactile feedback. Materiality of the table, the tablecloth.	**Designed:** Table and sliders easy to approach. **Experienced:** Finding position around the table, Using sliders intuitively.	**Designed:** Tables and table-cloths are familiar, roundness and division in to four **Experienced:** Feelings of togetherness around the table, triggering personal memories	Projection & physical design match. Setting is elegant. Enough space around. Positions around table can be found.
Information design	**Designed:** Limiting to only 4 annual datasets **Experienced:** Possibility to experience all the datasets in one session. Connection between year and value understood.	**Designed:** Annual datasets which do not contain empty values **Experienced:** Finding data from a certain year easy	**Designed:** Data provokes emotions. Data controls audio and graphics **Experienced:** Data affords understanding that climate change is happening	**Designed:** Using datasets related to understandable phenomena **Experienced:** Users understand these datasets are related to climate change	**Designed:** Choosing data which has meaning for the users **Experienced:** Users have a pre-conception about the data values	**Designed:** Phenomena represented by the data are familiar **Experienced:** Users' knowledge of climate change is expanded	The data is believable and has emotional value
Graphic design	**Designed:** Using only 4 different graphical elements **Experienced:** Easy to separate datasets	**Designed:** Use of basic colours, distinct graphic symbols and layers **Experienced:** Easy identification of datasets	**Designed:** Signals that the work functions, attracts people near the work **Experienced:** Visual representation of climate change data. Looking at the changes made by interaction.	**Designed:** Years, values and related graphics change when the slider is moved. **Experienced:** Relationship between data value and graphical element seen	**Designed:** An arrow points out the interaction spot, relationship between data values and graphic elements. Max and min effect planned. **Experienced:** Graphics react with interaction	**Designed:** Use of familiar graphics **Experienced:** Each graphic set recognised	Graphics function as a group, the work functions (has not crashed)
Audio design	**Designed:** Using only 4 different sound samples **Experienced:** Sound layers are distinguishable	**Designed:** Distinct sound layers **Experienced:** Easy identification of sound layers	**Designed:** Signals that the work functions, attracts users **Experienced:** Aural representation of climate change data. Listening to the changes made by interaction.	**Designed:** Sounds change as the slider is moved **Experienced:** Relationship between the data value and the sound can be heard	**Designed:** Relationship between audio effect and data value. Max and min effect planned. **Experienced:** Audio reacts with interaction	**Designed:** Using familiar, understandable sounds **Experienced:** Sound layers identified	Sounds function together as a soundscape, the work functions
Designing interactivity	**Designed:** Sliders are the only interactive things, only possibility is to select the year **Experienced:** The relationship between data years and values and the way the work is used is understood	**Designed:** Interactive spots work similarly: timeline goes from left to right, year by year **Experienced:** The work can be accessed from any point, in any order	**Designed:** Sliders offer sliding. The program responds as interacted **Experienced:** Waiting, looking, listening, causing changes: touching, trying again	**Designed:** Sliders natural to use with the timeline scale **Experienced:** A connection with the work is born, since the user changes the values	**Designed:** Slider scale matches timeline scale. Fade-out delays when the work is inactive. **Experienced:** As years are selected corresponding values are shown, visualised and heard as expected.	**Designed:** Sliding and sliders familiar from various devices **Experienced:** Using slides feels natural. Timeline navigation familiar (left-right). Finding own birth year.	Sliders trigger the work immediately (but does not stop)

playful audio-visual, tactile and spatial interactivity and the information presented: participants not only listen and look at a visual representation of the data but also read the actual values and years which are presented via text. The act of reading in a way steals attention away from the installation as an abstract audiovisual installation, which would be experienced more just by hearing, touching, moving into space and looking. It would be interesting to make the work more obscure once again, display the work without displaying any data or year values or perhaps with only the year numbers and data categories. However, as mentioned before, I wanted to keep the political aspect in the work — the work is not objective in relation to climate change. The information was also a vital element, as was requested by visitors, who tried out the work as it was displayed in Levi as part of a scientific exhibition with climate change as its theme.

Table 6. The Simplicity Matrix. Mapping the designed and experienced Qualities of Simplicity of Climatable.

7 *Evaluating Simplicity*

This chapter contains two types of evaluation: firstly, observational material from the very first installation of *Climatable*, which helped me improve my design, construct the Simplicity Matrix by mapping *Climatable*'s Qualities of Simplicity to it. Secondly, the material comes from the other end of the design timeline: a user questionnaire of *Climatable* and two other interactive installations, in which the validity of the Simplicity Framework and the Simplicity Matrix have been tested, and suggestions for a more general usage of the framework is then presented.

7.1 Observations of Climatable in the wild

To complement the Interaction design cycle from study, to exploration, to practice and back to study, the process of design exploration — trying things out, refining the design, needs to be tested against the aimed result. It was important to conduct this observation in

the wild, as the context of the installation always influences the user experience (Bengler & Bryan-Kinns, 2014). This is especially true with interactive art (Candy, 2014). Collecting data "in the wild" has its problems: with over 300 users observed over four short periods, it is impossible to observe everything. Further, installing a video camera to record participant reactions would have been impossible. There is less control in the wild than in laboratory conditions (Candy, 2014).

In the case of *Climatable* the main aim of the observation and other evaluations was to understand if the mapping of the Qualities of Simplicity was successful, and whether a low threshold for participant interaction was attained. The latter could be simplified as: how was *Climatable* actually used? In regard to this question, in the beginning, I conducted an observation of *Climatable* in use during its first installation, and also had discussions with *Climatable*

Where	When	Duration	Context	Research notes	Design improvements
Tandem -exhibition, St. Etienne Biennale, France	November 2008	1 month	A media art exhibition during an international design biennale	1st public presentation. User observation, discussion.	Adjusting the initial values. Lots of ideas for design improvement
Arctic Calling — Barents Spektakel, Kirkenes, Norway	February 2010	1 day	Visionary Arctic seminar on Northern and Arctic issues and art during a multidisciplinary art and culture festival	User discussions.	Design improvements: full scale projection, new typography. Change in datasets.
Stand-alone exhibition, University of Lapland, Rovaniemi, Finland	March 2010	3 days	Installation on the main corridor of the Faculty of Arts and Design	User discussions.	Project more or less rebuilt from scratch. First use of short throw projector. Leobodnar HID as the sensor interface.
Ilmastonmuutos -exhibition, Levi Summit, Kittilä, Suomi	March 2010	11 months	A pop-up science exhibition on Climate Change	User discussions.	Pointing arrows in the UI, timing improvements.
Arctic Wayfarers -exhibition, Edinburgh, UK	February 2017	3 weeks	An art exhibition on Arctic issues	User survey (evaluating the Simplicity Framework).	New and updated datasets. Arduino as the sensor interface.

Table 7. Climatable exhibition history.

users. Later on, a more thorough survey was conducted. As mentioned before, the installation has been exhibited on many occasions, in different kinds of contexts and for different durations. *Table 7* collects the exhibition history and contributions to research and design.

At St. Etienne Biennale, I observed whether user interaction with *Climatable* answers the design intentions. It was observed, whether the work attracted enough interest — the number of people trying it out — and how the interface and interaction methods were understood. Also, it was interesting to observe whether the feedback the work gave out was fast and sufficient enough. As *Climatable* was designed to be quite a minimal artefact in terms of content, it was interesting to see how long the participants maintained interest in the work. Other observations such as whether the work created social situations or additional interest towards the work by, for example, taking photos of it were also made. These observations may provide insight into the applicability of simplicity — it might not be for everybody, every artefact, every occasion, every content.

The work was installed in the St. Etienne Biennale in a built-in-gallery-room in one of the main exhibition venues, Batiment H. The installation was part of project Tandem, consisting of 4 media artworks: two interactive installations and two video projection installations each set up in its own small room. There was a bench where visitors could sit and watch the video projections, but as my work was a table I wanted people to stand around it. The visitors had to go past my work to see one of the other installations. Sometimes the gallery space was nearly empty, at other points there were perhaps 30–40 people in the four small gallery rooms. My work was in active use almost all the time when there were many visitors, leading people to sometimes wait to be able to try it out.

The number of visitors and their distribution based on their interest in the work is displayed in *Figure 24*. The observation periods lasted approximately one hour each, except for the last day, which was very busy and the test period was only 30 minutes. There were about 1.5 users every minute, except during the last day when there were more than 2 users per minute.

I conducted this observation by sitting in the same room but pretending to watch another video installation. This position left me more or less completely invisible to the visitors. The Biennale was a popular attraction, and there were people in the exhibition room nearly all the time. The busiest day was Saturday 22nd, during which the observation was shorter. The busy times differed somewhat from the quieter times: as there were more people in the gallery room and around my work there was less chance of interacting with the work in depth.

Altogether more than 300 people were counted during the four observation periods (*Figure 24*). I have chosen to include in my observations only people who showed some kind of interest in the work, leaving out the approximately 50–60 people who walked into the gallery, perhaps only glancing at my work very briefly and then walking away. These people cannot provide data which helps determine if the interaction is functional or not. Their behaviour perhaps tells more about their lack of interest in media art in general or about the fact that there just were too many people around and too much to see at the Biennale. However, I calculated in my observations people who paid an interest in my work but did not participate themselves, an observer group. For them it was enough to watch other people, perhaps their spouses, boyfriends or children use the work, understanding or learning how the work functions but not trying it out themselves. In a sense, they were picking up the skills needed to use such interactive systems in the future. It is also worth mentioning that sometimes the work was undergoing so much activity that it was difficult or impossible for everyone to be able to interact, or even get close to the table, so some people had to accept an observer role. This group accounts for about 20% of observed people. The majority of the observed people who tested the work or tried it out more thoroughly. There is a difference in testing and trying out: for many people testing only one or two hotspots are enough. I have labelled this as a "visitor" group: a small cause and effect —action is enough to make them satisfied. They figured out how the interaction works, grasping what the work was about, perhaps not having enough time or interest or possibility to use the work due to the busy nature of the gallery room. Perhaps the content was not interesting enough or did not make sense to them, or maybe the figures representing climate were perceived as too negative. This group was the largest of the observed groups.

Many others wanted to try out at least three, usually all four active spots. At this stage, I see

Figure 24. *Observations of users of Climatable.*

it would be appropriate to talk about users or participants: i.e. people showing motivation to try the interactive work from multiple points in time and space. This group figured out how the interaction works and wanted to experience all aspects of the work. This group was a bit smaller than the group who only tested the work but big enough to convince me that the work could raise interest which lasts a long time. Both of these groups prove to me, that the intended use designed by me matched the way the work was actually used by the users.

Out of the visitors and participants, many people also commented on the work to others or took photographs. These were also recorded during the observation and are displayed in *Figure 25*. When the work raised discussion or the desire to take a photo (the exhibition was held before the current era where everyone has a smartphone with a high-quality camera), this demonstrated that something in the design process was probably calculated correctly. Discussing the work might be more related to the phenomenon of climate change brought fore by the installation rather than about the smooth interactive situation created by the artist, so this group can perhaps be left more or less as a side note in this research. On top of the active users and the participants, there was an interest in discovering a group of users who I label as enthusiasts: people who spent a very long time with the work, trying out every little detail, wanting to find out how the sound and image work together with the data, or even trying to use many hotspots at the same time. This group is interesting, because they seem to enjoy interacting with the work more than others, trying to bend its rules, to test if it breaks or supports different or alternative usage mechanisms — to make it their own in a sense. They represent the group of playful users — users whose amount of input and effort can offer new insights for the interactive artists and designers. If it is possible to understand what makes them hooked, would it be possible to strengthen those features in future works or iterations? This clearly calls for further research.

In observations of *Climatable*, the enthu-

Figure 25. Enthusiast users of Climatable in St. Etienne.

siast group was, however, a minority. This can also tell something about the limits of simplicity. It seems as though some users wanted to add some complexity to the system, trying to create new ways to use the installation — hack the system. The rather small figure of enthusiasts (about 3–4%) communicates that the interaction and its possibilities made available in *Climatable* were rather limited and predictable, unsurprising; not allowing the users to choose from various options. More options would have meant a more complex system, and in the future, it will be interesting to develop interactive artworks where simplicity guides the initial steps, but the work can grow in complexity, block by block like a Lego-brick system. The actual use went beyond the intended use — users tried to find hidden things, or ways to use the system creatively — for which I am also happy, as this increases my knowledge of possible use scenarios and users.

The last group is the group of people I did not want to discover: the ones who were interested in my work and tried it out but did not understand its behaviour. Positively, the amount of these non-users was as small as the enthusiasts. The reasons why approximately 10 visitors did not grasp the proper way to use the work are probably manifold: most importantly, as the installation was not set according to my specifications, certain spots (the insides of the rings for example) which were supposed to be active on the table did not function. Also, the faulty setup caused problems with my then poor electronic skills related to using a light sensor (a pull-down resistor was missing). In the end, the sensors functioned from time to time but were unreliable or even misleading. The work was, in the end, most functional when triggered by using the sliders. Lastly, I assume the work did not meet everyone's expectations. The visitors who did not really understand the work might have had questions in mind such as: is the table surface a touchscreen? Does it sense my presence or my hand movements? Should I really touch the work? Some visitors had some initial trouble using the work, which probably reflected the same questions. Most of them did learn quite quickly how the work was used. In later exhibitions of the work I have tried to correct these mistakes, and make the interaction even simpler, clearer, and more easily guided. After St. Etienne the functions of the light sensors were stripped away and the sensors were covered totally.

In the end, the number of visitors who did not understand the work is quite minimal (about 3–4%), and as my main target groups (1–2 spot testing visitors and 3–4 spot testing users and of course the enthusiasts) account to almost 80% of the observed people I can say I have succeeded in building an interactive installation which is easy to grasp. As the things I was

interested in finding out were about the low threshold of interaction and simplicity as a tool for attracting people to try out the work, *Climatable* is in the end quite simple. It is not built to reward people who use the work for a longer period, hence the quite small percentage of enthusiasts. Together with the people discussing the work and taking the photos, the enthusiasts are definitely a group I want to know more about in the future. Altogether, the observation results hint that simplicity in audio-visual and interactive solutions can create an easily graspable work, but at the cost of the participation staying at a quite simple level. More complex participation needs more complex interfaces: more buttons or more functions to a button, more possibilities, more content, more personalisation. There could be a lot more content inside the system or programmed environment, but when the interaction is reduced to its minimum the method of participation does not really change. Observation using this method was only undertaken in the first of the five places *Climatable* has been exhibited in. This context must have enormous effects on the end results of the observation. The amount of visitors has not been this high in the other locations. Most of the users saw other people using the work, which facilitated hands-on trying out. This is, however, a natural and recommended occurrence in building interaction. The event — a design biennial — sets the work to be seen more in a context of design than art, although many other artworks and installa-

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Based on the user observation in St. Etienne, many improvements were made to Climatable, e.g.: the timing was improved, the interactive sliders were highlighted with pointed arrows, the animation was calmed down.

tions were presented at the festival and especially in our gallery as well. In later cases when the work has been exhibited I have observed users and talked with them, but have not collected as much data. I have improved the works based on these conversations but mainly based on my own judgements of what went wrong in the first exhibition. It is also a relief to state that I have not encountered people who did not understand my design or intended use of *Climatable* ever since the Biennale. However, a stronger connection between the Simplicity Framework, the Simplicity Matrix and the research was needed.

7.2 Evaluating the Simplicity Framework

The Simplicity Framework and the Simplicity Matrix have proven to be a fruitful tools for me as a designer: heuristically reviewing and iterating the design, observing users and finding out which details contribute or correspond to different Qualities of Simplicity has revealed valuable information for me about creating interactive art, and how the art is experienced. However, in order for the framework to be more universally applicable, more rigid research was needed and it was decided that we would test the framework out by conducting user-testing with three different interactive works with the same questionnaire (*Appendix B*). An overview of the interactive installations can be seen in *Table 8*. The first work was *Climatable*, the second an ambient interactive bio-artwork *TeaCup Tools* by Agnes Meyer-Brandis, and the third was an interactive amusement park experience, an installation prototype *Aurora Machine*.

The first test was conducted as *Climatable* was exhibited in Edinburgh as part of the *Arctic Wayfarers* -exhibition at Edinburgh Summerhall, between 25 February–19 March 2017. The questionnaire was mostly filled out by art audience members alone without guidance, and

	Climatable	TeaCup Tools	Aurora Machine
Artist(s) / Designer(s)	Tomi Knuutila	Agnes Meyer-Brandis	Ismo Alakärppä, Tomi Knuutila, Elisa Jaakkola
Location	Arctic Wayfarers exhibition, Summerhall, Edinburgh	Splice - Re-examining Nature exhibition, Oulu Museum of Art	SantaPark, Rovaniemi
Questionnaire executed in	February—March 2017	June 2017	August 2017
Photo			
Survey answers	23	16	24

Table 8. Interactive installations, which were analysed with a questionnaire (Appendix B).

the dates (filled by the survey participants) varied between 1st and 19th of March. There were 23 answered papers. The second questionnaire was conducted on 16th and 21st of June at the Oulu Museum of Art during the *Splice - Re-examining Nature* exhibition, with 16 filled papers. The third questionnaire was conducted by the author at Santa Park, Rovaniemi on the 10th of August 2017 and the answer count was 24.

The survey was devised to correspond not only to the Simplicity Framework (*Table 5* in chapter *5.3 The Simplicity Framework*) but also to both axes of the Simplicity Matrix (*Table 6* in chapter *6.4 The Simplicity Matrix of Climatable*): first of all to see if the Qualities of Simplicity can be found in the surveyed artefacts and secondly to find out if the media material appeared to be simple enough to use. The test should then reveal perceived simplicity — whether the Qualities of Simplicity could be identified by the audience and whether the different design components were understandable and supported interaction with the work. Thus, the questionnaire contains two main parts: Overall impression, with questions related to the Qualities of Simplicity and Media material, with questions related to the designed components and their perceived simplicity. In both sections, survey participants were asked to judge whether they would agree or disagree with different claims about the work. The scale ranged from 1 to 5, with 5 being the highest score supporting simplicity.

The first main set of questions, in the section "Overall impression," were related to the Qualities of Simplicity. Participants were asked to give their opinions on understandability, ease of use, intuition, familiarity, organisation, unnecessary elements, logical operation, work behaviour and feedback, physical operation and the design elements guiding use, or "what to do." The questions and Qualities of Simplicity are mapped in *Table 9*. The questionnaire was constructed mostly of questions without direct references to the qualities themselves. As can be seen, all of the questions can be primarily related to one main quality (only in one case two qualities), but all of them also contribute secondary evidence to other qualities. For example, the opinion about the work being easy to use can easily be seen to be related to intuitiveness, which is the primary evidence. Ease of use also can reveal something about the way the work was organised to clearly show what to do, and about tangible operation — and also it can be said that the design affords its use in a preferred way, utilising established design traditions. In the table, the primary contribution is marked in bold x, and secondary contribution in parenthesis and normal text (x). Concerning reduction, the main question was over whether "there were no unnecessary elements." For organisation, there were two main questions, over whether: "the

Overall impression questions and their relevance to Qualities of Simplicity	Simplicity by reduction	Simplicity by organisation	Simplicity of affordances	Simplicity of tangibility	Simplicity of intuitiveness	Simplicity of familiarity
The work was easy to understand	(x) - There was no unnecessary content			x - The content was understandable	(x) - It was obvious what the content is about	
The work was easy to use		(x) - It was clearly shown what to do	(x) - The work uses established (interaction) design traditions	(x) - The operation was easy to understand	x - It was obvious how to use the work	
I knew immediately what to do					x - It was obvious to know what to do	(x) - Familiar elements guided the usage
The work reminded me of an earlier work					(x) - Earlier experiences build up intuition	x - Familiarity between other earlier works
The work was organised well		x - Organising the elements worked	(x) - Organisation supported the preferred affordances			(x) - Organisation was familiar
There were no unnecessary elements	x - Unnecessary elements were removed	(x) - All the elements were in good order				
Operation of the work was logical		(x) - The order made sense		x -Operating the work made sense		
The work behaved as I thought it would			(x) - Preferred affordances were focused		(x) - Intuition was answered	x - The way the work operated was familiar
Physical operation of the work was easy	(x) - There were no unnecessary buttons or other physical hindrances		(x) - The physical design supported the preferred affordances	x - The physical and spatial design supported the usage		
The design guided me in what to do		x - The work has been organised in a way which guides the user	x - the design of the work focuses on preferred affordances			

Table 9. Qualities of Simplicity and the questionnaire answers which contribute to them.

work was organised well" and "the design guided me in what to do" Support for affordances was best answered by the claim: "the design guided me in what to do." Tangibility had three main supporting questions, concerning whether: "The work was easy to understand," "Operation of the work was logical" and "Physical operation of the work was easy." For intuitiveness, the claims were that the work was easy to use and that the user knew immediately what to do. Lastly, for familiarity, the questionnaire asked the respondent to judge whether the work reminded him or her of an earlier work, but also whether the work behaved as he or she thought it would. Supporting claims for the Qualities of Simplicity are easier to read in *Table 9*. Also, the way the claims support the Qualities of Simplicity are mapped in the table with one sentence. E.g. the claim: "The work behaved as I thought it would." Has been mapped to three places. For affordances, "Preferred affordances were focused." For intuitiveness, "Intuition was answered" and for familiarity, "The way the work operated was familiar." Many of the questions could be seen to contribute at least a little to even more of the qualities, but I've decided to focus on the main supporting factor and a maximum of two of the most important factors.

Using this table, and by giving different weights in the score for different questions for a certain quality, I have calculated more precise average scores for each of the Qualities of Simplicity. The weighted score is calculated in such a way that the main corresponding value is mapped at 100% and the secondary values at 50% influence. However, after calculating the answers from all three questionnaire results, there is very little difference in the weighted average and the main average. The overall trend can be seen just from the average scores of the answers for each question.

The second main set of questions was labelled as "Media material." This section seeks to find whether the different design components support simplicity (*Table 10*). Here it is clear how the questions match the different design areas, with perhaps the exception being the last question related to the content of the work. The content, of course, consists of all of the designed elements, but mainly from the textual, audio and graphical information, and the way it is interacted with. Again, the main trends can be found in the answers to each question, but I did calculate a weighted score for the values as well.

In addition to these two main categories, some basic background information, such as age, sex and experience with interactive art were asked. The questionnaire gathered some improvements and suggestions, as there was a question over whether something should be changed. The open comments field also yielded some thoughts for enhancement. An interesting question

Question and its relevance to media material	Physical and spatial design	Information design	Graphic design	Audio design	Designing interactivity
The graphical elements were understandable			x		
Interacting with the work was easy					x
The textual information was understandable		x			
Audio design supported interaction with the work				x	
Spatial design supported interaction with the work	x				
The physical design supported interaction with the work	x				
Content of the work was understandable		x	(x)	(x)	(x)

Table 10. Simplicity of design elements and the questionnaire answers which contribute to them.

in the questionnaire asked the respondents to give their opinion on whether the work was art, design, both or neither. To sum up the questionnaire, an average simplicity score was asked.

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To test out the Simplicity Framework, a questionnaire was made (Appendix B). The answers are mapped in two tables: firstly, to the Qualities of Simplicity in the table 9, and secondly to the simplicity of the design elements in table 10.

This has also been compared to average scores calculated from the Qualities of Simplicity and the design components.

It is worth noting and remembering, that only *Climatable* was constructed with simplicity in mind, and at the point of the exhibition in Summerhall, the design had been iterated and improved many times. The bio-artwork at the Oulu Museum of Art shares the same theme as *Climatable* — i.e. humanity's contribution to nature and climate change via CO_2 gas emission — but the style of *TeaCup Tools* is much more poetic and even cryptic. Also, interaction with

the work is very ambient and indirect. *Aurora Machine* was at a prototype stage, and had not been built with simplicity as a principle — the focus was to create a memorable experience for tourists through new technology and usage of natural materials for interaction; in this case, ice and water. As I present the results I will focus more closely on *Climatable*, since it is the artwork addressed in this thesis and discussed in detail in the previous chapters.

7.2.1 Simplicity in Climatable

THE FIRST TIME THE QUESTIONNAIRE WAS used was in Summerhall, as a part of an art exhibition. As it took my whole and only day to set up the installation, I did not have time to talk about the questionnaire too much — it was printed out, I explained the main points regarding how to fill out the survey to the exhibition organisers and the rest was left to them to manage. Some of the papers were filled by the exhibition-goers by themselves, some while the organisers were present. In the end, there were 23 answered papers, sadly in one-third of them the reverse side of the paper had not been noticed. Basic background information can be seen in *Figure 26*. The age and gender distribution seem to provide fruitful results. Most of the people had some background with interactive art, and they spent at least a few minutes with the work, some even more than this. Interestingly, the
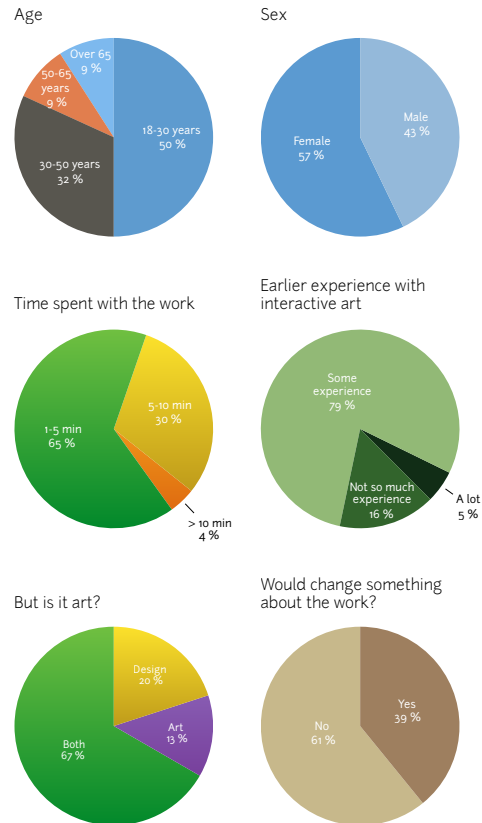
Figure 26. Questionnaire participant background info in Climatable.
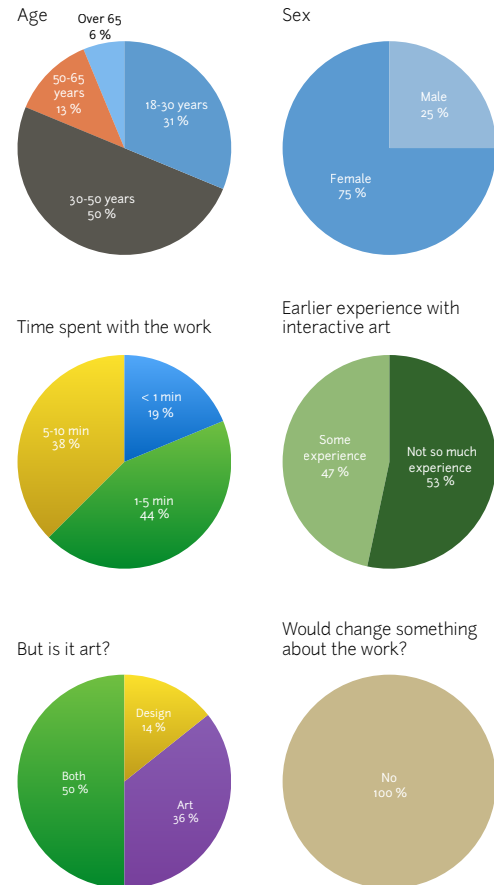
Qualities of Simplicity	Simplicity by reduction	Simplicity by organisation	Simplicity of affordances	Simplicity of tangibility	Simplicity of intuitiveness	Simplicity of familiarity	Weighted averages
Weighted simplicity average scores (1 = totally disagree, 5 = totally agree)	4.62	4.46	4.42	4.73	4.22	3.52	4.32
Design elements	Physical and spatial design	Information design	Graphic design	Audio design	Designing interactivity	Weighted averages	
Weighted simplicity average scores (1 = totally disagree, 5 = totally agree)	4.50	4.36	4.27	4.27	4.67	4.42	

Table 11. Perceived Qualities of Simplicity and design elements in Climatable.

work was considered to be both design and art, and a bit more a design piece than an artwork. This might explain why in some of the enhancement suggestions better informational content and explanations were sought after.

The results supported that simplicity is perceived well. *Table 11* collects the results. In average scores, out of the ten claims in the Overall impression (*Figure 27*) section about ease of use, understandability, etc. only one was below four, in the scale from 1 (totally disagree) to 5 (totally agree). In the Media material section the scores were all above 4.25 (*Figure 28*). The question about average simplicity produced a very high result: 4.58. For this question, there were only 13 answers, due to misleading questionnaire design: two different scales are mentioned in this question (1 to 10 and 1 to 5), and the fact that the second side of the questionnaire was not noticed by all who answered. An impression of the overall simplicity can also be achieved by calculating the average score from the answers for the Qualities of Simplicity (n= 23 in most cases), which gives an average of 4.25 (weighted 4.32), and an average score for the perceived simplicity of the design components (Media material) (n=15) of 4.44 (weighted 4.42). All these three results support each other well.

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Judging by the questionnaire answers, the Qualities of Simplicity in Climatable are clearly perceivable.
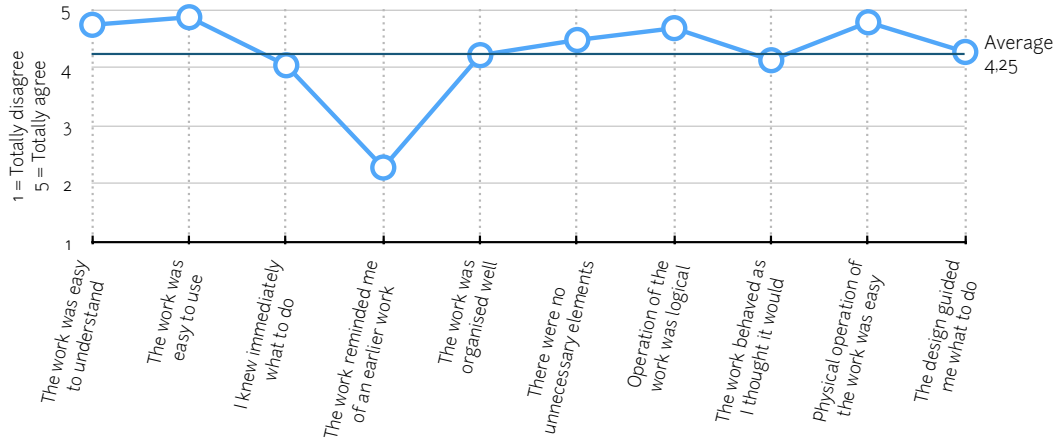
Figure 27. Overall impression average scores in Climatable.
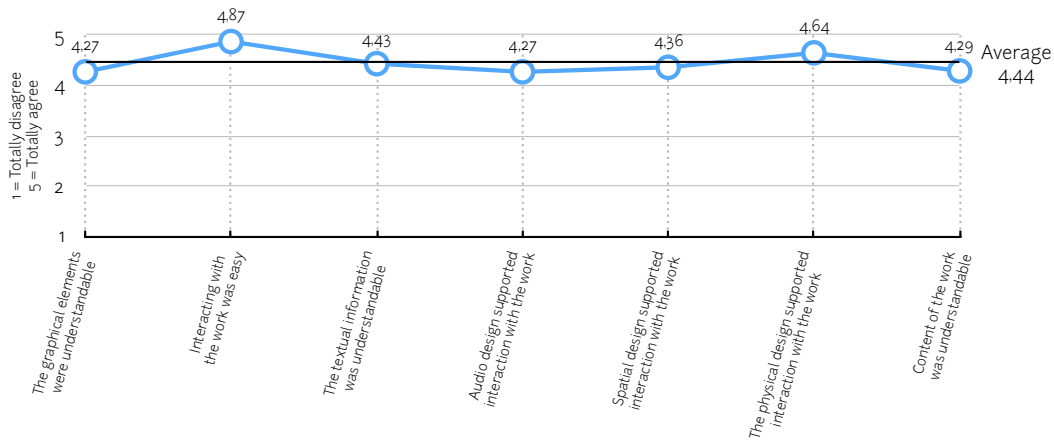
Figure 28. Media material average scores in Climatable.

With these results, it is fair to say, that according to this questionnaire simplicity is evident in *Climatable*. The only point not yielding an above average score was "The work reminded me of an earlier work." This question is perhaps a bit ill formulated — in the context of art, it is not considered a good thing that the work evokes an earlier work. This is, of course, related to simplicity of familiarity. After considering the other options supporting familiarity — such as, "The work behaved as I thought it would" — and questions about organisation and knowing immediately what to do, the weighted average of familiarity rises to around 3.5. A better statement to ask about in the first place would probably have been "Interacting with the work reminded me of an earlier work," "Using the work reminded me of an earlier work," or "The design of the work reminded me of an earlier work."

7.2.2 Simplicity in TeaCup Tools

THE SECOND TIME THE QUESTIONNAIRE WAS used (and the errors fixed) was in Oulu Museum of Art, with an artwork with a much more "ambient" interaction method than can be seen in *Climatable*. The interaction with the work happens as the amount of CO_2 in the exhibition room is measured, with the data being displayed on computer screens, but also manifested as physical movements of teacups.

Figure 29. Questionnaire participant background info in TeaCup Tools.

Qualities of Simplicity	Simplicity by reduction	Simplicity by organisation	Simplicity of affordances	Simplicity of tangibility	Simplicity of intuitiveness	Simplicity of familiarity	Weighted averages
Weighted simplicity average scores (1 = totally disagree, 5 = totally agree)	3.20	3.31	3.07	3.01	2.57	2.70	2.98
Design elements	Physical and spatial design	Information design	Graphic design	Audio design	Designing interactivity	Weighted averages	
Weighted simplicity average scores (1 = totally disagree, 5 = totally agree)	3.41	3.19	3.52	3.44	2.98	3.31	

Table 12. Perceived Qualities of Simplicity and simplicity of the design elements in TeaCup Tools.

I was first sceptical whether this artwork could be considered to be used as a comparison when questioning simplicity. However, many of the features are shared: the work has a spatial and physical design, it expresses values in graphical terms (and the movement of the cups create sound). In the end, exhibition participants can see how their presence affects the way that the interactive artwork behaves. On the other hand, this can also be seen as an interesting test for a wider usage of the Simplicity Framework and of the Simplicity Matrix.

The questionnaire was answered mostly by female visitors of varying age ranges. Most of them spent more than one minute of time with the work. Nearly half of them had experienced interactive art beforehand. Interestingly, while the work was perceived as an artwork and no one wanted to make any changes to it, half the of the answers still saw the work as both art and design. Participant backgrounds are illustrated in *Figure 29*.

With *TeaCup Tools*, the answers about perceived simplicity vary quite a lot: e.g. some see the work as easy to understand or to use while others do not. This is also true with media material: while graphical elements are mostly seen as understandable, interacting with the work, accompanying textual information, and its audio design, as well as physical and spatial design produce mixed results. Calculating averages, Qualities of Simplicity vary between 2.57 and 3.31. The usage of media material averages is a bit higher, from 2.98 to 3.52. The result for rating the simplicity of the work is 2.83, a bit lower than the calculated averages. *Table 12* collects the results.

7.2.3 Simplicity in Aurora Machine

The third time the questionnaire was used was during the initial test in the wild of a prototype in a design research project DiAr-We, creating innovations by combining Arctic natural phenomena with digital innovation. *Aurora Machine* can be thought of as an interactive amusement park or science centre attraction aimed at visitors — mainly families. The work was presented in SantaPark, which is a Christmas-themed amusement park in Rovaniemi. Participation in the work happens in two phases and places: first, a photograph is taken of the visitors and attached to an RFID-tag embedded on a 3D-printed snowflake. The snowflake is given to the individual visitor to wear around their neck. In the second phase, the snowflake is placed on the "aurora machine" — on top of a hidden mobile phone, which reads the RFID-tagged image and projects it to the wall, reflected through a pool of water. The photographic situation was staged so that there was a bright-coloured cloth in the bottom of the photo. The photograph is projected in such a way that the bright colour is only reflected through the water, and appears rippled on the wall on top of the people in the photo. On top of the table, a melting ice block was positioned, so that dripping water caused reflections, which looked a little like auroras.
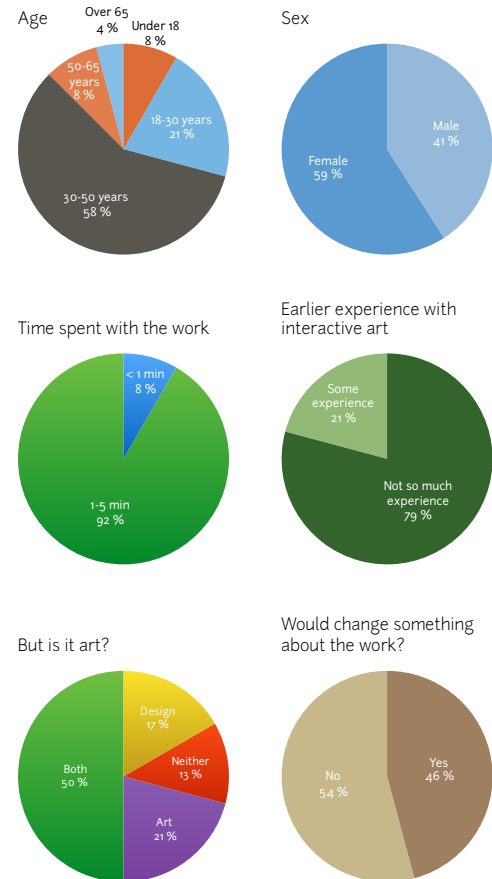
Figure 30. Questionnaire participant background info in Aurora Machine.

The context — an amusement park — brought in a different type of audience, specifically families with small children, although the survey was mostly filled in by the parents. Perhaps surprisingly, the work was seen more as an artwork than *Climatable* was. Participant backgrounds are visible in *Figure 30*. The installation asked participants to participate in the taking of photos, in listening to a story (told by an Elf!) about the *Aurora Machine* (*Picture 13*), then in locating where to place the snowflake in the installation. The ultimate goal was to try to get people to manipulate the auroras on the screen by trying to get the ice to melt faster to increase water flow, but in many occasions, they had to be instructed to figure out how to do it. Me and researcher Ismo Alakärppä were present at the machine, sometimes guiding the use of work, but mainly observing its usage, while researcher Elisa Jaakkola acted as the elf introducing the *Aurora Machine* to SantaPark visitors. There were a lot of things which did not work out the way we wanted in the installation: it wasn't obvious to the people what they had to do when they arrived at the installation. When they figured it out (or when we told them in some cases) the location where the snowflake was to be placed was not always easy to find. After this, some visitors realised they could (and should) touch the block of ice, but making it melt faster started to be physically challenging (*Picture 14*). All of these problems can be also discussed through the lens of the Simplicity Framework, and the answers to the questionnaire more or less support the observations: some visitors found it easier to use, some more difficult. The research project deals with using natural materials, such as snow, ice and water for interaction. However, for many of the visitors, the "magic" of seeing their picture appear on the wall without visible tech-

Qualities of Simplicity	Simplicity by reduction	Simplicity by organisation	Simplicity of affordances	Simplicity of tangibility	Simplicity of intuiteveness	Simplicity of familiarity	Weighted averages
Weighted simplicity average scores (1 = totally disagree, 5 = totally agree)	3.89	3.73	3.64	3.72	3.23	2.93	3.52

Design elements	Physical and spatial design	Information design	Graphic design	Audio design	Designing interactivity	Weighted averages	
Weighted simplicity average scores (1 = totally disagree, 5 = totally agree)	3.95	3.72	3.99	3.54	3.96	3.83	

Table 13. Perceived Qualities of Simplicity and simplicity of the design elements in Aurora Machine.

Picture 13. Aurora Machine setup at SantaPark.

Picture 14. Aurora Machine: trying to get the ice to melt.

nology seemed to be the most exciting part of the experience. While this project centres around experience design, focusing on simplicity could improve the interactive situation: this could involve designing the interaction with ice and water as the main focal point by removing unnecessary elements, focusing on physical and spatial design, and making clear what is tangible and what is not. Thinking about natural affordances and familiar aspects of interaction with water and ice, e.g. letting people play with water directly, could provide a more unique experience.

In the questionnaire, average scores for simplicity are quite high, although individual values range a bit. I think the survey also reflects the mostly positive general feeling the visitors had after the experience, as designers we noted many things that went wrong and which we would do differently if the work was to be rebuilt on some other occasion (it was a temporary installation for just one day). Different average simplicity calculations based on surveys gave scores from 3.4 to 3.83. *Table 13* presents the results for *Aurora Machine*.

7.2.4 Simplicity Framework: general trends

At the Summerhall, as the questionnaire was filled mostly without guidance, some participants (about 1 in 3) missed the two-sided test paper's reverse side. The other two tests

had a person helping out with the questionnaire so this mistake did not happen. However, some problems in the questionnaire were noticed: the overall simplicity grade was confusing in the first questionnaire since it mentioned both scales between 1–5 and 1–10, and two people pointed this out by drawing question marks on the answer paper. This was fixed in the other two tests. Even with this fixed, the final question (overall simplicity) was missed in nearly half of the answers for the *TeaCup Tools* and in some answers for the PhotoTable (as the *Aurora Machine* was called in the questionnaire). The survey could be better organised.

Figure 31 collects all the simplicity values from the three sets of questionnaires: answers to the last question (rate the simplicity of the work), main and weighted averages of the Qualities of Simplicity and the design elements. As noted before, simplicity in *Climatable* stands out compared to the other two. *Aurora Machine* was designed to be an interesting interactive experience, and while some thought was given to the design, a lot of difficulties were observed in regard to its usage. The questionnaire results support these findings. The focus in the design of the interactive artwork *TeaCup Tools* has most likely not been on user participation, but rather on creating a memorable and perhaps even a confusing experience. It might be argued that the importance of aiming for simplicity in the overall design increases as the desired level of participation increases. In the end, *TeaCup Tools* results do not suggest a terribly confusing complexity, perhaps just not a high degree of simplicity — though perhaps that is just what the artist has attempted to achieve.

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>
> The questionnaire used in this research can help to evaluate simplicity and aid the design of interactive artefacts in various phases.

The three questionnaire results do not point to overly serious problems when the answers were averaged. The average scores for most questions were equal to or above 3.0 in all three cases. Individual answers can provide better places to improve the design: if one or more participants say that the work is not at all easy to understand or to use, or that the work did not behave the way the participant expected, it should be noted by the designer. For both the *TeaCup Tools* and *Aurora Machine* there are quite a few respondent answers that disagree strongly or rather strongly (1–2 in the scale of 5) with the individual questions relating to simplicity in design.

The questionnaire can function well in various stages of the design process. *Aurora Ma-*
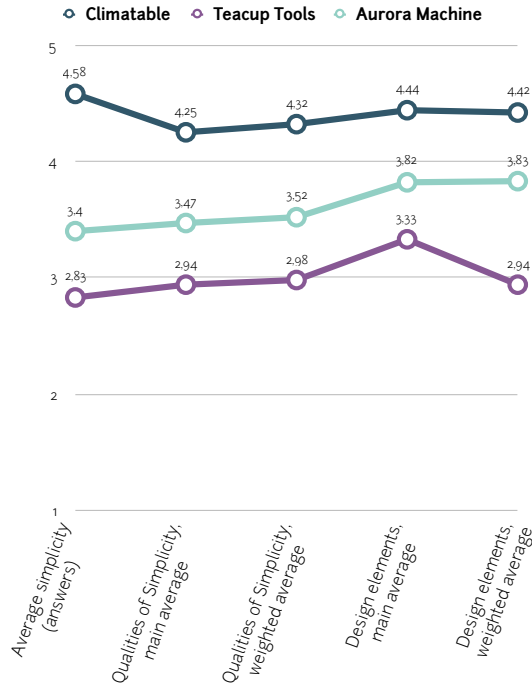
Figure 31. *Simplicity scores for the Interactive installations.*

chine was presented for the first time to an audience, while during the questionnaire, *Climatable* and *TeaCup Tools* were presented as "finished" artworks, although I am sure both works will be updated and changed in future exhibitions. Observations of *Aurora Machine* in use proved to be very fruitful, as was the case when *Climatable* was presented for the first time in St. Etienne. The questionnaires supported those findings rather well.

8 Emerging themes

THIS CHAPTER PRESENTS SIMPLICITY AS NOT only as something designed or perceived but also in terms of how it can be displayed by an (interactive) artefact. This is then supplemented with analysis into different modes of interaction. Discussion on these aspects is related to a paradigm shift which takes place as tangible, physical and spatial interaction increases in popularity. It can be said that the interaction itself becomes the content for the user (BARDZELL ET AL., 2010). Spatiality and social collaboration possibilities also raise the issue of performativity of the interaction process (BARDZELL ET AL., 2010; DALSGAARD & HANSEN, 2008). Spatial, tangible and performative interactions have always been explored in interactive media art. While this research has concentrated on simplicity, rather than on emerging, explorative ways of interaction, it is worth mentioning how the different Qualities of Simplicity influence different modes of interaction and constitute different aspects and paradigms of interactivity.

In this chapter, two timelines are created for the interaction event. First, from the designers' point of view, it is pointed out that the Qualities of Simplicity need to be taken into consideration during the design process. It is important to concentrate on different qualities in

different parts of the creative process. Some discussion also centres around how designing for different Qualities of Simplicity requires different levels of knowledge from the designer. For the users, a timeline for the Qualities of Simplicity as they appear on the interaction loop is built. Different Qualities of Simplicity become more evident during the interaction event. It is also discussed how important certain Qualities of Simplicity are for the experience of simplicity.

8.1 Designed simplicity

In the chapters above, simplicity has been defined through a theoretical framework and it has been discussed how these Qualities of Simplicity can be designed in the creative work of interactive media artists. I also discussed how simplicity can be experienced, using as examples well-known works of interactive media art. Next, I iterated the creation process of *Climatable* and mapped out Qualities of Simplicity which were related to it. User observation into whether this works furthermore gave me data on how the work was used and understood, and user surveys, in the end, gave me data on how well the Simplicity Framework and the Simplicity Matrix worked.

From the earlier discussion, two different aspects or manifestations of simplicity in an artefact or a system can be observed. One is the simplicity which has been created: applied in various parts of the (interaction) design, as an actively pursued goal of the artist or the designer. The other is the perceived simplicity, a form of interaction which is expressed during the user's experience (Landin, 2009). Here I reiterate the Qualities of Simplicity from the viewpoints of the user and the designer.

Some things keep reappearing in the design of interactive artefacts which are based on the findings of this research can be considered as *simple*. First of all, the formal characteristics of the work need to be addressed by giving attention to organisation and reduction: getting rid of the clutter, providing only the things that are meaningful to the interaction process. Secondly, making sure the functionality is in place — the design focuses on preferred affordances and is tangible. Conceptual coherence is created by designing for intuition and with familiar interaction methods, text, audio and images. All these are designed to guide the interaction process over time.

	1	2	3	4	5	6	7	8
Reduction		X	X					
Organisation	X	X						
Affordances							X	X
Tangibility						X	X	
Intuitiveness				X	X			
Familiarity					X	X		
Trust								X
Time	→							

Table 14. Designer's timeline.

Table 14 displays how different Qualities of Simplicity operate during the interaction process from the designer's point of view. Different Qualities of Simplicity are thought about in different phases of the design process. Typically, every Interaction design process begins with organising data into coherent entities. Organisation is followed or paralleled with reduction of unnecessary data and information. Designing for intuition typically should start early on in the process. Intuition should get users interested in the artefact, and to try different possibilities afforded by the interface during the interactive session. This means designing elements, which invoke exploration. Familiarity should be thought afterwards, to support solutions made only with intuition in mind — the designer should think about how the exploration will be answered. The kind of feedback which is given to the user, along with the actions and behaviours of the interactive artefact should be recognisable and familiar. It is related to how different kinds of information could be used, touched, selected and navigated. Familiarity leads to tangibility as well: it is important to design, what kinds of things should be used as input methods, how navigation takes place, how user selections will be communicated. This relates to the presentation, including graphical, audio and even tactile feedback: how does the visibility and audibility and the layout of the interface, for example, afford the desired interaction? Finally, the designer should use his or her knowledge to ascertain whether trust towards the system can be generated — whether the interaction methods, content elements, understandability and organisation of the information are consistent, there is proper fluidity, the feedback is consistent, and the

system is elegant enough.

To be able to use these features, a certain skill set is required from the designer. Although none of these is very easy to accomplish without experience and practice, some can be learned more easily than others. For example, organising information, graphics and the audio into navigable entities is a task comprising many tools and methods, such as card sorting, mind mapping, and various types of low-fidelity prototyping. However, coming up with a solution that is perfect for everybody is often impossible — the same data can be organised in many ways. Nevertheless, the task should be something that makes sense and gives an order to things, and I feel this occurs naturally in most of the interaction processes. Reducing things already requires more thought: what is essential to the content? When is fewer options better as a solution (is *less* always *more*)? Usually, the organisation process helps the reduction process, and after the content reveals itself, things snap into their places and the final quantities and qualities remain.

Designing things which are familiar needs a bit more practice. It is a very common mistake for designers to assume they know the skill-level, the jargon, the knowledge level, the assumptions of the user and the context of usage. The designer has a much bigger mental picture of the system or the product than the user. Probably the designer knows much more about similar products. Familiarity can be thought of as common sense, and often user testing is done in many phases of the design process to see if the users understand how to operate a system. Somewhere between familiarity and tangibility, one can locate affordances. Somehow they are based on familiar things, but these familiarities often remain unseen or unnoticed. Affordances are possibilities, and not one designer can think about all the possible affordances a product or a system has. Affordances relate strongly also to the notion of tangibility: things which are grasped or touched help us to do or understand something. Choosing the right interaction method so that things are tangible requires an even higher-level knowledge from the designer. When a correct method for interacting with the content is selected, things become understandable, graspable and tangible. As with many other Interaction design duties, this is a problem where there is no certain specific answer. I also believe the designer's experience in selecting the correct or most suitable method is crucial — however different designers might come up with different interaction methods.

The highest level of knowledge or expertise requires some kind of personal vision and responsibility from the designer. Building things or systems which are intuitive to use and build trust requires a strong design vision which thoroughly covers the process of a user interacting

with the system. The designer makes decisions which in his/her opinion support the users' intuition — the designer's intuition (born with a long experience of creating, using, and observing such systems) should contain the user's intuition. Designing for intuition differs from designing for familiarity: intuition works on a subconscious level, whereas familiar things are already recognised. Intuitive things raise curiosity, while familiar things can be easily contextualised. Along with designing for intuition comes building up trust towards the artefact. It really cannot be injected into it in a way that would guarantee it works with everyone in every situation, but certain things can be designed to increase trust of the user towards the artefact during interaction. Various options and different possibilities to make choices, selections and input things give the user more power and a feeling of mastering the device or system can foster trust if executed well. Exquisite elegance, attention to detail and a superb execution can make interaction more enjoyable. This offers a feeling of relaxedness which strengthens our trust towards the system (Maeda 2006).

8.2 Experienced simplicity

The users' experienced Qualities of Simplicity have been mapped to the matrix in *Table*

Table 15. User's timeline when experiencing interactive art.

6 in chapter 6 along with the designed qualities. It is worth recalling, that the experienced qualities differ from the designed qualities: the users' experiences will always differ from the designers' experience. For example, when the designer reduces elements, the user experiences clarity – he or she does not know what kinds of data or what graphical worlds were originally planned.

In *Table 15* different Qualities of Simplicity are mapped to the timeline of the user's interaction. An interaction process begins with using intuition to start experimenting somewhere. Soon, familiar things and behaviours are observed. Familiar things lead to tangible things, which afford the possibility of interacting with the system. We learn the ways in which the Interaction design affords us to use the work, perhaps trying out things which were not originally intended just to prove the point. After interacting with the system for a while, we start noticing how the interactive system has been organised. After this, we can notice the limits, its boundaries, what it contains and what has been left out, how the work has been executed, although as users we do not know all the options and possibilities which the designer has gone through. In the end trust (or distrust) is built between the system and the user, if it supports the previous mental models of the user, adding new material for the mental model to change, grow or expand — this happens both when the interaction experience is negative and positive.

I aim to address the importance of the different qualities in the construction of the experience of simplicity. Here I try to step into the user's shoes and understand how this experience happens inside the user's head (Colborne, 2009). Tangibility operates perhaps more in the realm of pleasurability than simplicity. We like to touch and understand things, and when things are clear they seem simple. As I mentioned, tangibility can be seen as the point of contact with the object or the system, as more or less bodily understanding. However, it is also an everyday experience which operates somehow unconsciously, and under various circumstances. Familiarity makes us more comfortable with a system or a product than plain tangibility. Familiar things are easier to identify than unusual things. Novel things and situations can perhaps arouse curiosity and adventurism and this can be very exciting, but it hardly adds to the experience of simplicity. Affordances take familiarity one step further, as the product or the system exhibits in its design what is possible, the users perhaps finding out new ways to operate with it.

As the product or system becomes more personal, and as the feeling of closeness increases, we can start trusting the system. Trusting a system or product leaves some responsibility for executing tasks to the product or the system, giving us more room to breathe, which helps us to feel

that the tasks are simpler. Organisation is needed so that the system appears coherent and understandable, and reduction of elements helps to clear the clutter and present the system as being as simple as possible. However, affordances and familiarity, not to mention long-term trust, cannot happen without the experience of trying something out based on intuition — trusting a feeling — which was successful. Intuition works on a subconscious level, but it is born after long and serious preparation (Löwgren & Stolterman, 2004) and in an interaction process, it guides every new situation before anything else kicks in. If the design fails to support intuition, the danger is that the system is never interacted with, or is interacted with in the wrong way.

8.3 Artefact simplicity — combining designed and perceived simplicity

One of the underlying ideas of this research has been the idea that the artefacts — interactive or not — can also exhibit or display the Qualities of Simplicity. The way the qualities are displayed can be seen as design goals for the designer, or points of connection with the work and experience for the end user. The point of view of an artefact nevertheless adds another layer to the way the Qualities of Simplicity are discussed.

The different ways the artefact exhibits the Qualities of Simplicity are collected in *Table 16.* In the same table, the main findings of this research about the Qualities of Simplicity from the points of view of the designer, the user and the artefact are also presented. Further, it introduces the concepts of Interaction modes or domains, which are discussed in more detail in the next chapter *8.4 Building complexity: three domains of interaction*.

In Interaction design, it can be said that the designers try to enable some kind of actions and perhaps aesthetic experiences for the users by designing the artefact in a certain way: embedding certain features into the artefact, leaving them out, organising them, using familiar conventions. The design expresses the designer's decisions. From the user's point of view, the artefact has qualities which can either aid or hinder interaction to happen. When the interaction flows naturally with no obstacles, the user experience is pleasurable, and the artefact feels simple.

Simple interactive artefacts express coherence and well-structured content. Artefacts

provide clear access points and ways of interacting. It is quickly clear what the interactive work is about, how the content is navigated and what is the scope of the interactive system. The artefact presents familiar interaction methods and interface components, and appears elegant overall.

Simplicity quality	Designer…	User experiences…	Artefact displays…	Domain / interaction mode
Reduction	Reduces elements	Clarity	Only the options which are needed	Real-time immersion / social interaction
Organisation	Organises physical and digital material	Coherence, logic	Well-structured content	Embodied participation / real-time immersion
Affordances	Creates preferred inter-action points	Consistency	Clear points and ways to interact	Social interaction / em-bodied participation
Tangibility	Creates visible and clear access points	Understandability, connection with the work	Graspable content and interactivity	Social interaction / em-bodied participation
Intuitiveness	Creates something which the raises the curiosity of the user	Interest, flow	Starting points for interaction	Embodied participation / real-time immersion
Familiarity	Creates identifiable elements	Connection with earlier works	Recognisable ele-ments and interaction methods	Real-time immersion / social interaction
Trust	Puts all her skills together	Trust	Elegance	All

Table 16. Qualities of Simplicity in relationship with the designer, the user and the artefact.

8.4 Building complexity: three domains of interaction

It would be foolish to claim that *Climatable* or any of the other interactive artworks presented in this research are be simple throughout. I claim that they all contain a lot of Qualities of Simplicity, which combined together create complicated, yet manageable systems. Thus, the research could also focus on complexity being built from simplified pieces. I have defined Interaction design as a physical time, event or action-based system, which takes place in space. Here I will study how the different Qualities of Simplicity in design together constitute more complex systems and could be mapped to more meta-level categories involving time, space, performativity, communication and physicality.

Although the Qualities of Simplicity seem to have a time-based occurrence in the design process (as argued above), they do not occur one after another strictly in a timeline. They cannot be used as a linear checklist for a designer, marking one thing done and moving to the next step. Design of an interactive system is a far more complex, iterative and cyclic process, and often even after the public presentation of the work the design is changed, details are fine-tuned, features even added, and some removed. In some cases, when designers undertake commercial work — often when releasing a new version of an existing product to the market — new features are more important than the improvement of product usability. Almost inevitably this means losses in usability since there are some changes to elements which have become familiar, some features have moved to different locations or are presented with new visual styles. New features bring in new learning challenges. This building of fuzzy complexity can also be something interactive artists crave for as they are showing the work for new audiences: they want to challenge the audience, tell of or display something new instead of improving interaction with the work. It could be argued, that by creating challenging interfaces artists are contributing to the field of interactive art — a position which I strongly oppose, as should be evident by now.

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Interaction is a process, in which the user is involved with her body and can make changes to the way the artefact behaves. To form a bond between the user and the artefact, trust between the two is needed.
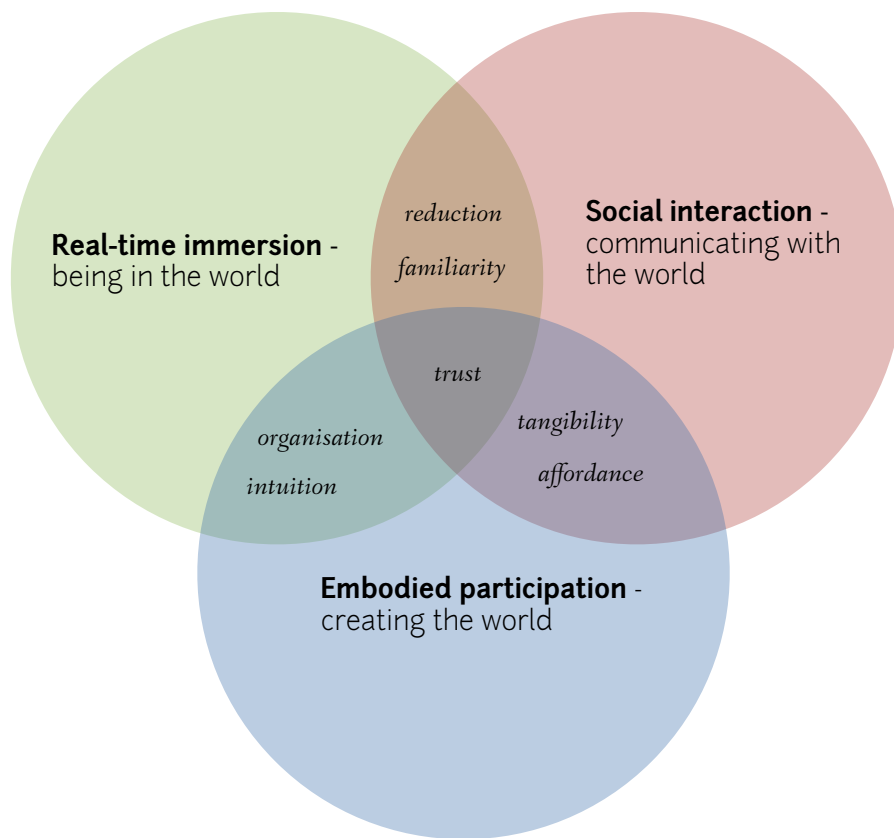
Figure 32. Modes of operation of an interactive process with Qualities of Simplicity.

In this thesis, the work has been changed so as to be easier to use between public presentations with the enhancement of the interaction experience in mind. I have focused on many detailed areas, improving them in order to distinguish different parts of the system — the complexity of the work is built up like a puzzle, with each piece receiving enough attention. A

simple user experience can be achieved, when complexity is shifted to the right place, building a continuity where each moment feels simple (Colborne, 2010). The main target in the end for me was to make sure the interaction flow has no hiccups.

But how can one design for interaction and what really constitutes the interactive experience? Using the Qualities of Simplicity presented in this research, three realms, domains or modes of operation of interactive processes have been formulated, which should be focused on in experience-oriented interactions. The modes are: 1) interaction as an immersive, real-time system between two operators, 2) interaction as a social event, 3) interaction as a performative and creative act. These realms can be found in more or less all interactive systems, although it is obvious that particular modes are emphasised more within certain systems than others. Looking at how they manifest themselves to the user, something can be revealed about the complexity of building simple interactions (*Figure* 32). These modes or domains do not have a set order in which they appear, rather they work side by side during the interaction experience. However, real-time immersion is seen as some sort of base for other modes. Social interaction situations, when interaction takes place through the idea of performativity, create three different kinds of roles for the user: spectator, operator and performer (Dalsgaard & Hansen 2008). In this research, the operators are discussed under the mode of real-time immersion, spectators in the mode of social interaction and interactors as performers when the mode of embodied participation is discussed. While the modes align rather well with the different user roles, it should be mentioned that besides the mode of social interaction, performative situations are of course social as well. The social interaction mode in this thesis is not reserved to spectators only, but discusses communication with the artwork and also other people — via and through the interactive artefact. Also the mode of real-time immersion is mostly discussed in situations that are not social.

8.4.1 Real-time immersion: being in the world

The first domain I look at in an interactive process is real-time immersion. Interaction is a time-based process. Real-timeness is manifested by system response or feedback to users' actions, which indicates that the system is up and running. The tasks the user executes are matched with system events, there is no noticeable or disturbing lack, the commands or controls

are answered. The user uses intuition to take the next step, and if all has been designed well, intuitive actions are predicted and mapped out. All the possible actions are reduced only to the ones needed, the system is organised in order for the human and the machine to communicate. When everything goes right, users are immersed in the system and motivated to explore the it (Löwgren, 2002). Thus, it can also be said that there are many simultaneous interaction loops: some which allow and require immediate action, some which require some mental pondering, and some which grow to be understood and reacted upon over time (Sellers, 2018). Re-al-timeness does not only refer to the fast action-feedback loops.

In *Climatable* planning and then later on constantly improving timing and the feedback that the system was giving was an important design issue. As the response time needed to be minimal, software decisions, even operation system version decisions, needed to be made. Restrictions to some graphical elements were made, some options were ruled out since they would have slowed down the computer too much. Data and graphics were organised and unnecessary elements left out, while on the other hand some details were highlighted by design. The way the sliders behave and how fast they reacted — and stopped reacting — was adjusted

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Real-timeness is a term for the various time-based interaction processes, which happen between the user and the artefact.

multiple times: from the first time the work was presented to after the last public installation had been set up and the first visitors in that exhibition had used the work. I made changes by judging a good timing which felt comfortable for myself and also based on user reactions and comments. The timing was designed to start immediately to answer the users' actions, but there was a small delay before the audio stopped and graphics disappeared when the interaction was stopped. Without the delay, the work would have seemed to behave in a jumpy way, muting the audio and hiding the graphics immediately when the interaction stopped felt uncomfortable. A small "sustain" or ellipsis as the interaction stopped seemed more natural than a full stop. Other things which aimed to communicate real-timeness even before the work was used were things that indicated that the system was functional: the circles rotated slowly and (in the last version) arrows pointed out where the sliders were positioned.

Immersion is a mental state, an experience, in which the person loses awareness of his/

her body, and the world surrounding it due to the elaborately simulated, other reality overtaking our senses (Murray, 1997). The machine and its world and the human and his/her imagination are merged into one entity. Immersion is a term often associated with interactive artefacts, such as virtual reality, and especially video games, but is also often discussed in relation to more linear and passive activities such as television watching and book-reading. It is often applied to media art installations, which fuse various human senses, though not all media art installations are immersive by nature (Grau, 2003).

Feedback and a good experience of flow are crucial for creating an immersive experience, which is built up over time. There is a danger however that immersion is lost if the system does not provide interesting new changes in data, interaction flow or story. When the participant's skills are balanced with the interaction difficulty, a flow-like immersive experience is created (Thon, 2008). The interface or interaction

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Designing for immersion can also be seen as a possibility to lengthen the interaction time for easy-to-use interactive works.

should not be thought of as separate from the function or the content, but rather disappears, blends in and becomes the content (Bardzell et al., 2010; Hassenzahl & Tractinsky, 2006) This creates a possibility for the visitor to focus on something, and to be involved completely in an interactive system. During this process, casual visitors, watchers, or listeners can become users — hooked on to the system. The flow-like feeling happens after the users' intuition has been supported. When the system behaves in a way that the user has predicted, the user feels that he or she is in control, and the satisfaction guides the user to want more. So, intuition retreats to the background and familiarity steps in: the user can contextualise and understand the system and its behaviour, its control and manipulation.

Pleasurable, playful and seductive interfaces, and interfaces which guide interaction are important themes in the field of Interaction design (see e.g. Khaslavsky & Shedroff, 1999; Lucero et al., 2014; Löwgren, 2002). Playfulness requires a user being immersed with the interactive artefact, in a certain context and situation. This emotional bond with the work is born even when simple systems are used. When a system corresponds to intended actions without delay, behaving as expected, trust towards it is increased. Without trust, there cannot be any immersion.

In my observations of *Climatable*, I consider that the users who spent a long time with the work, trying out most interaction points, had a stronger degree of immersion than the people who only observed the system or tried out perhaps one point only. The installation space and physical design of the table were also important in enhancing immersion — helping to forget that one is in a gallery place. In my works Almost Famous and Wish You Were There? the users see themselves through a video mirror image, and adding graphical elements, photographs, sound and movie clips to the live video in many layers makes the image on the screen more interesting and strengthens the virtual (immersive) realm.

Real-time immersion is linked with social interaction reduction and tangibility. Immersive experience becomes reduced, when it is communicated to others. The communication needs to use familiar patterns to avoid confusion. When users interact with the work and communicate parts of it — perform it — to others, they organise it in a new format, following their intuition to create new connotations and expressive possibilities within the interaction. This can only happen after gaining understanding, which is born via real-time immersion.

The feedback must be organised well in order for the immersion to grow. Performative participation can also be thought from the viewpoint of organisation: performing the piece is about organising it in a new way by the operator-performer. The operator, as well as the performer, uses intuition to advance in the interactive situation, turning real-time choices into meaningful actions and observable events. Finally, real-time immersion is linked to the two other modes of interaction by creating and supporting trust: we trust a system which lets interaction loops to emerge.

8.4.2 Social interaction: communicating with the world

IMMERSION IS ALSO RELATED TO NARRATIVITY, although the work necessarily does not tell a certain story. The "story world" is an immersive surrounding, which is born from the actions and reactions of the participants with the work. Exploring the world created by the interactive artefact creates a communicative situation. At its minimal level, communication happens only between the user and the system. The traditional Interaction design idea provides that communication is a two-way process when the designer's decisions — the interactive options in the artefact — are understood and acted upon. However, each user interprets, communicates

and in this sense also creates meaning individually, in the specific context and situation of the interactive event (Dourish, 2004). According to Dourish, instead of developing ways to use interactive artefacts, the Interaction designer should aim for artefacts which can not only accomplish tasks, but which can be moulded for different tasks — the users will determine the ways in which artefacts work (Dourish, 2004). This idea is easy to connect with the idea of performativity, but in this chapter, it is worthwhile to study interaction as a playful, explorative and communicative practice. Interactions which evoke curiosity and social ambiguity arising from the interactive engagement all serve as methods for creating communication between participants, and ultimately explorable playful situations (Hobye, 2014).

When creating for social interactions between multiple users the context has to be taken in account (Dalsgaard & Halskov, 2010; Hummels & Dijk, 2015). While social collaboration, communication and cooperation clearly is present in Internet services, social media, gaming, work life, and even television programs, public spatial and physical collaboration differ from computer or smartphone based social interaction. In interactive art installations such as *Climatable*, the environment changes not only by introducing physical, textual, graphical and audio-visual elements to the space, but also due to the possibility to interact with and through media. This can

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Designing for social interaction is designing for a playful interaction space for the participants.

happen both while interacting with the work and not interacting at the same time, the former way creating a communication bond between people. Different exhibition contexts also create different social situations — different audiences, different expectations about the work for the participants, and also different social relationships. Also the public setting brings forth the role of a spectator: someone watching other people using the work (Dalsgaard & Hansen, 2008) The diversity of situations is worthy of exploration by the designers (Dalsgaard & Halskov, 2010).

Also the artefacts bear social meanings and values. *Climatable* is recognisably a table with a tablecloth, and the sliders used for interacting with it are also familiar to users. Building on familiar things facilitates engagement with the artefact (Hornecker, 2006). Also the physical and spatial design have been considered carefully in *Climatable*: the size, the form and the location of the table in exhibited spaces have been designed to guide people towards interaction, to

enable multiple access points. Overall observation of what is going on has been made possible, control is distributed and the design lowers the threshold for interacting, all to facilitate social interaction (ibid.). Spatial relations affect our perceptions of a setting (Hornecker & Buur, 2006).

Climatable is designed to be used — and observed — by many persons simultaneously, allowing a social situation to emerge in which users can play around with the artwork it together. I observed situations, where people engaged with the work in pairs or groups: exploring, jamming, playing, hacking. An often-observed example was when two or more users tried to synchronise the year in each hotspot or to make the work as loud and busy as possible by finding the highest values. There was an amount of ambiguity in *Climatable*: the climate change information was not presented to be processed cognitively, but rather to be experienced emotionally. Also social ambiguity was present — there were no exact rules of how to interact with others, or if and how people should collaborate. There is a need for social meaning-making in collaborative interactive situations, when the artefacts and its surroundings don't match perfectly (Hobye, 2014). It should be pointed out however, that the design process of *Climatable* did not
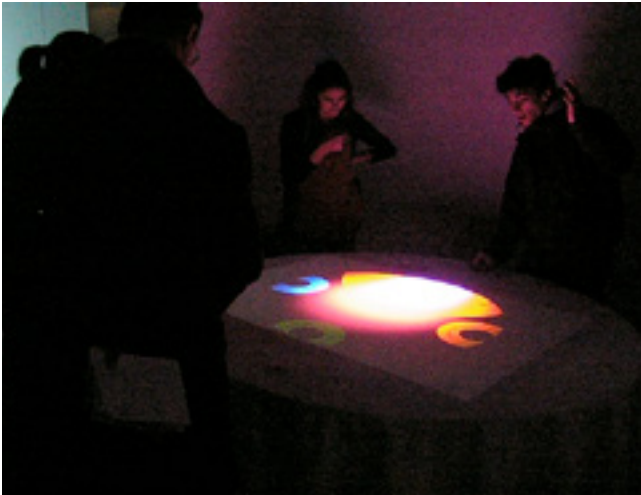
Picture 15. Using Climatable creates emotions.

aim for ambiguous social situations or creative collaboration — although the initial idea before the process began was to create a collaborative visual music instrument. The design process focused on simplicity, emotionally experiencing the effect of climate change and audio-visual immersion. The social and performative aspects were emerging aspects which were observed and analysed as the work was displayed in public.

When thinking about social interaction and real-timeness, the aspect of reduction is important: communication happens only using certain features of the whole, and reduction makes it possible to bridge between being immersed (an introversive action) and communicating (an extroversive action). This is also true with familiar things: they on the other hand attach us to the artefact, but are something which or with which we can communicate to others, since they are things which are most likely shared by other people.

Understanding something new is related to tangibility, and this can lead not only to communication, but also to performance: new and interesting features are pointed out and also improvised with, handled, presented, explored and experimented with. Communication and performativity is also about executing things. Different things afford different ways to communicate and to create and perform new meanings and ways of operation. From the social interaction point of view trust is needed in order for the communication to be believable, allowing the system to create its own interaction space, against the backdrop or the context in which the artefact is presented.

8.4.3 Embodied participation: creating the world

There is also another kind of satisfaction in using interactive artworks: the satisfaction of creating or achieving something — of performing with it. This pleasure derives from the fields of tangibility (touching, manipulating, understanding something) and affordances (i.e. the system allows the user to do and create something, participate in something, change something). There is a moment in the documentation of *Climatable*, where a teenager knows what is going to happen and explains the system to his friends around him. He moves the slider of the global mean temperature interactive spot, speaking the years out loud and as he reaches the last ten years and the warmest year which sounds and looks totally different he raises his hands up like a winner (*Picture 15*). This is obviously a performative act. The experience is also about claim-

ing authority towards the interactive work, a personal expression. The teenager feels he has founds something interesting about the work, created something new. Another observation was when a father explained very thoroughly to his child what the numbers, graphics and sound meant and how this reflected climate change. He used the interactive work and its contents as an educational tool.

Social and spatial design creates a public performance space (Bardzell et al., 2010). The users are observed by others, and as they are aware of this, interaction with the artwork becomes a performance, an act of self-expression, as documented in *Picture 15*. After a longer interaction loop, patterns, new features and possibilities start to be observed. In *Climatable* the users of the artwork can seek out different types of details from the work, make connections between the datasets and their lives, and create audio-visual compositions which they enjoy. These are the moments when users start to become creators, creating new meanings and connotations in their work.

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As the user interacts with the system, he or she learns new things from it, learns to use it in a certain style. This creates a new world between the user and the artefact. In public settings, this interaction is often performed.

We are constantly involved with everyday interactions, in which we know instinctively what to do. Digital interaction involves moving beyond the computer or the mobile phone screen, and gestures, arm, leg and eye movements, gravity, body motion and other multidimensional and multi-sensory methods can be incorporated to context-aware devices. These kinds of interfaces increase the performative aspects of interaction.

The challenge of building new digital interaction systems is that we cannot always use the things learned in real life as a guide. Interaction design creates experiences which happen in between physical and virtual worlds. (Ehn & Löwgren, 2003). Incorporating or mapping everyday actions to digital domain is not always an easy task to do. When designing physical and spatial systems and their interactions, tangibility and affordances should be taken into account, especially in social and communicative situations.

An art viewer is enclosed and embodied by an installation artwork. To experience it, one must move around and inside it, sensing the artwork from multiple angles. Thus, experienc-

ing even a non-interactive installation requires physical participation, which can be seen as a performance in itself. Installations are also often non-linear, they do not have to have a beginning or an end or a set goal, and they can be viewed for an indeterminate period, at any suitable time (Koski, 2007). In interactive art, the artwork offers tangible interaction points, and the participants' physical action trigger the work, they make it happen. The participants also decide the way or order the work is revealed, and each of them re-creates — not only experiences — a new path, chronology or linearity to the interactive artwork. This navigation can also exist in artworks in which spatiality is conceptual or virtual (Rokeby, 1998). An interactive installation could be a combination of all of these: a physical navigable space, a virtual navigable space and a conceptual navigable space. *Climatable* is a combination of physical and conceptual structures: first, it is a round table which the visitors can walk around, observe each other or participate in interaction. Second, each interactive point consists of a simple conceptual navigable structure: a timeline of certain scientific measurements.

Trust must also be taken into account when designing physical interaction. When users perform physical actions, they believe they will have an effect on the system. The boy using *Climatable* mentioned and illustrated in the documentation above had already learned something about the system and by trusting the system could also know what the causes of his actions were going to be. So did the people, who explained the system to others, or explored all possible datasets.

9 Discussion

THIS CHAPTER PRESENTS THE MAIN FINDINGS and observations of the research. This study has presented a constructive design research journey, in which theories of art have been augmented with Interaction design practices so as to be able to take the active user of interactive art into account. The concept of simplicity has been defined with a set of qualities (*Figure 18, p. 104* in chapter *5.2 Qualities of Simplicity*). Interactive art examples have been analysed from an Interaction design point of view by showcasing how different aspects of design create simplicity and affect the interactive experience (spatial, physical, audio, graphics, programming interactivity and information design). Simplicity has been thus regarded in this research both as a quality which can be experienced and designed — and is situated in the interactive artefact (*Table 4, p. 107* in chapter *5.2 Qualities of Simplicity* and *Table 16, p. 188* in chapter *8.3 Artefact simplicity — combining designed and perceived simplicity*). Examples of the Qualities of Simplicity in *Climatable* — the artistic part of this research — have been gathered to a Simplicity Matrix (*Table 6, p. 155* in chapter *6.4 The Simplicity Matrix of Climatable*). The validity of the Simplicity Matrix has been evaluated by analysing user research results in relation to three different interactive installations. Based on these findings, some ways in which interactivity

operates are presented, together with comments on how Qualities of Simplicity help construct these methods or domains.

9.1 Interaction design meets interactive art

IN THIS RESEARCH, IT HAS BEEN suggested that interactive art profoundly changes the view of art as a discipline. In the traditional view art happens in an art world, and centres around the active and creative artist and the passive observer: viewer, listener or audience member, whose participation is mostly mental, sometimes spatial, hardly ever physical. The feedback loop — if there can be recognised such a thing — between the two is very weak. Historically speaking, the break away from this kind of narrow view of art began long before there was any computational interactive art. Avant-garde art groups such as the Futurists, Dadaists, Situationists, Fluxus, and artists working with the Black Mountain College in 1940's and 50's created art and art events inspired by everyday life, using popular culture and mass media material, and often trying to break the distinctions between life and art, and who is an artist and who is not — at least in their philosophies and manifestos (see e.g. HAGENER, 2007).

Later on, participatory art encouraged people — locals, young, old and everything in between — to engage in actions together with, or guided by, artists. These actions include collaborative painting and sculpture making, creative discussions, performances and happenings. It is worth noting that this kind of participatory art has existed for quite some time, and there is a continuity to which interactive art can be tied to. The artists working with audience participation have created situations: possibilities for actions to take place for the participants, in a similar manner that an Interaction designer or an interactive artist creates possibilities for interaction. Similarly, the focus could be targeted towards the interactive artefact. Thus, the end result might be an interactive system, but its properties can be analysed without the user — or even without the designer.

It has been claimed that HCI methods cannot be used to evaluate art, and difficult interaction is perhaps something artists want to communicate. Many interactive artists do not need to consider about what happens when the work is put to the public — whether the works are understood or not, or even used or not (PAULOS, 2007). This research takes an opposing position. Interactive art differs profoundly from traditional art. Artists who don't take their audience into

consideration make users frustrated and disappointed, if the means for interaction is not understood. Interaction is an affective and emotional process, in which the users try to make sense of the artefact (Spillers, 2004). Interactive art has much more to offer than frustration towards interfaces, interaction and technology.

The research situates interactive art under the field of Interaction design, as an explorative practice carried out by an Interaction designer. Not all interactive artists are Interaction designers, but the position of this thesis is that they all should take into consideration what Interaction designers do: namely, take the user into account in their work. Interactive art becomes alive with its usage, and ignoring this is just not an option. This research looks at designerly practices in creating interactive art and concentrates on the concept of simplicity in lowering the threshold for participation in interactive art.

9.2 Simplicity – user, designer and artefact

Simplicity as a term in design research has been used quite vaguely. In this research, it has been defined to consist of six different qualities. These qualities are grouped into three categories: 1) formal qualities: reduction and organisation; 2) functional qualities: affordances and tangibility; and 3) conceptual qualities: intuitiveness, familiarity. In addition, trust is a discussed feature or quality, which can be born if the previous qualities are well constructed. The qualities have been combined from terms, which seemed to reoccur in various design guidelines. The qualities were collected from various sources and their relevance judged by analysing other interactive artworks, interviewing interactive artists and from observation during the constructive design research process of *Climatable*. Some other researcher or Interaction designer would probably use (and surely have done) a completely different set of qualities. Nevertheless, the way simplicity has been defined in this thesis is unique and can be seen as a useful set for others as well. I find that my chosen set of qualities to contribute well to the discussions of simplicity, complexity, and interaction aesthetics. Further research and discussion will most likely happen in these areas, as well as in the areas of simplicity and trust, and simplicity and user experiences. Finally, it would be really interesting to research the role of simplicity in relation to fun and playfulness within interactive systems and artefacts.

This research has shown that it is important to discuss simplicity from both sides of the

coin, as well as discussing the coin itself. We must take into consideration knowledge from the user's side, the designer's side, and the artefact itself. It has been possible to use the qualities related to the actions a designer can or should carry out, as well as the experiences the user could or should have. This duality and its relationship to the Qualities of Simplicity has been mapped in *Table 5, p. 126* in chapter *5.4 Simplicity and complexity*.

If we consider simplicity as an aesthetic quality of an interactive artefact, knowing about how it can be designed and how it is perceived in different contexts will help in describing it more clearly. In the interactive artefact — especially interactive installations — the aesthetic quality of simplicity should be considered from many aspects of design: spatial, physical, aural, visual, gestural and conceptual. Interaction design as seen in this research is very much a practice of handling both real and virtual space, managing time-based actions of triggers, feedback, and animations — guiding the interactivity to correct locations, in correct time and space. However, user experiences — as well as the experience of simplicity — will vary based not only on the appearance and user interface design, but also due to the various contexts of use: socio-cultural context, time and historic context, physical use context and even market context (Jääskö & Mattelmäki, 2003). The Artefact Functions differently in different contexts, and thus its interaction aesthetics can be studied separately. The argument in this research is that it holds its own knowledge. By talking about the three different types of knowledge, the research can bring additional insight to designer- or user-centred creative methods.

9.3 Simplicity Matrix and its evaluation

After establishing simplicity, I started constructing a matrix, locating Qualities of Simplicity in my interactive installation *Climatable*. I was able to find design solutions for all the different qualities. As an iterative process, things found at this stage also affected the design, and many things were improved. The matrix could be then updated. At some moment, the discussion about simplicity in the research was still a bit hazy and there was a need to discuss simplicity from both the sides of the user and the designer. I started updating the matrix with details of how simplicity was perceived. Making these changes contributed fundamentally to the research — the idea of simplicity as an aesthetic quality of an artefact, which can be designed and perceived finally was concrete.

In order to prove the Simplicity Matrix to be a more universally valid and usable tool, a user research study was made with three different interactive installations. All of them were found to be fairly simple to use, but what is more important is that it seemed that the Simplicity Matrix and the Qualities of Simplicity can be found in interactive installations and their role in constructing simplicity experience was proven. A different type of questionnaire or user research — an interview based perhaps — could reveal what kind of designed qualities can be found in the installations and how they help construct the experienced simplicity.

The Simplicity Matrix enables thinking about interactive artworks from many sides: graphical, textual and audio media material, spatial and physical design, and the way the interactivity in the software was built were all considered and analysed both from the perspectives of a user and a designer. Using and evaluating the matrix can help to illustrate problems in the design of an interactive installation or the reception or usage of it. The matrix can also be useful during the planning process, as a checklist of various aspects to take in consideration in the design as well as during the design process, as a heuristic review tool to find out if the design decisions which have been made are valid.

9.4 Three domains of interaction

To broaden up the Qualities of Simplicity towards interactive art and design in general, three domains of interaction were presented and discussed. I see the modes of operation as basic ingredients of any interactive process. Real-time immersion: the interaction happens here and now, and continues over time in a time-based process. We participate and interact with varying degrees of immersion, becoming one with the system. Social interaction: using the work to communicate meanings to yourself and to others. Playful, collaborative activity. Embodied participation: we use our physical and/or virtual bodies to participate, interacting is a mental but also a physical activity. This physical activity is also about performing the work, making new discoveries and presenting them. The last two modes are increasingly important in spatial and physical interactive situations, which create social encounters and exploration. It was noted how different Qualities of Simplicity support different modes more strongly than others.

The three domains are both designed and experienced. Designing interactions is about creating ways in which the interactive artwork functions, to create possible activities in an in-

teraction space for the user, the observer and the performer. Interacting with the artwork allows for understanding of the affordances created by the work — and ultimately by the designer — and doing something: activating, selecting, navigating, exploring (Kwastek, 2009). Put simply, the user is participating in the world mediated by the artefact. However, interacting with an artwork in a public installation is in itself a communicative and performative act in which the users reclaim the work and give new meanings to and with it.

9.5 Personal reflections

In the beginning, I thought I would be able to answer a problem which has troubled me in many interactive art exhibitions: bad usability, overly difficult interfaces, messy complexity. As some solutions to these issues were found, the focus shifted more towards the field of Interaction design. I got interested in the aesthetics of interaction form, but realised that what for me was more interesting was the multi-sensory aspect of interactivity — the interaction happens over time in a physical space, and in an interactive art installation context, detail should be given to the physical world as well as the digital software. The process also began with quite a simple view of interactivity which can be observed throughout this research: the division of the creative artist or designer and the user in to two different modes of knowledge, that somehow meet via the artefact's functions. This can be claimed to be an old-fashioned view of an interactivity, since different public contexts encourage users to communicate and perform the work. The separation of the two roles has helped to take a look at the Qualities of Simplicity from two different viewpoints: how they are designed and how they are perceived. However, in this research the discussion has not been guided towards playful or explorative interaction, or designing for prolonged interaction with more complex or flexible systems, aside from in the previous chapter.

My interest, which began in the field of art, especially interactive art, has shifted during the long research process. The research process in this thesis has personally been a journey from an interactive artist standpoint to an Interaction designer working with art installations. The original idea of making interactive art easier to use has resulted in an artwork which was iterated in various occasions and in relation to Simplicity Matrix, which looks promising to use as an Interaction designers tool. Learning to jump across the fields of design and art, and review

the whole process in an academic research setting has not always been easy. On the other hand, my work as a lecturer of digital media at the University of Lapland contains courses about media art and courses about Interaction design, so art, design and research into them are more or less familiar to me. Also, as I have been working on this thesis as a side project to my work as a lecturer the process has been very slow, and sometimes it was even hard for me to understand what parts of my earlier written text were discussing and how they were related to the material I was processing at the moment. Rewriting has taken place in some sections more often than others.

Although the term *user* sometimes has negative connotations, I have decided to employ it in most of the occasions in this research, hoping to focus on the actions and activity of the art viewer, which ultimately create the interactive art experience. The term participant is also present in the research, but for me, its connotations are more varied than the term user, and it allows very passive roles as well as active ones. For simplicity's sake, in this thesis, I have given the users a pretty narrow role. I have not really discussed how they are different and unique human beings with different behaviour patterns, beliefs and experiences with interactive systems. I have assumed, that they will be hooked to interaction almost mindlessly when the design is accomplished to a high degree. I also assumed that correct design solutions would be able to fix most possible problems. However, for me especially in this research, what has mattered most is not who the users are but the way they have understood how to use the designed artefact. For me as an interactive artist, this is something I aim for and supports my concentration on the artefact.

I have often worked as an interactive artist, creating and presenting installations which are meant to be touched, moved, handled, triggered — in one word: used. Many times the artworks have offered ways of operation, which are already common in everyday usage, but bringing these actions to a new context or making them execute a surprising result is something which has interested me as an interactive artist. A guideline I have followed when creating my own works has been that the user should not need to read and understand any instructions, it should be obvious what to do for him or her. On the other hand, on some occasions in my work there have been instructions, typically embedded to the visual interface — e.g. text: "Call number ### to create a virtual flower" displayed on the screen or on a projection. Also, a common practice for me is to observe if people "get it" — understand the way the work should be used or not. If there are problems, I try to fix them on site, adjusting the work to make it function better, or at

least make changes for the next installation occasion. It is often curious to see if the audience is willing to try the work or not — unfortunately, it seems that most of the art audience is still not accustomed to touch, talk, jump, crank, push or try things out even in an exhibition full of interactive art. I have not always succeeded — especially when the work is put on display the first time, I have noticed problems with interaction among many users. Some changes are needed, and it is difficult to admit to yourself that it is not the users who are to blame, but you and your design. Something should be fixed. This is a typical process in design, iterating to get things right.

There was no qualitative survey, which would have gathered data on how simplicity would have been explained or what kind of qualities the users would have labelled. However, with the user surveys on the Simplicity Matrix and even with observations in each of the installation cases, I could gather data about the user experience. As I was observing, I could see people who were just not interested or who were even too scared of trying out an interactive installation.

I have used interviews, observations, feedback and user research to learn about the relationship of users towards an interactive artefact. Sketches, reflection and self-reviews have given me information on the artefacts themselves. Iterated design, exploration and experiments have guided my designerly creation process. There are a lot more tools available to help artists and designers to understand users, the work and the creative processes. For the sake of this research, I see my methods as adequate and supporting my main claims. In the end, I stand behind my design philosophy: the designer's knowledge, which is articulated in the artefact knowledge contains knowledge of user behaviour.

9.6 Future work

There are many possible paths for future work. All of the main findings can be iterated and improved: user studies or interviews could be made to redefine simplicity with a different set of qualities, or to gain more precise information about how and why the different qualities function and co-function. The Simplicity Matrix as such can be used for different kinds of design and interactive art artefacts and manipulated or expanded by others. Interaction models and the three domains of interaction should be discussed further and tied up with the notions of

designer and user knowledge and the Artefact Functions more closely. All in all, a discussion of interaction aesthetics should be continued.

One interesting thing for further discussion would be the presentation context of the interactive artwork: how does the location, time and place where the artwork is presented change the user experience? Physical installations (especially interactive artworks) are typically put up in spaces such as galleries and fairs, that hold connotations relating to how to behave, or observe or perform, distanced from everyday life and its actions. They offer experiences in which the users can immerse themselves: in other words, separate themselves from the real life. The context makes the experience of the work different: the same installation can appear as an exhibition object in a science centre exhibition, a public space interactive installation to test out or to entertain, or an interactive art gallery art object. This was true for my *Climatable* installation. In this thesis, this discussion is mostly left out since I did not think it would bring about more information about simplicity, but it does have an effect on the way the content is understood — the tangibility of the work. Also, the attitude towards interactive things in general is different not only because different locations have different audiences but also because certain kinds of things are expected to be in different places: science centre exhibition objects are often interactive, but in a public foyer the interactive work is more of a distraction, which people want to pass by quickly.

The Qualities of Simplicity or the Simplicity Matrix have not really been challenged by other Interaction designers or interactive artists, as the research process has mostly been written as a monograph, and no further studies on their acceptance in the design community or suitability as design tools in different cases have been made. They have nevertheless helped me understand and improve my own creative work and guided analysis of other interactive work, which I respect. In the future, I hope that the Simplicity Matrix can be used, iterated and evaluated, benefiting and generating discussion in the interactive design and art communities.

Future research could also be targeted to works, which are location-based and towards creating art which is context-aware, art which knows something about the people using it and can adjust itself based on its location, time, surroundings, and ultimately the user. This way the immersion, real-timeness, social and embodied participation of an interactive experience could be tailored for the user. What would be the role of simplicity in a system, which learns new things? Can a system, which adapts to our needs be experienced as an interesting artwork? Perhaps it would be more interesting to talk about a system which adapts to the user's performative

and communicative engagements.

Another aspect to further research in the future is the relationship between simplicity and complexity and how complexity can support the fun and enjoyment of interacting. Any interaction, which wants to build a strong connection between an artefact and a user needs complexity. As I have argued before, simple pieces can construct more complex patterns. With simplicity in mind, one interesting field to compare Interaction design with is game design. Most games become boring quite fast if they are too simple or stay at the same level without ever really challenging the user skill level. However, too complex requirements on dexterity or near impossible puzzle-solving can also drive away most gamers. So do confusing game interface design, controls which do not sync with what you see on the screen, a poorly executed camera following the player — all examples of fuzzy complexity. It is interesting to think about the role of simplicity in a gaming environment: on the other hand, games typically teach the player how to act: the player's character learns new skills, finds equipment, which helps him / her / it on the journey, makes allies with other players or game characters which allow the character to take on the big boss, discover hidden places, access hazardous areas. In other words, the difficulty level rises. These are all typical examples of puzzle complexity, which builds from smaller building blocks. The interaction possibilities and the speed or phase are typically altered: You gain more skills or items you can use, but there is less time, the things move faster, the required dexterity and the enemies to defeat get more difficult during the game flow. Designing for fun in games surprisingly involves designing for struggle or failure, for complexity and for uncertainty. The player wants to try again once more, perhaps succeeding on the next try. On the other hand, game design also involves positive things such as captivation, discovery, fantasy and sympathy (Costello & Edmonds, 2007; Lucero et al., 2014).

It should be clear that not all Interaction design artefacts or interactive art needs to allow for exploration, to be playful or game-like, but some features which make things playful are good to keep in mind. Again, it is worth noting that this it not be the aim of interactive art to build hard to use interfaces — but perhaps to allow many ways to experience the same thing, to make it possible to discover new content, and perhaps to allow for trying out different ways of interacting with the work. Ultimately, in games we as players accept the fact that there are rules and unnecessary obstacles, and fun really is derived from the fact that we try to overcome these boundaries, learning how to behave in the (game) world. If we agree that this takes time, and we need to overcome certain barriers to proceed in the game world, perhaps we can say simplicity

in design is a key element which allows the exploration to begin in the first place and lets the journey be enjoyable, but that the game design or the game world should be complex enough to keep the players' interest up.

Further work could also be undertaken into the reception of art— how do experiences which interactive art offers differ from more traditional, passive art experiences? Instead of listening to music an interactive art installation can make you produce sounds on an electric or even physical instrument — a listener becomes a musician through interaction. The act of seeing a movie or theatre play where the main character has to sacrifice his or her child to save the planet is very different from the act of having to do this yourself in an interactive medium — e.g. in a game or a story told with virtual reality technology. The point here is not that the interactive experience would be better or even stronger — it is different. The pleasurability of interacting sometimes conflicts with the content, as in Matti Niinimäki's *Infinite Loop*, with which we began this research paper.

10 *Conclusions*

THE PROCESS OF CONSTRUCTIVE DESIGN RESEARCH has been fruitful for me in improving the simplicity of interaction of my installation *Climatable*. Observations, learning from users' knowledge and, on the other hand, developing the designer's knowledge have improved the work as it has been displayed. I have managed to explain simplicity in a way which also helps me to define and discuss other interactive artworks. However, I have also found some limits and boundaries regarding the topic of Simplicity. It was and still is a difficult term to explain, and it cannot be labelled as if applying a sticker to a given product or service, even though many of its qualities were identified and fulfilled. It can be misleading in situations that require complex actions or patterns, or when cultural conventions do not match the designer's intentions.

The concept of simplicity was defined and used as a guiding tool for the design process, but also as an experienced quality. Using Qualities of Simplicity as a guideline, I developed a designer's toolkit — the Simplicity Framework, which was filled as a Simplicity Matrix. A questionnaire gave some insight into its possible beneficial value to other Interaction designers and artists, but it is difficult to say how useful it will be. Further studies can help develop the toolkit:

the qualities can perhaps be different in e.g. service design, game design and product design. It would be interesting to know how and when to use the qualities during design processes and how to judge if simplicity is achieved.

All in all, this research paper has documented the various phases of the journey, different and alternating interests, new findings and theoretical discoveries. For me, the main interest in simplicity has never faded, rather I have found more support and evidence that is important to take it into consideration when designing interactive artefacts. It has been difficult to define what simplicity is in relation to the field of Interaction design: it can and has been discussed as a design practice, as a method, as an attribute, as an aesthetic quality of an interactive artefact, and as a combination of these. In this research, it has been used as an intended use quality and a designable goal, and as a quality which can be experienced. The constructive design research method is designer-centric, and supporting the user side of experienced simplicity was crucial to understanding the concept of simplicity more thoroughly.

As users of interactive art and artefacts are active entities, they create aesthetic experiences for themselves. Modularity and expandability are things which would function very well in interactive art, and creating platforms which allow for self-expression and co-creation is something to be encouraged when creating interactive art experiences. However, when creating these, simplicity should not be forgotten. The focus should be on how many different options are present at any given time for the user, how the participation possibilities are organised, what kind of participation the artefact affords, and whether the participation possibilities are familiar, tangible and intuitive. These will open doors for being, creating and communicating with the artefact.

The interactive artist wears two or even three hats at the same time: the hats of a designer, of an artist and of a user. An artist looks for new ways of expression, new ways of communication, new ways to interpret the world, and invents new possibilities — for an audience: the art world, for his or her fans, friends or family, for him or herself. The motivation for this is mostly personal. The designer tries to make the existing world better by designing better things, interfaces, systems, services — typically for other people: users, participants, consumers, clients. It is also important to think not only through an imaginary user, but also how the interactive artefact creates the users. It is an exaggeration to say that Interaction designers are interactive artists or vice versa — a large part of Interaction design is done for clients, not meant as an expression of the individual. Perhaps it would be more accurate to state that Interaction designers often need

to explore new interaction possibilities, new materials, services and systems — to step into the field of the unknown often attributed to artists. Similarly, interactive artists must care about their chosen methods, materials and expressions: physical materials, media materials, interface design and the spatial and temporal forms and aesthetics of interaction, designing them in a way that makes participation possible.

Simplicity in design research and practice literature has been ambiguously used, often explained as an entity which everyone should already understand and know how to execute in design innately. However, this research shows this is not the case and defines simplicity from one point of view. The simplicity of putting together small building blocks or puzzle pieces has been seen as a key to building more complex interactive artefacts. If the knowledge of how to use an artefact emerges from smaller, well-organised units, which are familiar and understood, simplicity works and trust is forged between the artefact and the user.

The research process combines Interaction design and interactive art practice together under the concept of Simplicity. In the future, I hope the Simplicity Framework and the Simplicity Matrix will be tested, with their weak and strong points brought to the fore to improve upon them. Further discussion on simplicity and complexity is encouraged, as well as for research on different aspects of the aesthetic experience of interactivity. Interactive art and its usage keep raising an important question: how does art function? Let the discussion continue.

Appendices

Appendix A: Email questionnaire for the interactive artists

This email below was sent to the participating artists of the Saa osallistua! / Please participate! exhibition and also to the organising team.

2011/3/25 tomi knuutila <tomi.knuutila@ulapland.fi>

Päivi, there hasn't been discussion about any publication related to LiveHerring (3 exhibitions) or this exhibition (*Saa Osallistua! / Please participate!*). I thought we make collaboratively a press release and/or a short 3-5 page pdf with a very brief documentation about each of your works. For that, I'd like to ask you a few questions. I can compile the end results into a press release, put it up on the LiveHerring website etc. So it will become a sort of a mini-catalog/book of the exhibition for you to keep also.
Also for the pdf I would need photos of the work, not all of you have sent me these. I guess a self-portrait would <be nice too. photo, hand-drawn picture, your favourite amoeba or whatever you want.
I suggest we do it in English, there really is no time to translate, and since we have a few non-Finnish speaking people in the group it would be polite.
Also, I'd like to use the results / your answers (anonymously if you wish) in my PhD, which handles possibilities to make interactive artworks more user friendly, mainly my solution is simplicity. In the thesis I am presenting and reviewing and discussing my own artwork, but also interactive artworks of others and also trying to get support for my main clause (basical-

ly: interactive art should be simple enought to use) by doing the traditional academic jour-
nal-and-book-commenting research and also by doing interviews with you guys. I can tell you
more about that later if you want are interested.

So can I use your answers in my PhD work? Yes [ ] No [ ]

Do you wish to remain anonymous? Yes [ ] No [ ]

I'll fire this press release thing up with two sets of questions, 3-4 questions at a time. If you
want, you can reply to all so you kind of get to know other people and their thoughts before the
exhibition too and perhaps also comment on each others comments. You can make your answer
short or long, whatever you prefer. I know most of you are busy with all kinds of things, but this
is really the only way we can collect material for the pdf-catalog.

1. Tell us a little bit about yourself (background, studies, work excperience, other artworks
you've done etc).

2. Tell us a little bit about the artwork(s) you are showing at the exhibition

3. Please describe briefly how your work is used, how does the audience participate / interact

4. How does the fact that there is audience participation / interactivity in your work change
your artwork or working methods?

Thanks in advance! I'll ask a few more questions when I read your answers. Less than two
weeks for the opening!

_____

Tomi Knuutila

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Appendix B: Simplicity Framework and Simplicity Matrix questionnaire

This is the questionnaire used to find out how Qualities of Simplicity work in Climatable and in other artworks. For each questionnaire, the name of the work, the creator, the display location and study conduction details were changed.

Questionnaire about interactivity in art

This questionnaire is related to Mr. Tomi Knuutila's PhD dissertation at University of Lapland, Finland. Answering takes 5-7 minutes. The results will be published as part of the research. You will remain anonymous. Any comments can be asked vie email: tomi.knuutila@ulapland.fi

Thank you for answering!

Name of the work: __Teacup Tools__

Created by: __Agnes Meyer-Brandis__

Displayed at: Oulu Museum of art, Splice exhibition, May-Sept 2017

The study conducted on (date): _____

Background information:

Sex

Male ☐   Female ☐   Prefer not to tell ☐

Age

Under 18 ☐   18-30 ☐   30-50 ☐ 50-65 ☐   Over 65 ☐

Time spent with the interactive work

Less than 1 min ☐   1-5 min ☐   5-10 min ☐   more than 10 min ☐

Earlier experiences with interactive art

Not so much ☐   Some experience ☐   A lot of experience ☐

How would you rate the following clauses:

1-Totally disagree 2-Somewhat disagree 3-Neutral 4-Agree mostly 5-Totally agree

Overall impression	1	2	3	4	5
The work was easy to understand	☐	☐	☐	☐	☐
The work was easy to use	☐	☐	☐	☐	☐
I knew immediately what to do	☐	☐	☐	☐	☐
The work reminded me of an earlier work	☐	☐	☐	☐	☐
The work was organized well	☐	☐	☐	☐	☐
There were no unnecessary elements	☐	☐	☐	☐	☐
Operation of the work was logical	☐	☐	☐	☐	☐
The work behaved as I thought it would	☐	☐	☐	☐	☐
Physical operation of the work was easy	☐	☐	☐	☐	☐
The design guided me what to do	☐	☐	☐	☐	☐

1-Totally disagree 2-Somewhat disagree 3-Neutral 4-Agree mostly 5-Totally agree NA- not available in this work

Media material	1	2	3	4	5	NA
The graphical elements were understandable	☐	☐	☐	☐	☐	☐
Interacting with the work was easy	☐	☐	☐	☐	☐	☐
The textual information was understandable	☐	☐	☐	☐	☐	☐
Audio design supported interaction with the work	☐	☐	☐	☐	☐	☐
Spatial design supported interaction with the work	☐	☐	☐	☐	☐	☐
The physical design supported interaction with the work	☐	☐	☐	☐	☐	☐
Content of the work was understandable	☐	☐	☐	☐	☐	☐

Would you change something about the work?

Yes ☐   No ☐

If yes, what would you change?

In my opinion, the work is

Art ☐   Design ☐   Both ☐   Neither ☐

In scale of 1 to 5, how would you rate the simplicity of the work? (1 - confusing, 5- very simple)

OTHER COMMENTS

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