Time as a Design Material

Master's thesis in Interaction Design and Technologies

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Gothenburg, Sweden 2020

MASTER'S THESIS 2020

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Cover: Long exposure photography of the Kuggen building
on Lindholmen, Gothenburg. Photo by the author.

Gothenburg, Sweden 2020

Abstract

This thesis explores in what ways time can be used as a design material in Interaction Design, and in what ways this shapes the aesthetic expression of the resulting design artefacts. The role that time plays in a design can significantly change its aesthetic expression, yet the topic has not received enough attention in Interaction Design.

Five "temporal themes" are defined through a literature review and interviews with practitioners from various creative fields. The temporal themes describe ways in which time can used as a design material.

The process of using these themes as a thinking technique, for ideation and design, is demonstrated through the creation of prototypes of experimental drawing applications. The prototypes are then evaluated from an aesthetics point of view to determine how the aesthetic expression is affected through the use of time as a design material.

Keywords: time, temporality, aesthetics, interaction design, design, prototyping.

Acknowledgements

My heartfelt gratitude goes out to my thesis supervisor Tomasz Kosiński, who has done a fantastic job managing to wrap his head around my idiosyncrasies and whims. This thesis would have been an unstructured mess without you.

Kristina Knaving deserves a hug for encouraging me to restart this thesis after a pause of ten years, kickstarting it with a fresh batch of ideas, and being a creative help throughout the project.

Finally, thank you Sus Lyckvi for finding my ideas interesting back in 2008 and not giving up on them. If you hadn't insisted that we write them up as an article, I don't know if this thesis would have been. It took me a few more years than I thought it would, but I got around to finish it, didn't I? Thank you for helping me get here.

Theo Hultberg Tolv, Gothenburg, January, 2020

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1

Introduction

As designers we consider artefacts we design in terms of various dimensions, such as space; how an object fills a space, how it moves in space, how it shapes space, the space between subject and object, and so on. However, we rarely consider how artefacts will behave with respect to time. The role that time plays in a design can significantly change its aesthetic expression, and not giving it enough thought can be detrimental to the design (Huang and Stolterman 2011).

Interactive artefacts and computer applications are often designed for efficiency and ease of use above other considerations. Time is typically considered in terms of duration and speed, and less is almost always better (Hallnäs and Redström 2001). Does this mindset limit interaction designers? Can thinking about time in a different, and broader way than fast/slow, long/short, lead interaction designers to uncover new possibilities?

1.1 Aim

The aim of this thesis is to explore how the use of time as a design material, and how thinking about time and temporal qualities of interaction can open up new possibilities for interaction designers to create desired aesthetic expressions.

In “Time, Temporality, and Interaction” (Lundgren and Hultberg 2009), we presented the idea of "temporal themes", or ways of describing the use of time in a design. The themes were reflections of trends and themes we saw in various creative fields, from music, movies, literature, to game design, and also Interaction Design. We proposed that these themes could be used as a thinking technique for the design process, and analysis. We proposed that by considering each one of the themes and what it would do to the interaction with an artefact, new possibilities would become apparent. These possibilities that would otherwise easily be overlooked as designers are not used to thinking about time as a material in itself. The themes, and the thinking technique has been used as a pedagogic tool for teaching Interaction Design by Lundgren (2010).

“Time, Temporality, and Interaction” was a preliminary effort in the analysis of this topic. This thesis provides a deeper exploration of the temporal themes. By analysing uses of time as a design material in diverse creative fields such as literature, fashion, gardening, games, and music, as well as examples in Interaction Design itself. These uses have been systematised, and analysed in the context of the temporal themes from that article, and new themes defined.

This thesis also demonstrates how these temporal themes can be used in

Interaction Design. It describes the process of ideating and prototyping interactive artefacts using the themes as a thinking technique, and then evaluating their aesthetic expression.

1.2 Research question

> *In what ways is time used as a design material in creative fields, and in what ways can it shape the aesthetic expression of Interaction Design artefacts?*

This thesis will explore the use of time as a design material, and how time can be considered in more ways than in terms of duration and speed. This includes moving beyond measuring only efficiency and usability, and to consider the aesthetic expression of artefacts, and its effect on experience, expression, and emotion.

1.3 Stakeholders

- Practising interaction designers
- Teachers of interaction design
- Students of interaction design

These groups will benefit from using, and reasoning about, time as a design material, to create new kinds of designs. Teachers and students can build on the results of this thesis to analyse and understand interaction in a new way.

The thesis project is carried out at the department of Computer Science and Engineering, division of Interaction Design, at Chalmers University of Technology in Gothenburg, Sweden.

1.4 Scope

Surveying how time is used as a design material in various creative fields is an enormous undertaking, because there are many creative fields and subfields to consider, many of which have extensive histories and bibliographies. The aim of this thesis is not to make an exhaustive list of every possible way that time can be considered in design, instead the scope will be limited to a few, selected fields, and the survey of each will not be exhaustive. This means that the classification of the identified temporal themes is not considered definitive.

Interaction Design is itself also a broad field, including everything from graphical and voice interfaces, tangible interaction, augmented reality, etc. Covering everything will not be possible in this thesis. While the temporal themes should be generic enough to be useful to interaction designers of all persuasions, the demonstrations of the themes included in this thesis will be limited to digital artefacts in the form of computer applications.

2
Theory

The ideas of this thesis stems from the author's own and other inspiring to previous works on the considerations of time and aesthetics in Interaction Design. Methodologically it builds on Research Through Design, and systematisation of knowledge with the use of Thematic Analysis.

2.1 Related work

Time has been considered in Interaction Design in many ways. Huang and Stolterman have written multiple papers on the topic, which also forms the basis for the dissertation of Huang (2015). There are also books, such as *Designing and Engineering Time: The Psychology of Time Perception in Software* by Seow (2008) that cover various aspects of designing with time in mind. However, both Huang and Stolterman (2011) and Orehovački et al. (2013) call for more Interaction Design research on the topic.

These works are approaching time primarily from a usability perspective; how different aspects of time influence the usability experience of a user and the efficiency of using an interactive artefact.

Designing and Engineering Time: The Psychology of Time Perception in Software discusses time from a psychology perspective, how duration, responsiveness, timing, and other factors affect users perception of interaction, but also how to design for these factors. For example, how to design user interfaces that convey duration, or timing, to the user so that they know what to anticipate.

Similarly, Huang and Stolterman (2011) propose a vocabulary for discussing temporal aspects of interaction. They discuss how temporal factors are often left out when designers present their ideas, and how these factors are often left to chance. One reason for this may be that temporal aspects of interaction have not been studied enough by Interaction Design researchers.

In other papers by the same authors, which form part of the dissertation of Huang (2015), they explore related topics on interaction and temporality. Many of these focus on how long term user experience changes over time frames such as months and years.

Hallnäs and Redström (2002) do not cover time and temporal aspects specifically, but make the case that aesthetics, and not usability, must take centre stage in Interaction Design. Like Huang, they focus on the long term experience, and conclude that aesthetic expression becomes more and more important as

interactive artefacts are experienced over increasingly longer time scales. Lundgren (2010) considers time as a design material in teaching Interaction Design, building on the ideas presented in Lundgren and Hultberg (2009).

Similar to Hallnäs and Redström, this thesis is primarily concerned with aesthetics, and not with usability and efficiency. This is not to say that one is right and one is wrong, rather that these are different points of view. It is also not necessarily a case of black and white, but concerns that form a scale. Both Seow (2008) and Huang and Stolterman (2011) discuss how time and temporal aspects affect user user experience, something which can be looked at from both a usability and aesthetics point of view.

2.2 Aesthetics of Interaction Design

Lim et al. (2007) argues that when considering aesthetics of Interaction Design, we should not be concerned with the appearance of artefacts, but with the "shape" of the interaction itself, "the phenomenon that emerges in-between people and digital artefacts". The authors call this the "interaction gestalt", as it is a composition of many parts that together make up a whole that is also greater than the sum of its parts.

Through studying interactive artefacts, Lim et al. arrive at twelve attributes that can be used to describe an interaction gestalt. They posit that designers can use these either to analyse an existing artefact, or to as tools for working in a structured way in the design process. The attributes can be used as a language for describing and explaining the motive behind design choices. This makes them similar to design patterns in software (Gamma et al. 1994) and architecture (Alexander 1977), and narrative techniques in literature
(Jose Angel Garcia Landa 2005).

Nine of the attributes proposed by Lim et al. concern spatial properties, while three are related to time and temporal aspects: *speed* (as in duration), *pace* (also described as rhythm or tempo), and *time-depth*. The last is more complex than the other two, and describes the sequence of events, from sequential events to events occurring at the same time.

Unfortunately Lim et al. (2007) do not go into detail on how they arrived at these particular attributes, although they mention that the catalogue of attributes as presented is a proposal. This suggests that it is possible to arrive at a different set of attributes through a studying a different set of artefacts. This could, for example, be in the form of attributes specifically describing temporal aspects.

Lim et al. (2007) stress that aesthetics of interaction design is not about the artefact itself, but about the interaction. This is in contrast with for example Djajadiningrat, Wensveen, and Overbeeke (2004), and Orehovački et al. (2013) who are primarily concerned with the appearance of artefacts, rather than interaction. They chose to limit themselves to considering aesthetics in terms of "beauty of interaction", and how beauty can improve usability. This is a common technology-centric view of aesthetics, and for example Lim et al. considers this unhelpful to designers, as it does not "provide usable knowledge for designers to creatively figure out how to embody aesthetic qualities into their design ideas"

(Lim et al. 2007).

A different take on the aesthetics of Interaction Design comes from Hallnäs and Redström (2002). Aesthetics, they argue, is "a logic of expression". Expression is the appearance (in its widest possible definition) of an artefact that is not related to its functional and existential attributes. They use the term "expressional" to describe a thing that has expression, like "appliance" is a thing that performs a function. Artefacts can of course never be pure appliances of expressionals, but always have aspects of both. The aesthetics of an artefact is the logic of its expression – in a way aesthetics can be seen as a formal debate, where the arguments put forth are the choices of material and given shapes.

Both Lim et al. (2007) and Hallnäs and Redström (2002) include time as a core component of their aesthetics of Interaction Design. The former defines speed, pace, and time-depth as three of the twelve attributes of they use to describe the aesthetics of Interaction Design. The former describe how interactive artefacts are in a big part based on temporal structures.

The temporal themes that will be identified in this thesis are meant to serve a similar function as the attributes of interaction gestalt presented by Lim et al. (2007), and will be built on the ideas around aesthetics of Interaction Design discussed above.

Using Hallnäs and Redström (2002) as a basis, this thesis will use "design" as reasoning with arguments formed from various materials, and "aesthetics" as the judgement made by an audience based on previous experience, culture, and expectations when it experiences and senses these arguments.

2.2.1 Slow Technology

A specific approach to aesthetics of Interaction Design with regards to time is the "Slow Technology design programme". In “Slow Technology – Designing for Reflection” (Hallnäs and Redström 2001) and other works such as “Designing Everyday Computational Things” (Redström 2001) and “Slow Technology – Foundations, Experiments” (Hallnäs and Redström 2006) Hallnäs and Redström lay out their ideas for a way of designing with technology to encourage "reflection and moments of mental rest rather than efficiency in performance".

According to their Slow Technology manifesto, technology should not be hidden away in an effort to decrease the complexity of a design, but celebrated in its own right. It is about exposing the materials used in such a way as to invite reflection on the design and the artefact itself. An artefact may be difficult, and take time to understand, if that invites interaction, exploration, and reflection. It is about making conscious decisions about aesthetics of technology, and the expressions of artefacts.

An example artefact that Hallnäs and Redström often use to describe their ideas is The Doorbell, which they describe like this:

> *Imagine an electronic doorbell that plays short fragments of a very long melody each time we press the doorbell button. To fully grasp the doorbell through its behaviour, we have to stop and reflect for a moment each time it rings and only over time we can grasp the whole*

> *melody. It is technology that claims time. Is this “slow” doorbell a better doorbell than the ordinary one playing the same two or three tones over and over again? The difference in aesthetics between the two doorbells is a difference in philosophy of design; the “slow” doorbell is not designed to be “just” an efficient signalling mechanism for non-reflective use, but rather an artefact that through its expression and slow appearance puts reflective “use” in focus. It is a doorbell designed for reflection in a world of expressions using time and presence as key parameters. (Hallnäs and Redström 2001)*

Slow Technology aims to provide an alternative agenda for Interaction Design. Designing artefacts for efficient, or "fast", interaction is all well and good, and in many situations the right thing. However, it is not the only way to think about the goals of Interaction Design, and doing so means missing a multitude of possibilities. Slow Technology puts focus on reflection, introspection, and expression. It is a way of making the interaction with artefacts also about the interaction itself, and the aesthetic expressions of that interaction.

Slow Technology recognises the importance of time as a design material. The doorbell described above is an example of time used as a design material in Interaction Design. The doorbell cannot be fully explained, or experienced without considering the time dimension. The design incorporates time as an essential part of the aesthetic expression of the artefact.

Hallnäs and Redström point out that Slow Technology is not meant to be "anti-use" or trying to make art out of design. It’s not about making things inefficient or take time just for taking time – that, they say, only leads to frustration and unpleasant experiences. Designing interaction where the interaction itself has a purpose, and evokes reflection, is instead making something taking time becoming pleasurable because it takes time.

The doorbell example also demonstrates how Slow Technology does not have to preclude usefulness and efficiency. The doorbell is still a doorbell, and in everyday use may even not be discovered to be anything but a doorbell. It’s when given time that it will reveal a different expression and afford reflection that a traditional doorbell won’t.

Hallnäs and Redström make the comparison that Slow Technology is gourmet cuisine to fast technology’s ready-made hamburgers. Both are food, and where one is for enjoying in itself, and where taking one’s time to enjoy it heightens the enjoyment, the other one is primarily for sustenance. We do have a need, and want, for both. We might not want to take the time to cook extravagant dinners every day, but we do enjoy it from time to time.

With its focus on time, and aesthetics, the Slow Technology design programme is a fount of examples of artefacts that consider time and interaction in creative ways. Hallnäs and Redström even describe Interaction Design as "a shift of focus from what a thing does as we use it to what we do in the acts that define use, and from the visual presentation of spatial form to *the act presentation of temporal behaviour.*" (Hallnäs and Redström 2006, p. 16) (emphasis mine).

2.3 Wicked problems & Research Through Design

As with many design issues the aim of this thesis constitutes a wicked problem (Buchanan 1992). There is no definitive formulation of a solution, no solution can be said to be true or false, and no test to verify if, for example, the temporal themes are correct, or not (Rittel and Webber 1974).

Why then, can this topic be researched? If there is no way to determine if the result is true, can it still be worthwhile? Can a catalogue of temporal themes, and demonstrations of those themes put into practice be valuable?

Yes, says Gaver (2012):

> *I argue on the contrary that an endless string of design examples is precisely at the core of how design research should operate, and that the role of theory should be to annotate those examples rather than replace them. (Gaver 2012)*

Design research also, continues Gaver (2012), often takes the form of manifestos. These suggest and argue for new approaches to design, and are often from reflections on the authors' own practice or inspired by other disciplines. Research through design is often generative and more concerned with what might be, than what has been. The development of temporal themes in this thesis can be thought of as such a manifesto Gaver (2012) describes.

Research Through Design, and Research as Design is an alternative approach to more quantitative and formal frameworks such as Human-Centered Design:

> *"design (as) research" is explicitly contrasted to human-centered design and usability testing, suggesting that the act and material of design and making, rather than observing or interviewing, constitutes the means of investigation and generation of new knowledge. (Martin and Hanington 2012)*

The Human-Centered Design approach to Interaction Design, in its focus on the functional and quantitative, cannot be used to evaluate the "inner design-logic" of artefacts, and will miss the expression, and existential aspects according to Hallnäs and Redström (2002).

2.4 Systematisation of Knowledge

The first part of this thesis, reviewing literature and interviewing design practitioners, is a qualitative effort consisting of systematising knowledge. Yoshikawa (1993) describes this as the process of "convert[ing] recognized and tacit knowledge [into] recognized and codified knowledge". In this context, tacit knowledge is the kind of knowledge that humans recognise and use, but have a hard time explaining or put into words – for example that which we consider to be common sense. Codified knowledge, in contrast, is organised knowledge using standardised terms, for example scientific knowledge. Finally, recognised knowledge labelled, or named, whereas unrecognised knowledge is things like expertise and skill.

The process of systematising knowledge includes "articulation", labelling and naming phenomenon (instances of knowledge) using the vocabulary of the domain, "collection", which means assembling the labelled phenomena, "codification", establishing the structure and relationship between the phenomena, and "crystallisation", the generalisation of the codified phenomena. The outcome of this process is codified (standardised), recognised (labelled) knowledge, for example in the form of a new theory (Yoshikawa 1993).

The process described above is performed in the context of a background theory, which is used to interpret phenomena before articulation. Once a Systematisation of Knowledge process has produced a new theory, the background theory can be evaluated and improved using this new theory. This is, however, not easily done in a design context, argues Yoshikawa (1993), for reasons close to those argued by Gaver (2012): it is often not meaningful to describe the outcome of design research as right or wrong – it can at most be determined to be effective and useful, or not.

Researching the use of time as a design material in other creative fields, and the synthesis of that knowledge into temporal themes is systematising mostly tacit knowledge in the form of descriptions of artefacts and practices into recognised and codified knowledge in the form of temporal themes. The process described by Yoshikawa (1993) can serve as a guide for this work.

2.5 Thematic Analysis

Thematic Analysis is a method for qualitative research used "for identifying, analysing, and reporting patterns (themes) within data" (Braun and Clarke 2012). It is suitable for example when you have interview data, or other unstructured, qualitative data that you want to analyse and systematise into themes. These themes "capture something important about the data in relation to the research question, and represent some level of *patterned* response or meaning within the data set." (Braun and Clarke 2012). While it was developed in the context of psychology, the authors posit that it can be used in many disciplines and theoretical frameworks, and isn't limited to analysing interview data[1].

Thematic Analysis exists in many forms, Braun and Clarke name their version "reflexive Thematic Analysis", emphasising the self-searching, and iterative nature of their version of the method. In their guides to the method[1] they note that the steps of the method include subjective judgements.

The themes defined by a thematic analysis are not necessarily the most frequent, or prevalent in the data, but what best answers the research question in the mind of the researcher. The themes are also not, and should not, be the questions asked to the interviewees (Braun and Clarke 2012).

Thematic Analysis is, in the variant taught by Braun and Clarke (2012), performed in six steps:

1. The researcher(s) familiarises themselves with the data, through reading and re-reading, transcribing, etc., while also in the back of their mind looking for patterns and deeper meanings.

2. The data is *coded*, or labled by what appears interesting to the researcher. These codes can be *semantic*, things that are in the actual data, for example something someone says in an interview, or *latent*, things that are in the subtext, alluded to, or interpreted from the data. Coding can be done in multiple passes, and codes can be changed, added to, and revised. This process can be done by attaching notes to the data in its raw form, or by writing sticky notes, the exact details are not important.
3. The coded data is sorted and grouped into potential themes. Multiple codes may combine into a theme, but individual codes can also become themes. There may be sub-themes. This step is preferably done in a visual way, for example by arranging sticky notes with the codes.
4. The themes are reviewed, combined, split into separate themes. The goal is for the themes to form a meaningful, coherent pattern, and be clearly distinct from each other. When the themes have been revised, they are judged against the whole data set. If there are themes that don't fit, the previous steps, reading, coding, theming, are repeated iteratively until the themes fit all the data.
5. When the themes are finalised they are named and described in one or a couple of sentences.
6. A report is produced describing the process and the final themes. The themes are presented along with "evidence", representative pieces of data that demonstrate their validity.

It should be noted that the process begins even before the first step, when the researcher will be considering patterns while the data is being collected.

Braun and Clarke say that one way to do coding/theming is to start with existing codes and themes and iteratively add more themes[1].

Thematic Analysis produces themes that describe qualitative data in relation to the research question. In this thesis it will be used to analyse the data gathered from a literature review and interviews of practitioners of different design disciplines.

[1] Braun and Clarke have collected additional resources about reflexive Thematic Analysis at https://www.psych.auckland.ac.nz/en/about/thematic-analysis.html

3
Methodology

To support and structure the research and design process of this thesis, design methods and practices sourced primarily from Martin and Hanington (2012), and also from IDEO (2009), will be used.

3.1 Double Diamond

The Double Diamond (Stickdorn and Schneider 2010) design process will be used as the overarching framework. This process was originally developed by the Design Council (Council 2007), and is in different variations often used in the design industry, especially the Design Thinking community. It is similar to the Stanford Design School's five step Design Thinking Process, and IDEO's HCD process.

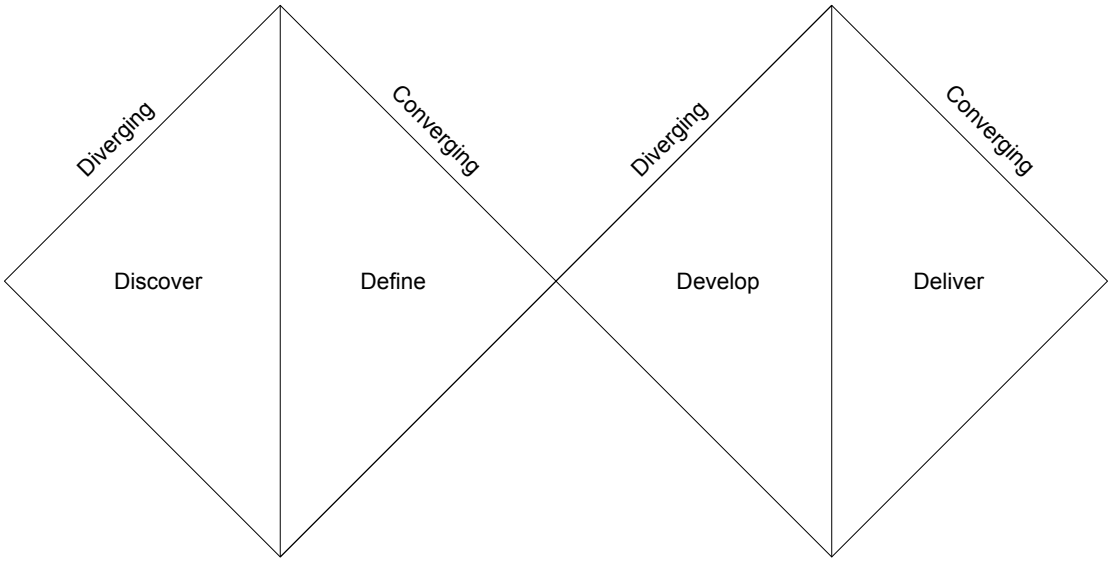

Figure 3.1: The Double Diamond design process

The Double Diamond process divides a project into four main phases:

- Discover/Research
- Define/Synthesis
- Develop/Ideation
- Deliver/Implementation

The first and third phase are "diverging", their purpose is to open up possibilities, whereas the second and fourth phases are "converging", their purpose being narrowing down ideas and findings.

In practice the converging and diverging phases are performed in an iterative manner to refine the work. This is especially true for the Develop/Deliver phases, where discoveries made during implementation require new ideation, which requires changes to the implementation, which discovers new problems, and so on.

The first diamond, comprising the Discover and Define phases, focused on finding examples and background on the temporal themes, and new themes not previously described. These phases were about establishing the theory that the later phases will build on, which in the case of this thesis is the classification of temporal themes.

The second diamond, comprising the Develop and Deliver phases, focused on using the temporal themes in practice, through demonstrating how they can be used in practice, and how the result can be evaluated from an aesthetic perspective.

The following sections cover the tasks and methods that were used through the four phases of this project.

3.2 Discover phase

The Discover phase is about research and making sure that the rest of the work stands on a solid base.

To find examples of uses of time as a design material in different creative fields, a literature review (Martin and Hanington 2012) was performed in combination with interviews of design practitioners. The goal was to find examples of uses of time as a design material in Interaction Design and other creative fields.

3.2.1 Selection of creative fields

The fields were chosen primarily based on the initial work in “Time, Temporality, and Interaction”: music, cinema/television, and game design. During the early stages of the project the list was expanded through brainstorming together with my advisor, and through preliminary research. The selected fields are described below.

Narratology was a topic we touched on in “Time, Temporality, and Interaction” through making examples from cinema and television, but there is a whole research field that has a lot to say about time and temporal aspects that was not considered in this initial effort. I decided to expand the analysis to this field,

following the track pointed out by for example Orehovački et al. (2013). This part of the research was probably the most rewarding and inspiring to me personally.

Architecture was a field that emerged through the initial brainstorming. The idea was that since buildings are designed to last for a long time, but are also exposed to wear from humans and the elements, architects should have developed practices for dealing with the effects of time and use. A preliminary literature search turned up very little written on subjects such as how architects work creatively with materials that change over time. I reached out to academics at the School of Architecture at Chalmers, as well as practising architects in my network. The former never responded, unfortunately.

Fashion, like architecture, deals with materials that are are worn by use. Companies such as Nudie Jeans Co. have made wear a part of their brand, with the idea that it's only through use that the full aesthetic expression of a pair of jeans can be achieved. This first perfectly with the idea of time as a design material. Fashion being a less academic field than for example architecture meant that I expected interviewing designers would yield better information than a literature review.

Music is a vast topic, and I decided that it would be better to interview practitioners and ask for their input than try to find the relevant papers and articles myself. My creative supervisor had some good suggestions of people who where both music performers and interaction designers, which would increase my chances of finding good examples of time used as a design material.

Horticulture is perhaps a somewhat surprising field to include, but I had an idea that gardening is a very interesting design field when considering time as a design material since it has to consider seasons. I chose to include horticulture specifically to capture examples related to seasonality.

Photography is something I personally find fascinating, and wanted to include it in my review. Since I already had quite a few domains already I decided to cover it only briefly. I knew there were good examples of time used as a design material, and finding some material on these could be fit into the schedule.

Game Design can in many ways be thought of as something that contains many aspects of narratology, as well as Interaction Design. The computer game Braid was released around the time when I started the work that would end up in "Time, Temporality, and Interaction", and it so beautifully captured some of the ideas of time used as a design material. There are a wealth of examples of time used as a design material in games, and games in general (both computer and board games) often have temporal components built into their rules systems.

Interaction Design was of course included, and has some examples of time used directly or indirectly as a design material. As it is also the aim of this thesis to explore how time can be used as a design material in Interaction Design based on examples from other fields, this field was not the primary focus.

Adding more design fields, and even giving each of these fields all the attention they deserve would have required much more time than available in the project – instead each chosen discipline was covered to the extent possible to realise within the thesis timeframe.

3.2.2 Literature review

The study of narratology, architecture, photography, and game design were wholly or in part done as a *Literature Review* (Martin and Hanington 2012, p. 112).

I primarily used Google Scholar and Research Gate, as well as Wikipedia and other online resources to find material covering time, temporality, and other themes in relation to design. The material I was searching for were both academic papers, but also non-peer-reviewed articles, blog posts, and websites covering design.

When evaluating whether or not to include a source in my review, I read the abstract, quickly scanned the text, and made a judgement of whether or not it was relevant to my research question. If that was the case, the material was saved and later read more thoroughly. During the in depth reading I extracted sentences and paragraphs that were potential examples of time used as a design material, or described concepts and terms that were related to time. This extracted data was indexed by design discipline and used as input to the analysis in the Define phase.

I also looked up the papers that cite “Time, Temporality, and Interaction”, and scanned them for interesting material. One such paper gave me good input on narratology, which was a surprising, but welcome find.

3.2.3 Interviews

Interviews with design practitioners of the selected fields were performed to gather examples of time used as a design material. The interviews were meant to complement the literature review where literature was hard to find, or too extensive. Each discipline has its own terms and traditions, and finding sources relevant to "time as a design material" can be hard. Filtering the question through interviews with expert practitioners was one way to create a short cut.

Prospective interviewees were chosen by *Brainstorming* (Martin and Hanington 2012), followed by asking friends, acquaintances, and the thesis advisor for introductions. The prospective interviewees were asked for an interview via email, with an explanation of topic of the thesis and what kind of information was wanted from them. Not all responded, but there was a certain overlap and redundancies so in the end all selected disciplines were covered.

The interviews started with a short briefing on the thesis and its aim, and an explanation of the term "time as a design material". To illustrate the term, examples of how time affects design were given, for instance how materials age and acquire patina, how tempo changes the expression of music, or how materials such as grass and shrubs grow and change – as well as how designers may consciously or unconsciously use these effects in their designs.

The purpose of the interviews was to gather background knowledge, and a hope was also to gain unexpected insights and find new angles. To achieve this the interviews were semi-structured, rather than formally structured. As described in Martin and Hanington (2012), there was a "guiding set of topics" in the form of broad questions that were asked in all interviews (see below). These

questions were worked into the conversation in different ways, and sometimes multiple times, to ensure that, they were answered.

As the interviews were exploratory in nature, and there was no quantitative data being sought, the semi-structured, rather than structured interviews or formal questionnaires were used. This process is also similar to the one presented by Hsieh and Shannon (2005), who describe how one can, for example, follow up with targeted questions at the end of the interview to make sure that all topics are covered.

Completely open ended and unstructured interviews would also not have been suitable. Even if there would have been the overarching theme of talking about time and temporal aspects of design, there would be a risk that the interviews spun off on tangents and would be hard to compare to each other. By having a prepared set of common questions the interviews became easier to relate to each other and common themes could be extracted.

The common questions asked in one form or another in all the interviews were as follows:

- *Can you give examples of how time is used to achieve different expressions [within your design field]?*
  This is the core question, but also one that the interviewees weren't expected to be able to answer directly. Many designers work with temporal aspects, but it seems to rarely be though of as such – it's thought of as properties of the material, or process, or not explicitly considered. This question was woven into the conversation multiple times during the interviews, and gave shorter or partial answers at different points. The concept of time as a design material in itself required getting used to, and the interviewees could give more examples later in the interview.
- *Are temporal aspects [such as wear, degradation, weathering] seen as something positive, or something negative (or both in different circumstances)? Do materials acquire patina, and is that something desirable?*
  The temporal aspects of materials is often in the form of degradation, and sometimes this is desirable, and sometimes not. This question relates to material, and was relevant to most fields, but not all.
- *Are there aspects of time not related to materials [in your design field]?*
  Materials seem to be easier to talk and give examples about, but not all temporal aspects need to be tied to the materials that the designer works with. In some cases the materials may not be the primary thing in the design, or not physical. Degradation and wear may not be a factor for the material (for example if we consider time as a design material, time is not subject to degradation as far as we know).
- *Are there terms and names for temporal aspects [in your design field]?* It seems like designers are not used to think of time as a design material, but there are often other names, or names that include the temporal aspects of the practice.

The interviews lasted between 30 minutes and one and a half hours, depending on the interviewee's time constraints and talkativeness, with most

lasting just over an hour. Many topics were covered during this time, and since time is something that most don't consciously think about as a material in itself, a lot of the conversation was about the practice itself, to try to figure out if there were temporal aspects there, and then ask more focused questions about those things.

During the interviews notes were taken, but the interviews were not recorded. If anything was unclear from the interview notes the interviewees were available for clarification.

In place of the interviewee names, codes such as "architect A", "fashion designer A", and "musician B", are used throughout this report.

The interview notes were later read through and sections that were potential examples of time used as a design material, or described concepts and terms that were related to time were extracted. This extracted data was indexed by design discipline and used as input to the analysis in the Define phase.

3.2.4 Summaries of the collected qualitative data

Summaries of the data gathered in the literature review and interviews can be found in Appendix A.

3.3 Define phase

The define phase is about picking the best material from the Discover phase and chose what's worth keeping and what does not belong in the final product.

3.3.1 Analysis of the qualitative data

The data extracted during the literature review and from the interviews during the Discover phase was analysed and systematised using *Thematic Analysis*, and guided by *Systematisation of Knowledge* as outlined in section 2.5 and section 2.4. This resulted in a set of themes that described the data.

The thematic analysis was performed by coding the extracted data, then finding themes in the codes, evaluating those themes against the codes and data, to finally arrive at final themes that described the data in a meaningful way. The following describes these steps in more detail.

As suggested by Braun and Clarke (2012), before coding the data all of the data extracted during the literature review, as well as the interview notes were read in one sitting, to make sure they were all fresh in the mind.

Certain initial codes had been on my mind during the data collection, and after the initial reading I had even more ideas for codes. These initial codes came from the "temporal themes" from “Time, Temporality, and Interaction”, as well as the time-related attributes of Lim et al. (2007), and of course the data collected in the Discover phase.

Braun and Clarke (2012) describes how coding can be inductive (bottom-up), or deductive (top-down), but that in practice it's a mix between the two. Being inductive in coding means letting the codes come out of the data, while being

deductive may be a more theory based approach where there exists a prior framework that the data is viewed within. Because of the aim of this thesis is to expand the exploration of previous work, the stance for this analysis is more towards the deductive side than the inductive.

The data, in the form of extracted text, and named concepts from the literature review, and key phrases and concepts from the interview notes, were entered as "cards" in the online application "Trello"[1] (see Figure 4.1). The idea was to get the data into a format that would be convenient to work with when coding. I could have used sticky notes on a wall, but as I needed to be able to work on the data from different locations, Trello provided a close enough solution. Trello has two main concepts: cards and columns. Cards can be put into columns, and any number of cards and columns can be created. My method was to create a column for each code, and code data by putting cards into the corresponding column.

Braun and Clarke (2012) suggest performing coding in printouts of the raw data directly, and while this would have been possible, putting extracted texts, quotes, and named concepts into cards in Trello is to me equivalent to highlighting the same passage of text in a document and writing codes in the margins. It should be noted that the authors also say "[Thematic Analysis] is not prescriptive about how you segment the data as you code it (e.g. you don't have to produce a code for every line of transcript). You can code in large or small chunks; some chunks will not be coded at all." (Braun and Clarke 2012).

To be able to keep track of where each piece of data came from, the cards were colour coded by design discipline. This narrowed down the scope sufficiently that if I, for example, forgot where a concept like "rhythm" came from I could look at the colour code and see that it was from one of the interviews from the field of music.

When all data had been entered there were about 160 cards. Although you shouldn't focus on numbers when doing reflexive Thematic Analysis [2], this number gives an indication about the size of the data set.

During the first coding each card was considered in turn, and given one or more codes both from the set of codes I had in mind, but also codes that emerged during the coding. As mentioned above, coding was performed through moving a card into the column corresponding to a code. New columns were created for new codes, and cards were duplicated when coded with multiple codes.

After the first coding session there were about 30 cards that received no codes. After trying again to find relevant codes for these cards I eventually decided that they were each in a different way a poorly chosen piece of data that was in fact not relevant to the research question. I realised that I had not been completely focused on the research question when extracting data in the Discovery phase. Some data had been chosen perhaps more because it was generally interesting, and not actually because it was related to the research

[1] https://trello.com/

[2] This is discussed in the FAQ Braun and Clarke have published about the method, and which can be found at https://www.psych.auckland.ac.nz/en/about/thematic-analysis.html

question. For example, fashion designer B talked a lot about circularity and sustainability, which are interesting topics, but not related to the research question of this thesis. While reading the interview notes it was hard to not extract those sections, especially since it was a topic also brought up by fashion designer A. At the same time, I prefer having had to filter out this data in this phase, rather than being too narrowly focused during the Discovery phase and perhaps risked missing something that was relevant on second thought.

After the first coding there were ten codes, some used only a few times, and some used on a lot of data. The most frequent code was applied to about 30 pieces of data.

While reviewing the coded data I determined that the codes that were most frequently used probably had nuances that could be described better. By analysing these in more detail I found new codes and ended up with 16 codes in total.

Since this projects is done by me on my own, it felt appropriate to get some outside input into the analysis, to ensure I hadn't got stuck in my pre-conceived notions or some local maxima. To do this I did a form of *Card Sorting* (Martin and Hanington 2012) with a person not involved in the project. The amount of time you can ask of someone is limited, and I determined it would not be possible to ask them to dive deep into the data by themselves. Instead, I had to introduce them to the data and grouping it into something at least close to the codes and themes of Thematic Analysis. The purpose of Card Sorting is to see how someone groups items into categories, which is not dissimilar to how Thematic Analysis groups data into themes, and I decided it would give me some validation and insights into my own analysis.

I created a physical setup of my cards in the form of sticky notes, and over the course of a couple of hours I showed each card in turn to the person, gave a short background on where it came from and what it meant, and asked the person to come up with a new group for it, or put it in an existing group. The outcome was eight groups of cards, partly overlapping with my previous coding, but not completely.

These groupings are not identical to coded data, but similar enough that they can inform them searching for themes. The underlying data is the same, and the process that led to them is similar. The desired outcome from a Thematic Analysis is themes, and coding is a means to that end. Having a different source that informs the searching for themes is not strictly by the book, but there is also no rule against adopting these groupings as codes for my data, if that makes sense to me as a researcher.

Having my own codes, and the groupings with the outside insights, searching for themes was the next task. According to Braun and Clarke (2012) codes can become themes directly, but more often codes are combined to form themes. The number of codes at this point, if the Card Sorting groupings described above are included, were 24, and Braun and Clarke suggest aiming for around six themes.

To search for themes, I wrote down the codes on sticky notes, and started putting them together in groups that represented potential themes. The outcome

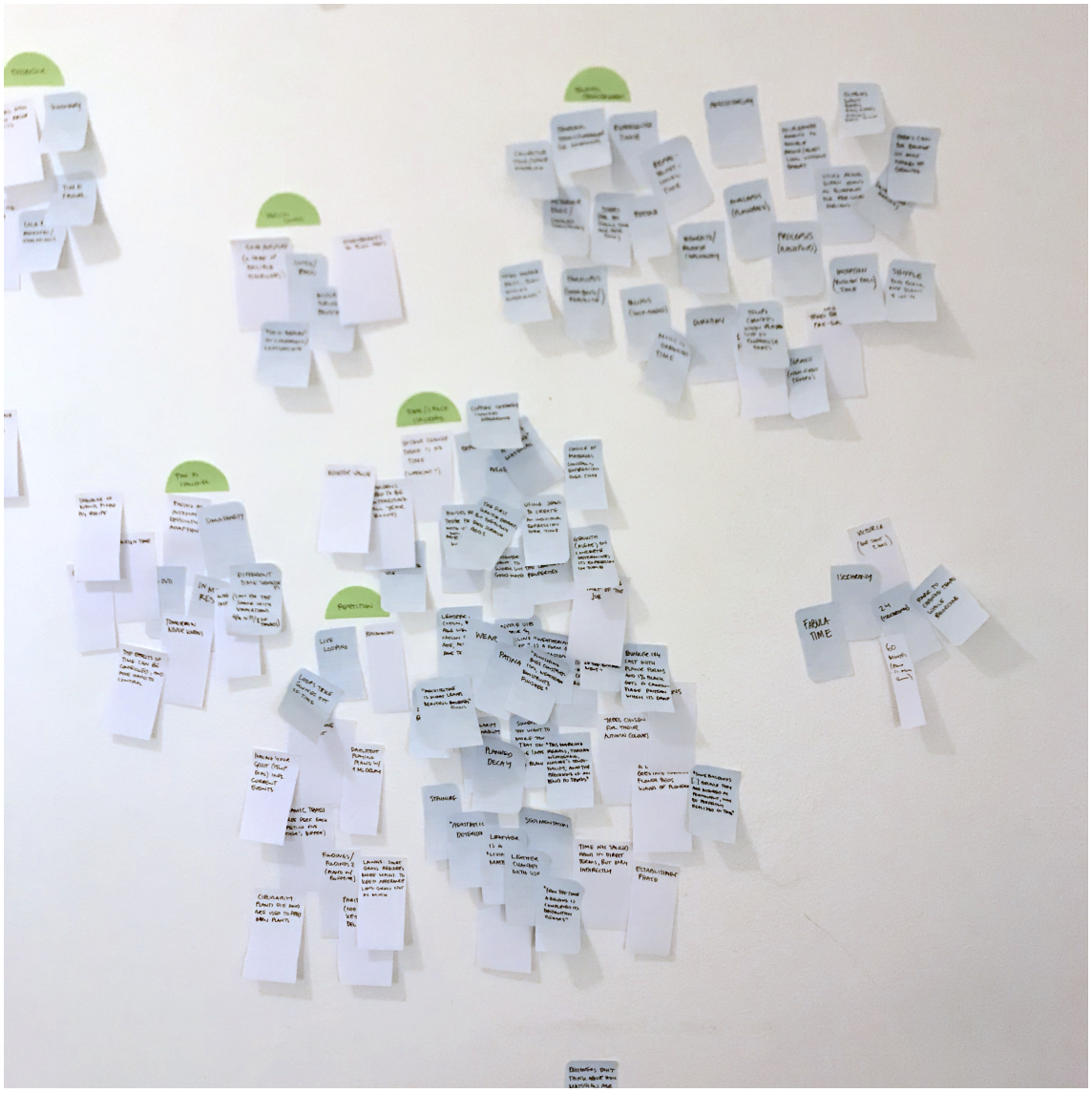

Figure 3.2: Card sorting in action

of this was five themes that were mostly disjoint, even though some codes could end up in either of two themes.

The process of finding themes is not deterministic, and it is subjective. Braun and Clarke say "analysts are like sculptors, making choices about how to shape and craft their piece of stone (the “raw data”) into a work of art (the analysis). Like a piece of stone, the data set provides the material base for analysis and limits the possible end product, but many different variations could be created when analyzing the data."

When potential themes are defined they should be checked against the data, and you should ask yourself whether the themes are indeed themes, or codes in disguise, what the quality of the themes are, their boundaries, and so on.

Figure 3.3: Searching for themes

3.4 Develop phase

In the Develop phase the output of the Define phase is used to generate ideas for what to implement in the Deliver phase, building on the learnings from the previous phases.

Put more concretely, in this phase I made use of the themes found in the previous phase, showing how these can be used to create interactive artefacts using time as a design material, and how such prototypes can be evaluated from an aesthetics, rather than usability, point of view.

The outcome of this phase was prototypes of artefacts created through the process described below, as well as reflections on how the ideation process works when designing with time as a design material.

3.4.1 Ideation

Using time as a design material in an Interaction Design project does not have to be different than using other materials. You can use the methods you know and are comfortable with to start with, and then add the simple thinking technique we proposed in “Time, Temporality, and Interaction”.

The thinking technique described in “Time, Temporality, and Interaction” is performed by looking at an artefact and considering how time is expressed in it already, for example by looking at the temporal themes and considering each one in turn, analysing how the artefact could be described in terms of that theme. Then, you turn it around and ask a series of "what if?" questions. Taking

one or more of the other temporal themes and considering how the artefact would be if time was expressed according to that theme, and variations of it.

As the method described above works best with existing artefacts, or at least rough ideas of what kind of artefact is being designed, I started my ideation process by using the methods *What to Prototype* (IDEO 2009) in combination with *Brainstorming* (Martin and Hanington 2012), as well as *How Might We* (IDEO 2009). These were used to come up with rough ideas for artefacts that also would be simple enough to make a description of the process easy to follow. I also looked at the Slow Technology design programme, being concerned both with temporality in Interaction Design, and with the aesthetics of interaction, for inspiration.

In “Time, Temporality, and Interaction” we created drawing applications as a way to explore the temporal themes, and of the ideas generated for this thesis, I decided that again using the concept of a drawing application would be the most appropriate. Many of the other ideas were bigger in scope, and more complex, requiring more time to implement and probably more difficult to evaluate. My judgement was that to be able to complete this part of the thesis in the time alotted in the schedule, a simple concept such as these drawing applications was best. It would also be interesting to see if the results were similar to the results we presented in “Time, Temporality, and Interaction”.

Drawing applications are, at their core, very simple interactive artefacts, but also support activities that everyone has done at some point or another: doodling, scribbling, drawing. Most people should be able to start using a simple drawing application with very little introduction, and given that the interaction is so simple, that the effects of changing the drawing experience by adding temporal aspects should be clear, and not, for example, an artefact of the test instructions, or complexity of the task.

In line with trying to keep the scope down I also limited myself to a very basic concept of a drawing application, one where you can draw lines of different colours, but no other features like undo, drawing predefined shapes, or even erasing.

Using the thinking technique from “Time, Temporality, and Interaction” I looked at what role time plays in such a simple drawing application, and then how the themes that came out of the analysis in the previous phase could be applied to the application to create various aesthetic expression. Considering, for example, the theme "chronology", I asked myself what would happen if the linear chronology of a drawing application was disrupted by flashbacks, like in a film, and what a flashforward could mean in the context of drawing.

Some of the ideas that came up in this ideation exercise weren’t feasible, it’s unfortunately not really possible to look into the future as a flashforward might require, but other ideas looked promising. These were carried forward into a prototyping phase.

As should be the case with design and development projects, the ideation and prototyping were not performed linearly, but iteratively. I started working on prototypes, and used what I learned as inspiration for new ideas, and so on.

3.4.2 Prototyping

A basic drawing application was developed to serve as a platform for creating prototypes that explored the ideas generated in the ideation, as described above. It was built as a web application, to make it accessible to anyone with a web browser. I was thinking that I might want to evaluate the final prototypes remotely, and this would have helped with that. The application had minimal controls, matching the narrow scope I had defined, and with the aim that this would limit confounding factors and help focus the evaluation to the aesthetics of the interaction, not aesthetics of the application itself, or its features. The controls were a slider to choose the thickness of the brush, and a colour picker to change colour.

The application was built in a way that would make it possible to develop new prototypes quickly. It provides the drawing interface, the rendering of the drawing, management of what has been drawn, and so on, and provides a plug in architecture that allows me to write small pieces of code that can manipulate the lines that have been drawn, including width and colour, as well as the current brush size and colour. This means that to create a new prototype I don't have to think about how to draw lines to the screen, I only need to think about how the prototype should manipulate the state to achieve the desired effect. The requirements for this plug in architecture were uncovered iteratively while implementing the first few prototypes.

The basic drawing interaction, and some early prototypes were tested informally with friends and family to weed out bugs and make sure there weren't any obvious problems. One thing I considered during this testing was whether to include the brush size and colour controls, or make the prototypes even more minimalistic and remove those as variables in the evaluation. In the end I determined that without them the prototypes appeared cryptic, and less like drawing applications. Including them meant that the prototypes had a measure of familiarity, and would probably be accepted as drawing applications by the testers.

All in all I created five working prototypes, and also a few that were not fully developed, either because they became too complex, and therefore unlikely to be good candidates for evaluation, or because the idea didn't work out as I had hoped.

3.5 Deliver phase

The Deliver phase is about narrowing down the ideas from the Develop phase into the final product. For this project this means choosing prototypes from the Develop phase to evaluate, perform the evaluation, and analyse if and how they achieve the desired aesthetic expression they were designed for. The Develop and Deliver phases are usually performed iteratively, and this has been the case in this project too – for example, when the prototypes to evaluate had been selected I iterated back to the previous phase and improved the fidelity of these prototypes.

3.5.1 Prototype selection

Because of the time constraints of the project, only two of the prototypes from the Develop phase could be evaluated. The prototypes were broadly divided into two groups: one where the brush colour changed over time in different ways, and another where the lines that had been drawn were changed over time. The former group primarily represented the theme "timelines" and the latter the theme "chronology".

The prototypes in the second group where on the whole more complex and would be harder for a user to master. For example, probably the most complex prototype was an attempt at "visual live looping". In it, lines behaved like sounds, they were drawn and faded out, and they could be recorded and looped. Other similar prototypes were inspired by the musical instruments developed by musician B (see section A.6) and had the same fading lines, but different echo effects that brought lines back after a while. This prototype was determined to be too complex at an early stage and never fully completed.

The prototypes from the first group were simpler and more directly expressed one of the themes. They didn't alter the lines that had already been drawn, only the colour of the brush while lines were being drawn. This colour change effect is out of the users' direct control, but as it is slow and gradual, it is less surprising and more direct than the effects of the second group.

To minimise the effect of confounding factors when evaluating the prototypes, the less complex prototypes were chosen, i.e. those from the first group. A future work could evaluate the prototypes from the second group, and also artefacts that express the other uncovered themes, to see how the different themes can be used to design different aesthetic expressions.

3.5.1.1 Description of the selected prototypes

The two prototypes in the first group were similar beyond that they explored the same theme. In both, the brush colour changed, but they differed in how the change happened. In one, which I call Colour Pen, the colour changed only as you were drawing, while in the other, called Colour Wheel the colour changed continuously whether you were drawing or not. The change is gradual, the colour goes through a rainbow of hues in about two minutes in both if you draw continuously. The two minute period was selected during prototyping as a balance between being not so slow as to not be noticeable, but also not so fast that the impression is that the user wouldn't have time to use the colour before it changes.

Both prototypes were, in line with the Slow Technology design programme, intended to encourage reflection and a curious stance in interacting with them, inviting exploration and experimentation. Colour Wheel has a tempo, or rhythm, to it, which takes away some of the control that you have in a traditional drawing application. Colour Pen does not have its own rhythm, time really only passes in that application when the user does something, and while it in one way takes away control over the colour it doesn't take it away completely like Colour

Wheel[3]. Taking away control from the user was not intended as a way to limit the user or make them feel not in control in a negative way – rather, it was more a way to make drawing more like playing a real time computer game, where things happen outside of the player's control are part of the experience.

In addition to the two prototypes described above, a drawing application with no temporal effect, i.e. no change in colour, was also created, with the intention of using it as a baseline to the other prototypes in the evaluation.

3.5.2 Prototype evaluation

The aim of this thesis is to look at aesthetic expression rather than usability, and to that end I wanted to find a way to demonstrate how to evaluate that. In line with my research question I wanted an answer to the question: has the desired aesthetic expression been achieved?

As mentioned above, the prototypes were inspired by the Slow Technology design programme, which has some broad suggestions on how to evaluate artefacts from the point of view of aesthetics rather than usability. What it means to evaluate something from an aesthetic point of view, assess aesthetic expression and experience, and isolate it from other aspects of an artefact, is hard to do. According to Hallnäs and Redström (2001) the focus should be on the "inner logic and aesthetics" of the artefact, and can be, for example, in a form similar to art or design critique, but also more in empirical ways, for example with observational studies, interviews, or questionnaires, where the focus is to gather the reactions and emotions of the participants. Unfortunately the authors don't go into detail about how they have performed their evaluations, and only briefly describe one case where they used a questionnaire.

Schindler et al. (2017), however, have a much more concrete method for assessing aesthetic experience that is applicable to various fields, including design. They developed *Aesthetic Emotion Scale* (abbreviated to "AESTHEMOS"), a questionnaire where the participant rate how intensely they felt certain emotions on a scale from one to five. The questionnaire was developed by combining the aesthetic emotion and experience descriptions from different fields of aesthetic study, and distilling these down to a set of 21 emotional scales. Each of these was represented in the questionnaire with two questions, making the questionnaire 42 questions in total. The questionnaire was developed to be applicable broadly, for examples in domains such as art, design, and architecture, and has been used in the literature to study aesthetic expressions of, for example, tactile art (Martillano 2019), perfume (Diessner et al. 2019), and opera (Scherer et al. 2019).

To evaluate aesthetic expression, I believe that AESTHEMOS can be a useful

[3]The names of the drawing applications are more or less arbitrary. The "pen" part of Colour Pen comes from my mental model of what is happening, it's like you're drawing with a pen where the lead is not layers of graphite, but layers of coloured pigment, and as you draw the pigments are deposited on the paper, revealing pigments with different hues, that are then deposited on the paper, and so on. The "wheel" in Colour Wheel instead comes from how I'm thinking of it as having a rainbow coloured wheel that spins and the colour drawn is whatever is at the top of the wheel at the time when you draw.

tool. It captures the aesthetic experience and emotion of the testers, which is of course not the same as aesthetic expression, but caused by it. This is similar to how a usability test measures how the test users performed as a measure of the usability of the artefact.

The output of AESTHEMOS in the form of average scores on the 21 emotional scales gives an idea of what aesthetic emotional response that the tested artefact elicits. By comparing the expression I intended for each prototype with these results, and including a basic application as a control, I could get an idea about whether the designs turned out as intended or not.

Describing one's emotions is not easy, and different persons may interpret questions differently. When using the English language questionnaire with participants that are not native English speakers the results may also be affected by misunderstandings about the meanings of specific words. This is somewhat controlled for in that the questionnaire includes two questions per scale that are then averaged, making each similar to a Likert-type scale.

AESTHEMOS is primarily a quantitative tool, and for this thesis I knew I was not going to be able to recruit enough participants in the time allotted to this phase of the project to reach an appropriate level of statistical significance. At the same time, my goal with this part of the project is also to demonstrate how artefacts can be evaluated from an aesthetics point of view. Therefore I'm doing it in a way that could be scaled up in a future study with more participants.

3.5.2.1 Study procedure

To evaluate the prototypes I recruited colleagues, friends, and acquaintances and asked each to test one of the prototypes, or the basic drawing application, and then fill out the AESTHEMOS questionnaire[4]. Each prototype, as well as the basic drawing application was tested by three people. Which prototype that each person tested was chosen at random.

The tests were performed at the test subjects places of work, I came to them, and we sat in a quiet space without any other distractions. They used my computer to perform the test, and the only thing displayed on the computer screen was the drawing application.

The basic drawing application was included to get a baseline result, in other words, something to compare the results of the two prototypes against.

Hallnäs and Redström cautions against not framing the evaluation properly with the subjects, as it's easy that the artefact is "perceived merely as some poorly designed and, as a result, useless tool" (Hallnäs and Redström 2001). Therefore, the application was introduced to the test subjects by describing it as an experimental drawing application for artists, that could also be used by non-artists. This is not strictly true, since these prototypes have no actual purpose beyond this study, but it is also not untrue, as they could be developed into that.

From the pilot testing of the prototypes, five minutes seemed to be a good amount of time to be able to explore and try things out, but not long enough for

[4]The questionnaire can be found in Appendix B

them to loose interest. The temporal effect, i.e. the change in colour, of the two selected prototypes cycled through a rainbow of colours in about two minutes, which meant that five minutes also gave the testers time to see the colours repeat at least once.

Before the test subject started drawing I instructed them that they were to draw for about five minutes, but that it was up to them to determine when they were done, it was all right to stop early, or continue for more than five minutes. I also said they were free to draw whatever they wanted, but suggested they could make a christmas card if they wanted to. Since the test was about the experience of the interaction and not about the finished drawing, I made this suggestion to make them start drawing and not spend time planning or thinking too much about what to draw.

While they were drawing I took notes of any reflections they said aloud. I did not specifically ask them to think aloud as I wanted them to draw and experience the prototype, and not to judge and give feedback, but I also wanted to capture any insights that could be relevant for the analysis.

During the test I did not comment, help, or suggest anything to the test subject. On direct questions, for example "how do I change colour?", I politely said I could not help.

After completing the test, the testers were asked to fill out the AESTHEMOS questionnaire, judging their aesthetic experiences and emotions they had felt. Filling in the 42 questions took them around two minutes, and the whole test, including introduction, and some discussion afterwards took between 15-20 minutes.

The AESTHEMOS questionnaire uses the word "it", both explicitly, as in "I found it distasteful" and implicitly as in "Amused me". To make sure that the test subjects responded with how they felt towards the right thing, I made sure to introduce the questionnaire by specifying that the "it" that it referenced was the experience of drawing with the application, and not, for example, the application, or their drawing.

Finally, since the drawing happened on my computer, I offered to take a screenshot of their drawing and send it to them if them wanted. See Figure 3.4 for examples of what was drawn by the participants.

3.5.3 Data analysis

When all the tests were completed the responses to the questionnaires were collected in a spreadsheet, and keyed by the 21 AESTHEMOS emotional scales[5]. The numbers were fed into a pivot table with emotional scale on one axis, the drawing application on the other, and the averaged responses as metrics. The cells were colour coded according to the strength of emotion to show hot spots (see Figure 4.2). This colour coding made it easier to see patterns in the data, compared to looking at the raw numbers.

The desired aesthetic expression of the drawing applications were then compared to the aesthetic emotions reported by the test subjects. I did not have

[5]See section B.2 for the mappings between question and emotional scale

AESTHEMOS in mind when I made the prototypes, and I had to make a judgement about how to translate the intended aesthetic expression into what aesthetical emotions would be expected. E.g. from "encourage reflection and curiosity" I would expect "fascination", "intellectual challenge", and "interest" to be reported.

The baseline application wasn't designed to have any specific expression, it was supposed to be neutral. Neutral in this context does not mean that I expected the test subjects to report no emotion, or the same strength of emotion on all scales, though. Drawing with the basic application was, for example, not meant to be unpleasant. Instead, I was expecting to see low scores on negative emotions, and low to medium scores for positive emotions.

In the analysis I also took into account the notes I had taken during the tests, which included remarks about the mechanics of the applications, but also reflections on what was happening, and what the test subject tried to achieve, and exclamations of surprise.

3.5.3.1 Limitations

The number of participants in the evaluation were too few to make any definite conclusions from the questionnaire. For example, it could be that the difference between the baseline, and the two prototypes on the "Intellectual challenge" emotional scale are down to chance. Since the test subjects were all people that I know, they were from a fairly homogeneous age group, with similar backgrounds, which also would affect the result. In a future study the evaluation could be repeated with more participants, from more diverse backgrounds, to validate or reject these results. The numbers from the questionnaire were analysed with this in mind.

Figure 3.4: Outputs of users' testing of the prototypes

4

Results

The thesis results consist of the identified temporal themes as well as the insights on their application to digital prototypes. The latter was done through the creation of two drawing applications that explore one of the temporal themes, and an evaluation of them from an aesthetics point of view.

4.1 Literature review and interviews

The analysis of data gathered by the literature review and interviews was made using Thematic Analysis. The results is the codes used to describe the data, and the themes identified within the codes.

These sections make references to the collected data, refer to Appendix A for summaries and descriptions of the referenced works.

4.1.1 Codes describing the collected data

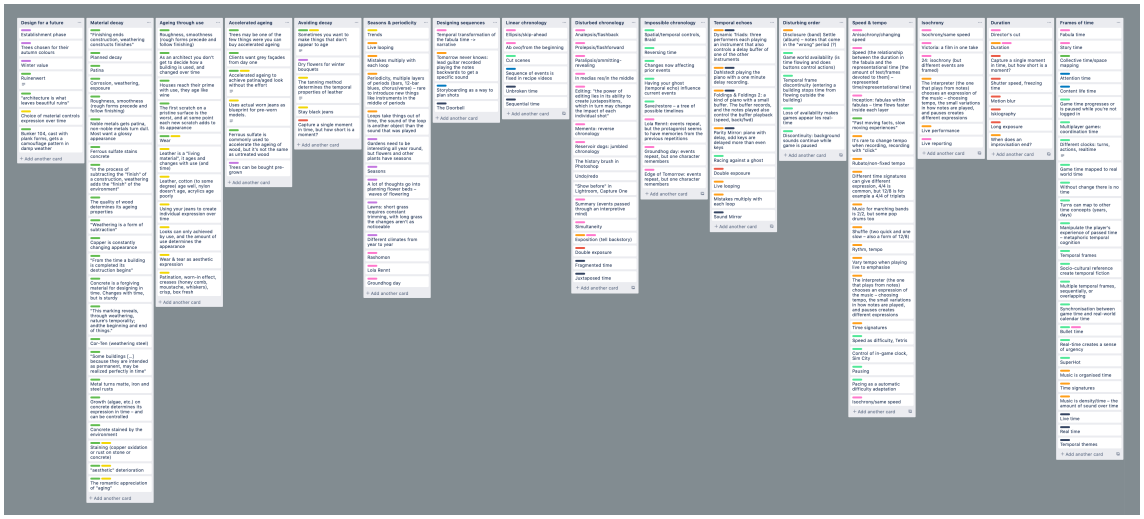

Figure 4.1: The coded data in Trello

The coding was done by grouping cards that were colour coded by design discipline and this turned out to create an unanticipated insight: with the data grouped by code I could see a pattern in the colours. The data from architecture, gardening, and fashion were largely coded with the same set of codes, and the

data from music, narratology, and game design with another set of codes. Photography clumped together in a few codes, but wasn't clearly a part of the two larger groups.

At first I took this as an indication of poor coding, that my coding was too specific to each design field, but after some more thought another idea emerged: architecture, gardening, and fashion deal primarily with the physical world, while music, narratology, and game design are about creating imaginary worlds. In the physical world, decay, ageing, use, and so on are dominant when considering time, and the direction of time cannot be reversed, for example. In the music, narratology, and game design new time lines can be created, and time can be worked with more directly. This is echoed in the interview with musician B where he said "music is organised time". Music is of course constrained by time in many ways, but the design of music, composing, interpretation, improvisation, is relatively free to organise things in time.

This division into two fairly separated groups is an interesting outcome from the point of view of Interaction Design. Interaction Design is in many ways a combination of design disciplines dealing with the physical world, like industrial and graphic design, combined with the non-physical, abstract, or imaginary, like computation.

The following sections describe the codes that were used in the analysis, along with example data for each. The codes that came from the card sorting exercise are described as "meta codes".

4.1.1.1 Design for future appearance

This code applies to data that is about designing for an anticipated future appearance. For example, architect A talked about how concrete can be cast in different ways to affect how it will appear when weathered. Another example from architecture is the idea of ruin value, that buildings can be designed to become beautiful ruins. horticulturist A said, on the subject of how gardeners design for all seasons, that "[they] can be chosen for the way their leaves turn yellow and red in autumn, and how they go together during that period of the year".

4.1.1.2 Material decay

This code describes data about how materials decay over time, through use, wear, and weathering. For example, architect A talked about how metals start out shiny but turn dull over time, and untreated wood greying. Both architect A, the literature on architecture, fashion designer A, and fashion designer B talked about posititive and negative aspects of material decay, "patination" is a (mostly) positive aspect, but materials also wear out and end up ugly or unusable. "Weathering is a form of subtraction" is a key quote from the analysed architecture literature.

4.1.1.3 Ageing through use

This code describes data where ageing is primarily related to use and not just time. For example, architect A said that houses reach their prime with use, and how scratches and stains form over time and eventually create desirable appearances. Fashion designer A, and fashion designer B talked about "living materials", materials that age and change their appearance with use. Fashion designer B said that some looks can only be achieved by use, and that wear & tear influences the aesthetic expression of jeans.

4.1.1.4 Accelerated ageing

This code describes data on how designers sometimes attempt to simulate ageing through use to, for example, create a product that has the desired worn, or aged, appearance. Fashion designer A talked about different methods for tanning leather to create a soft material otherwise only achievable through use, and fashion designer B explained how he uses worn jeans as blueprints for creating "pre-worn" designs. Architect A used treating façades with ferrous sulfate to accelerate the greying process as an example.

4.1.1.5 Avoiding decay

This code describes data where the designer attempts to create an artefact or product which appears to not age. Architect A mentioned how concrete can be treated to change very little over time, to keep its appearance and fashion designer B talked about "stay black jeans", a product that was the opposite of "dry denim" (which ages through use). Fashion designer B said that just as there are those who consider wear and tear to be the most desirable property of clothes, there are sub cultures where the ideal is instead "box fresh".

4.1.1.6 Seasons & periodicity

This code describes uses of time with repeating periods. In horticulture, seasons are always a factor in garden design, said horticulturist A. In music, looping techniques can be used to repeat the same sounds over and over, and create layers of sound, said both musician A and musician B. Musician B also said that the looping "takes the sound out of time", and that the looped sound is a different sound than its original. In cinema many films have used repeating periods of events to tell a story in a specific way, for example "Groundhog Day", in which the protagonist relives the same day over and over again, but remembers the previous iterations and learns from them, and "Run Lola Run" which portrays a similar situation. In fashion, trends are a form of periodicity, fashion designer B said, for example, that a 70’s trend is also an echo of the 20’s. Styles come in cycles and repeat, adding something on each iteration.

4.1.1.7 Linear chronology

This code describes data referring to four of the temporal themes from “Time, Temporality, and Interaction”: "live time", "real time", "unbroken time", and "sequential time", as well as techniques from narratology such as "ellipsis" (meaning to skip ahead in the story).

4.1.1.8 Disturbed chronology

This code describes data where a story is told in a non-linear order. Examples of this are narratological techniques such as "analepsis" (flashback), "prolepsis" (flashforward), and "in medias res" (starting from the middle). These are used in non-linear narrative films such as "Reservoir Dogs", "Memento", and "Pulp Fiction", in which scenes are presented out of order. This creates suspense, and interest, for example by hiding key events until they are ready to be revealed.

4.1.1.9 Impossible chronology

This code describes data such as saving and restoring in games, and the concepts used in the game "Braid" where the player can reverse time, but some actions are special and are irreversible. Films such as the aforementioned "Groundhog" day, and "Run Lola Run", but also "Edge of Tomorrow" describe the repeating sequence of the same events, but the protagonist somehow remembering the previous iterations and can therefore respond to the events differently each time.

4.1.1.10 Designing sequences

This code initially encompassed all the data for previous three codes, "Linear chronology", "Disturbed chronology", and "Impossible chronology". A second iteration of the coding process resulted in splitting it into multiple codes in order to better represent the nuanced information. It can be thought of as a group of codes that describe data about how events are put in various orders to create certain expressions.

4.1.1.11 Temporal echoes

This code describes data such as the game "Mario Kart" (as well as other racing games), where you can race against yourself from a previous race, as well as projects described by musician B where otherwise regular instruments are fitted with buffers that record and replay sounds at a future time.

4.1.1.12 Disturbing order

This code describes data that describes violations against the expected sequence, speed, or duration of events, for example how in some games you enter a different "temporal frame" during certain parts. For example, when entering a building in "Grand Theft Auto" it doesn’t matter how long you stay

inside, no time will have passed outside of the building when you exit. Musician A also described how music often consists of repeating patterns, such as chord sequences, or verse-chorus-verse structures, and that a composer or performer can create tension, or interest by breaking the expected sequence.

4.1.1.13 Speed & tempo

This code describes the data that referenced rates of change, rhythm, etc. For example musician A talked about how different time signatures, such as 4/4 and 12/8 in music could be used to create different expressions, and how a band could change the tempo when playing a song to create a more dynamic expression, or emphasise certain parts such as the chorus. In cinema, the film "Inception" describe worlds within worlds where the time of inner worlds runs slower than the outer worlds.

4.1.1.14 Isochrony

This code describes examples of the narratological technique by the same name, which describes stories that take as long to tell as the events they describe. The film "Victoria" describes a night in Berlin in a single, two hour long, take, and in the TV series "24" every minute on screen is a minute in the narrative. Performances of for example music are also arguably isochronous in that the piece takes the same time to perform as it does to experience.

This code also appeared as a meta code in the card sorting exercise, describing the same data.

4.1.1.15 Duration

This code describes data where the main parameter in the design is the duration of an event or events. Photography deals a lot with duration, where shutter speeds control the appearance of the resulting image. The photographer can either freeze time with a fast shutter speed, or create motion blur with a slow. Very slow shutter speeds are examples of long exposure photography, where minutes, or in extreme cases hours, are captured in a single photograph. In musical improvisation, practised by for example musician B, there is an open question as to when a performance ends, i.e. what is its duration? The audience, having never heard the piece before, can, for example, be kept in suspense in that there is no cue for when the piece will end.

4.1.1.16 Frames of time

This code describes data that relates to temporal concepts. For example, in narratology terms such as "fabula time", and "story time" describe different aspects of the narrative. In game design, meanwhile, there exists concepts such as "temporal frames", and in Interaction Design "temporal themes" were proposed in “Time, Temporality, and Interaction”. In western music, says musician A, "time signature" refers to the number of beats per unit, for example

4/4, 3/4, or 8/4. These are all examples of temporal concepts used to describe aspects of time in these fields.

4.1.1.17 Time as a side-effect

This meta code describes data where the temporal aspects are side-effects and not the primary goal with a design. For example architect A talking about different materials and their ageing properties, and how materials acquire stains from their surroundings. Some of these effects are desired, and planned, but architect A, as well as fashion designer A also mention how sometimes people come to value things that are old and worn because of how they happened to turn out, they stained or wore down just right. This is not necessarily design, but an interesting consequence of design, which can serve as inspiration, and could be made intentional.

4.1.1.18 Temporal transformation

This meta code describes data that describe how the order of the sequences of events is chosen, or speed and tempo is varied. Examples from narratology include "analepsis" (flashback), "prolepsis" (flashforward), as well as the different kinds of "clocks" in games, turn based, action based, realtime, etc. It also includes musician B saying "music is organised time", and the double exposure technique, where two events are juxtaposed together in one photograph.

4.1.1.19 Time/space challenge

This meta code describes data where the designer deals with the temporal aspects of physical materials. Examples include patination in its many forms, how materials change through weathering and use, and "ruin value", considering how buildings will appear not only when in use, but also when they eventually become ruins. In gardening, Horticulturist A says, how gardens appear in autumn and winter must be considered, not only spring and summer. Trees, for example, can be chosen both for their autumn colours, but also for their "winter values", how they appear in the winter months.

4.1.1.20 Repetition

This meta code describes data that includes some kind of repeating aspect, such as "looping" mentioned by musician A and musician B, the musical instruments built by musician B that include delays of different kinds, and examples from cinema such as "Rashomon", where the same story is told from different perspectives, and "Run Lola Run", where the protagonist relives the same events over and over again.

4.1.1.21 Time as challenge

This meta code describes data where the designer deals primarily with time in itself. For example time signatures in music, described by musician A, pause as

a feature in games, or the song "Tomorrow Never Knows" where the notes for the lead guitar were played backwards when recorded, so that the recording could be reversed to create a particular sound. These are examples where time is explicitly manipulated or described.

4.1.1.22 Save & restore

This meta code describes together the data such as save and restore in games, and the undo and redo features in many computer applications, which both are ways of being able to go back in time and try a different approach. The experience of using, and therefore the expression of, an application with an undo feature is surely different from one without it. The propensity of the user to experiment knowing that there is a possibility to go back is probably greater than if every action was final, just like being able to save can make players try risky of fun things, as they can always go back to the last save point.

4.1.1.23 Time travel

This meta code describes data where events repeat, like in the film "Run Lola Run", or games such as "Braid" where time can be reversed, and narratological techniques like "analepsis" and "summary" and "exposition" (two ways of describing prior events).

4.1.2 Themes describing the collected data

Based on the codes, as described above, a set of themes were identified. The themes capture broader patterns of the data than the codes, and are the outcome of the subsequent analysis. These themes are intended to be used as a basis for discussing time as a design material in general, and for how it relates to Interaction Design.

4.1.2.1 Physical materials

This theme captures the temporal aspects of the choice of physical materials. Physical materials are subject to wear, weathering, and decay in all its forms, whether intended or unintended. The materials deteriorate over time through for example use, wear, or exposure to the elements, and this deterioration is almost completely inevitable. Different materials experience deterioration differently, and can be treated to deteriorate faster or slower, or in certain ways.

Deterioration can be desired, as in patination, or undesired. It can also be intended, as when a jeans brand like Nudie Jeans Co. designs jeans meant to be "worn in" to create the desired aesthetic expression, when architects select materials whose appearance changes with time, or unintended and just a consequence of physics. Unintended consequences should probably not be considered as design, but could, for example, later be used as inspiration for design.

The end result of decay can be so desirable that products are pre-aged to the desired appearance, for example through treating jeans to create a worn-in look, treating leather to be softer, or using ferrous sulfate to make a wood façade turn grey.

This theme was formed from the codes "Design for future appearance", "Material decay", "Ageing through use", "Accelerated ageing", and "Avoiding decay", but also "Time as a side-effect" and "Time/space challenge".

4.1.2.2 Sequences

This theme describes ordering of events. In literature, cinema, games, and other fields such as music, that are not constrained by "physical" time, different orderings of events can be used to create different expressions. A murder story needs to wait until the end to reveal certain facts to keep up suspense, and would have a very different expression if described without flashbacks, or other similar non-linear techniques.

In works such as "Foldings" and "Parity Mirror", musician B uses delay effects in improvisation to, in a way, play together with himself, juxtaposing different events together. In other projects the delay effect is more complex and affected by what is currently played, not only juxtaposing, but also repeating and transforming previous "events" into new. Similarly Hallnäs and Redström (2001) in their work "Sound Mirror", create an artefact that "[tells] the near history of the room" by playing sounds recorded 5-15 minutes ago.

Double exposure photography is another example of juxtaposition of events.

In games such as "Braid" and "Prince of Persia: Sands of Time", time can be controlled, and for example reversed, a very different experience from regular platform games that they are otherwise similar to.

This theme was formed from the codes "Designing sequences", "Linear chronology", "Disturbed chronology", "Impossible chronology", "Temporal echoes", "Disturbing order", "Temporal transformation" and "Time/space challenge".

4.1.2.3 Temporal variation

This theme captures the flow of time, such as speed, which can be described as the relationship between the duration of events in different temporal frames. In some mediums such as cinema, television, and games, events can be shown in slow motion, for example to emphasise quick motion that would otherwise be hard to follow.

Other works may use isochrony to create a different feeling, like in "24" where the audience are meant to experience some of the urgency that the protagonist is feeling when racing against time to stop the terrorists.

Varying the speed of the narrative or music piece is a way to set the expression of a work, for example musician A describes how one can dynamically change the tempo when performing live to emphasise sections, or

create a specific dynamic. Both musician A and musician B describe how artists interpret a work through, among other things, choosing the tempo.

This theme was formed from the codes "Speed & tempo", "Isochrony", and "Duration".

4.1.2.4 Repetition

This theme describes how events are repeated either in a loop, or through a reset to a point in time, with subsequent resets forming a sort of tree of possible futures that weren't explored. The undo/redo feature of a computer application has many similarities with save/restore in games. Choosing to include such a feature changes the expression of a game – consider, for example, the experience of trying to complete "Super Mario Bros.", a game without any possibility of saving progress, compared to a later game like "Doom" where the state of the game at any point in time can be saved and later restored. The player is likely to experience the dangers of "dying" in these games differently.

By coincidence, perhaps, similar narratives are portrayed in for example cinema, in films such as "Groundhog Day", "Run, Lola, Run", or "Edge of Tomorrow", where everyone but the protagonist seems to be unaware that events are repeating. The protagonist can eventually solve their problem through trial and error, similar to how a player plays the same game over and over again, trying different ways and learning to anticipate what will happen.

Games like "Braid" and "Prince of Persia: Sands of Time" have a different take on the save/restore feature where time can be reversed when a mistake is made.

Perhaps less obviously, a similar thing happens in the real world with humans and nature adapting and anticipating for example the changes in weather that comes through the changes in season. Horticulturists design with, and against, the seasons to create gardens that are interesting all year round, or have specific expressions in some seasons, for example by choosing trees for their autumn colours. Similarly fashion deals with trends, that are repeating cycles of ideas and styles.

This theme was formed from the codes "Repetition", "Save & restore", and "Time travel".

4.1.2.5 Timelines

This theme captures how chronologies relate to each other. Designers must consider different timelines when thinking about time as a design material. In fields not constrained by "physical" time, multiple timelines may exist. In any narrative there is always the "fabula time", the time in the described world, and the "story time", the described time. There is also the time in the world of the reader, or audience.

In games, the way time is framed can change and many overlapping timelines may exist. In multi player games there may be one main timeline that governs what happens when you play, but there can still be a separate timeline for your character in that when you log out it no longer exists on the main timeline.

This theme was formed from the codes "Frames of time", "Time as challenge".

4.2 Prototype evaluation

Subtype	AVERAGE of Baseline	AVERAGE of Color Pen	AVERAGE of Color Wheel
Anger	1.3	1.0	1.3
Awe	1.8	2.0	2.3
Being moved	1.3	1.3	1.5
Boredom	2.3	2.0	1.6
Confusion	1.3	2.3	1.9
Enchantment	1.5	2.0	2.5
Energy	2.3	2.8	3.6
Fascination	1.8	2.7	3.3
Feeling of beauty/liking	2.6	2.5	3.4
Feeling of ugliness	1.3	1.7	1.6
Humor	3.5	3.7	3.9
Insight	1.0	2.2	2.4
Intellectual challenge	2.8	2.7	3.8
Interest	3.0	3.5	3.9
Joy	3.3	3.2	3.9
Nostalgia	2.3	2.2	1.5
Relaxation	3.5	3.2	3.0
Sadness	1.3	1.0	1.3
Surprise	2.0	2.5	2.6
Uneasiness	1.3	1.0	1.3
Vitality	2.0	3.0	3.1

Subtype	AVERAGE of Baseline	AVERAGE of Color Pen	AVERAGE of Color Wheel
Joy	3.3	3.2	3.9
Interest	3.0	3.5	3.9
Humor	3.5	3.7	3.9
Intellectual challenge	2.8	2.7	3.8
Energy	2.3	2.8	3.6
Feeling of beauty/liking	2.6	2.5	3.4
Fascination	1.8	2.7	3.3
Vitality	2.0	3.0	3.1
Relaxation	3.5	3.2	3.0
Surprise	2.0	2.5	2.6
Enchantment	1.5	2.0	2.5
Insight	1.0	2.2	2.4
Awe	1.8	2.0	2.3
Confusion	1.3	2.3	1.9
Feeling of ugliness	1.3	1.7	1.6
Boredom	2.3	2.0	1.6
Nostalgia	2.3	2.2	1.5
Being moved	1.3	1.3	1.5
Uneasiness	1.3	1.0	1.3
Sadness	1.3	1.0	1.3
Anger	1.3	1.0	1.3

Figure 4.2: The aggregated AESTHEMOS questionnaire responses, grouped by emotional scale (vertical) and application (horizontal), sorting by scale (left) and by average score (right)

Three drawing applications were evaluated. Two of which were prototypes where the colour changed as the testers were drawing, and one which was a basic drawing application with no such temporal effects. The latter was included in the evaluation to get a baseline that the other two could be compared against.

When analysing the emotional scales I looked at the individual scales, but also groups of scales defined by AESTHEMOS, such as "negative emotions". These groups, called "subclasses of aesthetic emotion" can be found in section B.3.

The questionnaire results indicate that the baseline application scored low on negative emotions, but in the middle of the scale on positive emotions, with "relaxation" and "humor" slightly higher. The average score of that last emotion was, however, skewed by one participant reporting very strong emotion on both questions on this scale. The participants testing this application did not express anything specific about the application during the test, their comments were mostly about how it's difficult in general to draw, and especially on a computer – something almost all test subjects said. With a larger study, outliers like these would even out, or could be handled by various statistical methods to have a lesser impact on the overall results.

The questionnaire responses indicated that bot the prototypes featuring temporal effects scored higher than the basic drawing application on almost all emotional scales, especially on emotions such as "interest", "fascination", "energy", and "vitality" (see section B.2 for the full list of AESTHEMOS emotional scales). This was also reflected in the comments the test subjects made while drawing, and my impression coming from observing them. The participants using these two prototypes seemed to be more engaged, and were, for example, curious about how the change in colour worked. Some test subjects mentioned that they thought that you could probably develop strategies for how to use the effects, for example letting the colour decide what you drew and when – when

the colour was brown you could draw a tree trunk, when it was green the leaves, and so on, moving between different parts of the drawing as the colour changed. That the participants explored the temporal effects and were thinking in these terms indicates that the two prototypes were more interesting and engaging to them, than the basic drawing application, as expected.

Ordering the questionnaire results by average score and the prototypes from least to most apparent temporal effect (i.e. the basic drawing application followed by Colour Pen and then Colour Wheel), a pattern emerges that shows stronger reported positive emotions, and what Schindler et al. (2017) calls epistemic emotions (e.g. intellectual, thinking-related, emotions) as the apparent temporal effect increases (see Figure 4.2). If the pattern would hold in an evaluation with a larger group of people, it would be in line with what I intended to achieve with these prototypes, and in line with my impression from observing the test subjects. However, the differences in reported emotion strength are not huge, and the sample size small enough that this could be the result of chance.

Looking at the differences between Colour Pen and Colour wheel on the emotional scales, the most pronounced differences are "intellectual challenge", "energy", "fascination", and "feeling of beauty/liking", where Colour Wheel scored higher, and "nostalgia" and "boredom" where it scored lower. For most of these Colour Pen scored close to the basic drawing application. However, the test subjects reacted on the whole very similarly to these two prototypes. While one test subject did figure out a strategy for getting the colour they wanted in Colour Pen – drawing nonsense until the right colour appeared – most testers used whatever colour happened to be the current colour. Not all elaborated on whether or not they understood the mechanics behind the colour change, and at least one tester of Colour Pen was convinced that the colour changed as in Colour Wheel. A couple of participants said that they considered the changing colour to be a positive thing, and that it helped them get over performance anxiety as they felt they were not good at drawing.

Emotions that could be considered to be related to confusion and frustration, such as "surprise", "anger", and "uneasiness", scored about the same for all three applications. The specific emotional scale "confusion", though, scored higher for the two prototypes with temporal effects. This was, however, not something I observed. None of the participants expressed what I interpreted as confusion. This inconsistency could be due to the limited data set, or to differences in how I interpreted the comments and behaviour of the participants, and what they felt they experienced.

A frustration that almost every participant expressed was that it was difficult to draw on a computer. Another frustration voiced by perhaps half of the participants, including testers of all three applications, was that there was no way to erase a line. Two of the participants testing the basic drawing application figured out that they could draw with white to erase, but this option was not available to the testers of the prototypes with temporal effects as they could not change colour themselves.

5
Discussion

There are two main parts to this thesis: the development of temporal themes, and a demonstration of how these can be used in practice. The first part consisted of a literature review and interviews, and resulted in a set of themes that cover how time is used as a design material in a number of creative field. The second part demonstrates how these themes can be used in Interaction Design, through the creation and evaluation of two drawing applications that explore one of the temporal themes.

5.1 Literature review and interviews

The five themes identified in the analysis of the literature review and interviews, describe distinct aspects of temporality in design. "Physical materials" describes temporal aspects of the physical world, whereas the other four temporal aspects of systems are not constrained by physics. "Sequences" describes order of events, and whether or not all events are included. "Temporal variation" instead describes the flow of time, as in rhythm, tempo. "Repetition" deals with loops of time, and finally "Timelines" the relationships between different kinds of time.

This makes a richer description of how time can be used as a design material than what we presented in “Time, Temporality, and Interaction”. In that initial work on the topic we considered primarily sequences of events, and their relationship to real world time. The results of this work indicate that there is a broader range of temporal aspects, for example speed, duration, and aspects of repetition not covered in the initial article, as well as a very interesting division between "physical" time and "imaginary" time. That there exist more temporal aspects of design than sequences is not surprising, and something that has been suggested by for example Lim et al. (2007), as well as Orehovački et al. (2013).

The clear separation of temporal aspects relating to physical materials, and imaginary timelines such as those in narratives is interesting from the point of view of Interaction Design. Interaction Design deals both with physical materials and non-physical, imaginary materials. Interactive artefacts usually have some tangible form, in the form of input controls, but they also often have a digital, largely intangible element. Computational technology in many forms, and graphical user interfaces, are closer to narratives than to physical materials (even though graphical interfaces are sometimes designed to appear like tangible interfaces, e.g. skeumorphism).

5.1.1 Temporal themes as a thinking technique

In “Time, Temporality, and Interaction” we proposed that temporal themes could be used as a thinking technique in design, both for analysing and for designing new things. The technique is very simple, you analyse an artefact by considering it in relation to each of the themes, describing it in the terms of that theme. As an ideation technique it is equally simple, and works through asking "what if?" in the context of each of the themes.

Take the word processor in which I’m writing this, as I’m writing I’m typing and deleting, revising, changing, rearranging. I can analyse this activity by considering the themes one by one. When looking at it in the context of "Physical materials", for example, I can ask if there are any aspects of the activity that degrade over time, and if so if the degradation increases or decreases it’s perceived value. Many times there will not be an answer, and that should be seen as an opportunity and a possible approach for a new artefact.

When ideating in a design process you can use the themes to generate ideas by considering them one by one and asking a "what if?" question. For example, when creating a new kind of word processor, and looking at the "Temporal variation" theme, you can ask "what if there was a rhythm to the application?". What would rhythm mean? Would it mean that you had to type at a certain number of characters per minute, for example? How would that change the experience of using the application?

Many ideas generated this way will probably appear useless, or only create confusion and frustration. This is also true in general for idea generation, however. Perhaps the idea above, adding rhythm to a word processor, evolves into adding rhythm to a e-reader application, and suddenly you’ve invented a competitor to Spreeder[1] – a speed reading app that shows words and phrases at a fixed pace, ostensibly to help you read faster.

In the following sections I discuss some ideas that could result from asking these questions in relation to the five themes uncovered by the analysis.

5.1.1.1 Physical materials

What would it mean for an interactive artefact to be "worn-in" and create an ever changing aesthetic expression? Unintended consequences of wear, such as tangible interactive artefacts breaking down are probably common, but what about wear that creates patina or makes the artefact more comfortable? Can interaction with a tangible artefact become more desirable the more it is used? This could be in a physical sense, as with jeans or leather, materials that age gracefully and become more desirable with use, but perhaps also in a digital sense? Using physical materials that patinate would certainly achieve the goal of making the artefact as an object more desirable over time, but what about the interaction? How can artefacts be designed in such a way that aesthetic expressions of interaction develop over time?

Consider an interactive artefact that learned from its user. It would learn to anticipate the user’s behavioural patterns, and use this to create smoother

[1] https://www.spreeder.com

interaction. Perhaps anticipate what the user wanted to do, and present the most likely option first, or even just do it, without prompting? This could go too far and become creepy, but perhaps there is a goldilock's zone where, through use, the interaction would become more pleasurable? This could be considered a form "wearing-in", and something that could only be achieved through use over time.

Similarly to how fashion designer B uses a pair of worn jeans as blueprint for the design of pre-washed and pre-stressed jeans, an artefact that has been used and learnt from its user could be replicated for other users. This is not dissimilar to how machine learning, a building block now being used more and more in Interaction Design, works in practice: a model is trained on the behaviour of one or more users, and then the trained model is used by all other users.

In a way, this is what services like Spotify or Netflix, already do. They suggest songs, and films based on their users' listening, and viewing habits. The suggestions supposedly get better with use[2], and thus the interaction becomes more pleasurable. Nudie Jeans Co. have created pre-stressed jeans using the worn jeans of celebrities and influencers as blueprints – Spotify and Netflix could make it possible to subscribe to the recommendations that the same celebrities and influencers get, and thus create an equivalent of pre-stressed jeans for their services.[3]

5.1.1.2 Sequences

In "Time, Temporality, and Interaction" we looked at sequences of time and how they changed the aesthetic expression of interaction. One way we explored this was through the design of a set of drawing applications that demonstrated the different "temporal themes". The same ideas could be used to demonstrate the "Sequences" theme, which was not included in that work.

One of the drawing applications in "Time, Temporality, and Interaction" was inspired by live looping, which were discussed in the interviews with musician A and musician B. Lines that were drawn faded out over time, how sounds from a musical instrument. At more or less random intervals, lines would reappear. There was no way to control the reappearance, it happened by itself. Even though it was inspired by live looping, in fact it was more similar to the musical instruments described by musician B, where sounds are delayed. There was not as much logic to when the lines reappeared as in the instruments created by musician B, but there is a distinct similarity. We experimented with adding controls to the application that would allow you to choose which lines would fade and reappear, and which would be permanent. Other drawing applications could be made in the same vein, with controls that would be closer to loop decks used

[2]Anecdotally, some people value the recommendations to such a degree that they make sure not to let other people choose what music to play on their accounts without activating the "private session" feature first. This feature, among other things, makes sure that the songs that played are not considered when Spotify recommends songs in the future.

[3]The described feature is similar, but not identical to shared curated playlists. The difference would be that the playlist would be based on the recommendations that the person sharing it would get, and not what they had actively chosen to include. The person sharing the recommendations would only be able to influence the contents by listening to songs, or watching films.

in live looping. These could be used to create visuals in the same way as someone performing with a loop deck creates music.

The lines that reappeared in the drawing application described above could also be thought of as flashbacks. This leads to the question what a flashforward would be? It's of course physically impossible to show what the user will draw in the future, but it can be predicted. Using predictive algorithms it could be possible to made a guess at what the user will draw in the future, based on what they've drawn so far, to some extent. A similar effect could be added to word processors, using machine learning models for text generation[4]. A suggestion for the next word, sentence, or paragraph, could be displayed as you typed[5], showing you a possible future as a kind of flashforward.

5.1.1.3 Temporal variation

When thinking about this theme it strikes me how a lot of interaction is in a way isochronous. Typing, as I'm doing now, or drawing, or anything else that is primarily driven by my actions happens at the same pace as I experience it. Not considering undo, it's a linear, real time, activity. What if it was not? What if activities like these had a rhythm and tempo? Perhaps all that would happen would be that you'd get completely stressed out trying to follow the tempo, or perhaps you would get a lot of work done, but either way these are changes to the aesthetic expression of the interaction. You would feel different, you would experience something different.

For "Time, Temporality, and Interaction" we created a drawing application where the colour of the brush changed continuously. Whether you were drawing or not the colour would change through all the colours of the rainbow. This created a fixed tempo that you could work with in different ways. You could choose to draw something appropriate for the current colour, ignore the colour, or wait for the desired colour to become the current colour. For example, if you were drawing something green and the colour turned into blue you could choose to let it inspire you to start draw something new that is blue, water, sky, or a blue dress, or you could stop drawing and wait until the current colour became green again.

5.1.1.4 Repetition

This theme relates closely to the undo feature of many computer applications. Just having an undo probably changes the way a user feels when using an application. Without undo, mistakes can be costly, but with undo mistakes can easily be corrected. Does this increase the users' propensity to experiment? Like in "Groundhog Day", does having access to an undo feature make it possible, like its protagonist, to learn things through repeatedly trying and experimenting with cause and effect?

The same thinking applies to save/restore in games: when you're on the last level of "Super Mario Bros." you are probably not in the mood to try something

[4] For example using OpenAI's GPT-2, see https://openai.com/blog/better-language-models/

[5] In fact, this is already done in a limited fashion by Google's Gmail service.

new, since a mistake would mean having to play the whole game again from the beginning. The same situation in "Doom" is very different, and it should be possible to explore this theme by, for example, creating variants of computer applications or games with and without undo/save and observe the difference in expression this creates.

5.1.1.5 Timelines

Like "Sequences", this theme again comes back to “Time, Temporality, and Interaction”. When looking at sequences of time we also considered the different "temporal themes" on a scale of how close they were to "reality". Things can be designed with temporal aspects close to real world time, or far from it. In each case there is a relationship between the time experienced by the user and the temporal aspects of an artefact. For example, in common computer applications such as word processors, or drawing applications, the time between actions does not change the outcome. Typing at a hundred characters per minute or per hour makes no difference in the timeline of the word processor. The timeline of the word processor is defined by actions, and no time passes between actions.

The drawing application from “Time, Temporality, and Interaction” described above, was inspired by live looping, can also be analysed and described in terms of "timelines". Considering only the fading of the lines, and not the echoes, what we did was to change the temporal aspects of a traditional drawing application with something closer to "reality", where time passes regardless of whether there are actions or not. This is perhaps not how drawing on paper works, but it’s closer to playing a musical instrument. A tone is produced, and it quickly fades away. This radically changes the expression of the application.

The drawing application described in subsubsection 5.1.1.3 formed a pair with another, similar application. Together they explored this action-driven versus clock-driven internal time: in the first the colour of the brush would automatically change at a fixed pace through the colours of the rainbow, whether you were drawing or not. In the second the colour would change through the same scale, but only as you were drawing. If you wanted to draw red lines, and the current colour was blue, you had to "use up" all the hues from blue through yellow first. In the first you could instead just wait for red to become the current colour. This is an example of differences in timelines, not dissimilar to the different "temporal frames" in games (Zagal and Mateas 2010). The first drawing application can be compared to traditional variants of the first person shooter (FPS) genre, where the player must constantly react to enemies appearing and has no control over the flow of time. The second drawing application is more like a non-traditional FPS like "SuperHot" where time does not flow unless you move. In that game, if you stand still everything else, including enemies and bullets, are as frozen in place.

Another way that timelines can relate to each other is how the calendar of a game like "Animal Crossing" or "World of Warcraft" relates to the calendar of the real world. In these games, some events only happen on specific dates. What if other computer applications worked like this, where certain things were only available on certain days? What if, for example, a word processor only allowed

its users to use the typeface Comic Sans on April 1st?

5.2 Evaluation of the prototypes

The Colour Pen and Colour Wheel prototypes seem to have been experienced differently than the basic drawing application by the testers. They were more engaged, interested, and curious, and in the questionnaire reported stronger emotions on the positive and epistemic scales compared to the basic drawing application. There was some difference between the two prototypes, which could be related to the difference in control that I had designed. The results indicate that these prototypes achieved the intended aesthetic expression. It also seems like I managed to frame the test in such a way that the testers didn't feel confused and frustrated by the prototypes.

The basic drawing application was reported as enjoyable, and scored very low on negative emotions. While it was designed with no specific expression in mind, I expected the experience of using it to be neutral to positive. The reason for this was that I expected the participants to be curious and interested in the experiment, and thus a positive attitude towards it.

That "relaxation" was a strongly felt emotion surprised me, but in hindsight I think it makes sense; drawing and doodling without a purpose is probably a calming activity. It could also be explained by the participants being familiar with drawing, and drawing applications, but I would not expect only familiarity to produce such strong emotion. Even though the number of participants is too small to draw any firm conclusions from the questionnaire results, they do align well with what I expected.

While the testers of the basic drawing application enjoyed using it, the testers of the Colour Pen and Colour Wheel prototypes were more engaged. Their questionnaire results indicate that they felt stronger positive and epistemic emotions than those using the basic drawing application, and their reactions while drawing showed that they were curious about how the applications worked, and that they were interested in what was happening. Emotions such as "fascination", "intellectual challenge", and "interest" were especially strong for the testers of Colour Wheel, and for example "boredom" lower.

The questionnaire results show differences between the Colour Pen and Colour Wheel prototypes in line with what I was expecting to see. In Colour Wheel the application takes control to a larger extent than Colour Pen, and I was expecting this to be reflected in the emotional scales mentioned above. However, I cannot say the same thing about the reactions I observed during the tests. My impression of the testers of both of these is that they behaved and reacted mostly the same way. They were interested in how the colour change effect worked, but didn't react differently to the two application. Perhaps the relatively short duration of the test, five minutes, was a factor that made the two applications appear more similarly than they would have if the testers had been using them for a longer time. Perhaps a larger study would show if the questionnaire results or my observations are closer to the truth.

The testers adapted to the changing colour in roughly two different ways, with

overlap between the testers of Colour Pen and Colour Wheel. The first was to continue drawing what they were drawing and let the colour change, even though it wasn't "right" (e.g. a christmas tree with parts in green, turquoise, and blue), and the second was to move between different parts of the drawing as the colour changed (e.g. draw grass when the colour was green, and shift to a water as it turns into turquoise and blue, and so on). Some testers used both strategies, some one or the other. One of the testers of Colour Pen also came up with the strategy of "wasting" colour to make the one they wanted come back quicker.

Some testers of Colour Pen and Colour Wheel said they felt that the changing colour was a positive feature. They were not confident in their drawing skills, and not having to choose the "right" colour for things made them feel less stressed about getting the drawing right. One said, while drawing a blue croissant, that if they had had a way to change colour, they would have enjoyed the experience less as they would have been focused on getting the details, such as colour, right. Another variant of this was how some testers reported how they let the current colour guide and decide what to draw. As the colour changed they would move on to draw things that were "appropriate" for that colour. This was a somewhat unexpected outcome, and perhaps a future study could include questions trying to uncover if this is a common reaction, or an artefact of the group of testers in this evaluation.

When designing Colour Pen and Colour Wheel I was thinking about the "Timelines" theme, and how different styles of computer games express time and create different aesthetic expressions. Colour Pen is closer to a strategy game where the player can plan and think about their next move for as long as they like. Colour Wheel, in contrast, is more like a real time game, where the player must react to the things that happen, in this case the colour changing. I was expecting the testers of Colour Pen to be more planning, as they had more control, and the testers of Colour Wheel to instead react to the changing colour. The results were not that clear cut, and while one tester of Colour Pen figured out that they could "waste" colour to get the one they wanted, I think that the other testers were thinking that the colour was changing continuously, and acted as if it were. Perhaps telling the testers how the applications worked before the test, giving them tasks specifically designed to make them uncover and work with the effects, or giving them more time to explore them would have made the difference between the two applications more clear.

Since Colour Pen and Colour Wheel don't work as you would expect a typical drawing application to work, in that the brush colour changes, I was expecting to see emotions related to frustration scoring higher for these than the basic drawing application. This could be the case, since "confusion", and "surprise" both scored higher for both prototypes compared to the baseline, and "boredom", which could possibly be said to be related, scored lower. However, these differences are small, and for example "anger" and "uneasiness" scored more or less the same across all applications. There were no strong expressions of frustrations expressed from the test subjects, except for almost everyone saying that it was hard to draw in general, and especially to draw on a computer. My impression is rather that the test subjects were curious about the temporal

effect and wanted to understand it, than being frustrated or confused by it.

The reason why there was little confusion and frustration reported could also be explained by how the test sessions were framed. I followed the suggestion of Hallnäs and Redström (2001) and introduced the applications as experimental, which primed the test subjects to not necessarily expect a drawing application like one they were used to. I believe this was a good thing, as I suspect that otherwise I would have gotten the result that confusion and frustration was the experience of using these prototypes. Instead I think I managed to filter out that noise to get a better signal that includes other emotions too.

The evaluation was performed with nine test subjects testing one of three applications each, in other words there were three testers per application. This is not enough to draw any firm conclusions from the questionnaire results alone. I think that the AESTHEMOS questionnaire is a useful tool for the difficult task of evaluating something from an aesthetics – rather than usability – point of view, and I would have liked to be able to perform a full scale study to see what the results had been. Using it in combination with observation, as I've done was also useful, however. I think that had I relied on observation alone, or asked open ended questions and analysed the results I would have missed some details. For example, it is interesting that even though I expected a difference between the Colour Pen and Colour Wheel applications, I did not observe any distinct difference in the reactions of the testers, but the questionnaire responses indicate that there is a difference. That difference is also in line with what I had expected to see. A larger study could make the questionnaire results more reliable and resolve this issue.

There is also a possibility that the differences I believe I observed between the basic drawing application, my baseline, and the two prototypes, could be explained by something else than the fact that the prototypes were using time as a design material. The novelty factor of the applications may account for the stronger emotional responses of for example "joy" and "interest", and the same could have been achieved by using another kind of design material. A more rigorous study design is needed to control for this.

This evaluation also used aesthetic emotion and experience as a measure for aesthetic expression. Aesthetic expression is a property of an artefact, and aesthetic emotion what it does to someone who interacts with it, but they are not the same, and it's possible that the aesthetic emotions that the testers reported could be caused by aesthetic expressions in the prototypes that were other than those I intended. Another approach would have been to have evaluated the prototypes for example in a design critique session and have experts assess them from a theoretical point of view.

5.3 Reflections on the thesis project

Looking further and wider into various creative fields than we did in "Time, Temporality, and Interaction" also widened and deepened the results in terms of examples of time used as a design material. I'm especially happy about including narratology, for its well developed language about temporal

transformations, and for its thoughts of the relationship between the timelines of the story and the audience.

At the same time, I was disappointed by the lack of literature on temporal aspects in architecture. I was expecting to find more creative uses of weathering and decay, but while what I found was interesting reading, it was very thin. The practising architects I interviewed talked about the effects of time, but unfortunately I did not get the chance to talk to architecture researchers, who may have been able to direct me to relevant literature.

The temporal themes defined in this thesis ended very different from those in “Time, Temporality, and Interaction”. In fact, the themes from that article could almost all be said to fit in one of two of the new. The reason for this, I think, can to a large extent be explained by the inclusion of creative fields that deal primarily with physical materials, such as architecture and fashion, as well as the deeper look into narratology.

It was unexpected to me that the analysis would reveal such a strict divide between the creative fields dealing with physical materials, and those that do not. In hindsight it make sense, and might be a variant of what we in “Time, Temporality, and Interaction” described as a scale between closeness to reality and degrees of freedom for the designer. Physical materials are inherently closer to reality, and put hard limits on designers’ freedoms.

When ideating on how I could create prototypes to demonstrate time used as a design material in Interaction Design I had many ideas, but most were not possible to implement for practical reasons. The fact that I’ve worked on this thesis alone has also put limits both on the amount of ideas, their quality and development, and the possibilities for implementing them. In the end I explored the same theme we did in “Time, Temporality, and Interaction”, in part because of the prototypes I built back then those two, as a pair, have continued to fascinate me.

One happy surprise from the evaluation of the prototypes was that some testers said that they felt less self-conscious about drawing when drawing in the two prototypes with temporal properties. They felt less pressure about drawing well when there were aspects that weren’t under their control. This would be an interesting topic to research further.

It was difficult to find a way to evaluate the prototypes from an aesthetics point of view. The AESTHEMOS questionnaire that I ended up using is not suitable for the number of participants that I could recruit, unfortunately. However, the alternative, design critique, did not feel like it would have been as good of a demonstration of how time can be used as a design material in general, as I believe it is harder to scale up. Larger scale projects may get better insights from asking their potential future users, and AESTHEMOS can, for example, be used in tandem with more traditional usability tests to cover both aesthetics and usability, if needed.

For me, the aesthetics point of view is really important. I have come to firmly believe that in the academy, Interaction Design concerns itself too much with usability. As Hallnäs and Redström (2002) noted 18 years ago, computational technology has moved on and is no longer primarily about *use*, but about being

a part, a *precence* in peoples' lives. This requires a different mindset in design. There is still a place for efficiency, usability, and more traditional HCI approaches, but I believe they are niches, not the main stream.

5.4 Ethical considerations

The aim and scope of this thesis was to produce a new tool for interaction designers, and show examples of its application in practice. When creating tools for other designers to use, it is important to also consider the way it can be used, and anticipate malicious uses. Malicious uses could include the invention of new dark patterns, ways of tricking and misleading users, based on temporal themes. I did not see any such patterns while working on the project, but they may exist.

In terms of applied methodology, this thesis includes material from interviews with design practitioners. The interviewees were informed about the purpose of the interview, and be asked for consent to have their thoughts and ideas included in the final report. See subsection 3.2.3 for the interview procedures.

The prototypes were evaluated using volunteer participants. These test participants were informed about the purpose of the test and asked for their consent to their input to be included in the final report. The participants were not subjected to any risk of harm during the tests. See subsubsection 3.5.2.1 for the prototype evaluation procedures.

The research for this thesis was not performed at the request of any private company, or organisation. It was performed independently and without conflict of interest.

6

Conclusion

In “Time, Temporality, and Interaction” we proposed six "temporal themes" that described different ways that time could be expressed for an interactive artefact. We proposed that these could be used to analyse existing artefacts and also as a thinking technique to come up with ideas for new designs. We did not have the opportunity to go into depth in identifying those six themes, and in our concluding remarks we noted that our inspiration for the article came primarily from entertainment; films, games, music, etc. We presented examples of design artefacts, in the form of simple drawing applications, that explored these themes, and while we tested them with interaction design students, it was only an initial and unstructured exploration.

To explore how time can be used as a design material in Interaction Design, this thesis widened the scope to many more design and aesthetic disciplines to see if there were more to the concept of time as a design material than we had uncovered. I also applied a more robust methodology by which I arrived at five new, broader temporal themes. To demonstrate these themes in action, and see how they can be used to affect the aesthetic expression of the resulting design artefacts, I designed new drawing applications in the same vein, and showed one way to evaluate them from an aesthetics, rather than usability, point of view.

The wider scope of the research in this thesis uncovered a more nuanced and detailed picture of how time is used as a design material. The consideration of additional creative fields that are constrained by physical materials, such as architecture, added another dimension: patination. Narratology also added a vocabulary that can be used to describe the effects we discussed in “Time, Temporality, and Interaction”. Though the themes from the initial article overlap with the themes presented in this thesis, the new themes are much broader in scope and depth.

What the five themes, "Physical materials", "Sequences", "Temporal variation", "Repetition", and "Timelines", represent, just as the themes in “Time, Temporality, and Interaction”, is a system for thinking about time as a design material when designing, and analysing interactive artefacts. Like the attributes of interaction gestalt proposed by Lim et al. (2007), these temporal themes can be used by designers as tools in the design process, and as a language for describing and explaining design choices in relation to time.

In the second part of the thesis I made an attempt at demonstrating, in a very limited scope, one way in which the themes could be applied in Interaction Design. This consisted of describing the design process of two "temporal drawing applications" that were created using the themes as a thinking

technique. I also evaluated whether these drawing applications achieved the aesthetic expression I intended by using AESTHEMOS, a questionnaire for evaluating aesthetic emotion, as well as an observational protocol.

These drawing applications were designed, in line with the Slow Technology design programme, to encourage reflection, curiosity, as well as inviting exploration and experimentation. The test participants that used them were more engaged, interested, and curious, and overall reported stronger emotions on the positive and epistemic scales, compared to test participants using the basic drawing application that served as a control. There were also differences between the two drawing applications consistent with my intentions. Even though the results could also be affected by, for example, the novelty factor of these applications, this indicates that it is possible to use time as a design material to shape the aesthetic expression of interactive artefacts.

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A

Appendix A: Summaries of the literature review and interviews

This appendix contains summaries of the literature review and interviews conducted in the first phases of this project, for each creative field analysed. These summaries form the basis for the themes described in subsection 4.1.2.

A.1 Narratology and narrative media

In narrative media like literature, movies, and TV series, time is used creatively in many different ways to tell different stories.

Narratology separates the "represented time", or "fabula time", the timeline in the described world, or "fabula", from the "representational time", the time that the reader or audience to read, watch, or otherwise consume, the work (Onega and José Angel García Landa 1996, p. 109). Book authors, or film directors, can use the relationship between these to create different aesthetic expressions, by telling the story slowly, quickly, or varying the pace and create *rhythm* in the work (Genette 1980, p. 88).

Between the fabula time and representational time there is also the narrative time, the selection of events in the fabula time that tells the story, and Jose Angel Garcia Landa (2005) considers these to be more or less the same thing.

Stories are usually *anisochronous*, where the fabula and narrative time move at different pace. As the term suggest, there is however an extreme in *isochrony*, where the fabula and story time flows at the same pace. This is unusual, but can be found in for example cinema and televison. Jose Angel Garcia Landa (2005) uses sports broadcasts as an example, where reporters are reporting on what happens, as it happens, describing and perhaps creating a narrative of what is going on in, for example, a football match.

A number of isochronous narratives can be found in cinema and TV. For example the series "24", where agent Jack Bauer must stop terrorists from doing what terrorists do. Each season of "24" consists of 24 episodes, each depicting one hour of a day and continuing from where the previous left off. The fabula time does not pause even for commercial breaks, which is clearly displayed in the form of a clock that appears before and after each break. With the commercial breaks each episode represents one hour, and takes one hour to watch. A cinematic example is the film "Victoria", which portrays a night in Berlin

in a single, two hour long, take.

In anisochronous narratives the author uses pace and rhythm to select and emphasise events in the fabula. "Some [events] are rendered at great length, some galloped through or rapidly summarized, some dismissed with perfunctory sentence of two, while others are even passed over unmentioned" (Onega and José Angel García Landa 1996, p. 109). Speed, pace, rhythm, these are one set of terms for describing one aspect of the temporal properties of a narrative, and that can be used to create different expressions.

While neither Genette (1980) or Jose Angel Garcia Landa (2005) mention it, the story time can also flow slower than the fabula time. Slow motion effects are common in cinema and televison to emphasise an event. In a scene in "The Matrix" time is slowed down to show how the main character, Neo, can now manipulate the physics of the world and move at extreme speeds. More rarely time is sped up without skipping ahead, so called *time-lapse*, but it has been used to emphasise the lapse of time.

A very common technique when telling a story is the use of flashbacks (Jose Angel Garcia Landa 2005), or "analepsis". This is a method that breaks the "natural" chronology of the story to include a past event, for example as a way to frame or explain a "current" event. This technique exists in literature, although it usually takes the form of *summary* (Jose Angel Garcia Landa 2005), events retold by a character, but is especially common in cinema (Turim 2014).

In cinema, and television, the technique is common, but it is also sometimes taken to its extremes. "Sunset Boulevard", for example, begins with a corpse floating in a pool, and the rest of the film can be thought of as a flashback describing the events leading up to that scene. In "Memento", part of the story is told in reverse chronological order as flashbacks from flashbacks, in a way meant to convey to the audience the experience of having no near-term memory. Somewhere in between these two films is the non-linear narrative of "Pulp Fiction", in which the scenes are presented out of order, and the first and last scenes joining together, making it almost circular.

Analepses can jump back far in time, or to just before "now", and can overlap with events that have, or will be shown. For example, the audience may already have been showed a scene from one angle, but are later shown the same events, as an analepsis, from a different angle, which reveals something that was previously unseen.

The opposite of analepsis is prolepsis, or "flashforward". This technique can be used for example to create anticipation, foreboding, and suspense. For example, when the audience is shown what is going to happen, they don’t necessarily know how it is going to happen, or what will lead the story to that point. This creates a different atmosphere and expression than if the events were unknown. In a way, the first scene of "Sunset Boulevard" could be interpreted as a prolepsis, it is all down to what is interpreted as the narrative "now" (Jose Angel Garcia Landa 2005). In the film "Reservoir Dogs" the scenes are presented more or less out of order, with the opening scenes being followed by scenes describing events close to the narrative end. In this type of narrative what a flashback and flashforward is, is open for interpretation.

Narratology has a wealth of terms for describing when the expected chronology of the story is disturbed, in addition to analepsis and prolepsis there is for example *ellipsis* (skipping ahead) and *paralipsis* (a kid of analepsis where the event is not in the distant past, but was previously ommitted from the story) (Jose Angel Garcia Landa 2005). Collectively, these narrative techniques that break the timeline are called *anachronies* (Genette 1980, p. 48). A story can start *in medias res* (in the middle of things), or *ab ovo* (from the beginning, literally "from the egg") (Jose Angel Garcia Landa 2005).

Breaking the the expected chronology of a narrative can be used to induce different emotions in the audience, like a feeling of suspense, or mystery, but also to create interest and curiosity. Some types of stories require anachronies, for example the classical detective story, where all will be revealed at the end, but if we were shown the events in chronological order the story would be mostly banal.

Describing events that happen simultaneously in the fabula can require anachrony in some mediums. In literature the timeline of the story only allow for one event to be described at a time, and the events must be placed in some order, or interleaved. In cinema and television techniques such as split screen have been developed to convey simultaneity when showing the events sequentially or interleaved would not, for example, describe well enough the importance of these events happening at the same time
(Jose Angel Garcia Landa 2005).

The order in which events are shown, and which events are shown, can be used to change or create different meanings in the described events (Nelmes 2011).

In a narrative, events can also be described again. Repeating the exact same story over and over can of course easily become boring for the audience (which of course is an aesthetic expression in its own right), but usually the technique is employed by telling the story from different points of view, or with small variations. In the film "Rashomon" the same story is told multiple times, from the point of view of different characters. This is a way to map the events of a fabula to different stories. Another example is the film "Run Lola Run", where the protagonist has 20 minutes to save her boyfriend's life. After failing to do so and being killed, the film starts over at the first scene and the events are played out once again, but with a small difference that multiplies and changes the course of the story. Lola still fails, but when the film again starts over it is as if she remembers the previous repetition and avoids the obstacles to save the day. This kind of repetition is called *frequency* by Genette (1980, pp. 113–115).

"Run Lola Run" also touches on an interesting aspect of narratives, that they are generally *causal* (Jose Angel Garcia Landa 2005). Even when the order of events in the story are not laid out in the expected chronological order, they are almost always causally linked. The audience may not be shown the events that caused the current events to happen until later in the story, but there is still a causal link. In "Run Lola Run" causality is mixed up with repetition and it appears as Lola is learning from events that are in a "past" that no longer exist. This may be a reference to computer games, and what the audience is shown is

different attempts of a player to succeed in a mission, and restarting from a save point when failing. This theme has been portrayed in other films too, famously in "Groundhog Day" where the protagonist finds himself waking up to the same day again and again, with no one around him seemingly noticing. At first he wastes the days away, but eventually uses them to try various self improvements, such as learning to play the piano, but also searching for a way to end the loop. More recently, in the film "Edge of Tomorrow", the protagonist gains the ability to reset time (although through dying) during an alien invasion, and uses this to hone his combat skills to eventually defeat the invaders. Many players of games such as "Doom" or "Halo" that saw the film probably drew a parallel to their efforts in mastering those games.

Narratology considers time in many forms: there is duration, both in terms of fabula time, but also as in story time. Events in the fabula have different extensions in the fabula time, but also in the story time, and the relationship between these can be used to, for example, emphasise, or deemphasise events, and create a rhythm in the story. There is speed, as in the relationship between the fabula time and the story time, which can be used creatively in different ways, for example by showing the events at the same speed as they happen, or by varying the speed of time to skip over events, and emphasise others, and to create suspense for example during an action packed sequence. There is order, where the expected chronology is broken and events are shown in an order that creates the desired expression. A story can be filled with mystery or suspense by paralipis, feel action filled by starting in medias res, or create anticipation by showing future events in a flashforward. Deciding the order of events in the story changes the meaning and expression of the events, and the story as a whole. Finally there is frequency, or repetition, which can be used to provide different interpretations of the same events, or emphasise their importance.

A.2 Architecture

"Finishing ends construction, weathering constructs finishes" writes Mostafavi and Leatherbarrow (1993, p. 5). In one pithy quote they capture an important, but underexplored[1], aspect of architecture. All buildings age, the materials they are made up of change, deteriorate, and this causes first changes in appearance, and eventually the end of the building as a building. But can this decay be controlled, must it be only a negative force? Mostafavi and Leatherbarrow (1993, pp. 6–16) asks this question in their introduction: "Aging, then, can be seen as either benign or tragic—or as both. This raises the question: beyond the general category of weathering as a romantic form of aging, are there other specific ways the unending process of deterioration can be understood, and then intended? Is it possible that weathering is not only a

[1] the architect and Yale professor Alan J. Plattus notes in a blurb on the back of *On Weathering: The Life of Buildings in Time* that this is "a largely neglected theme in architecture", and that "few have considered the material consequences of the temporal dimensions with respect to either the making or the experience of architecture"

problem to be solved, or a fact to be neglected, but is an inevitable occurrence to be recognized and made use of in the uncertainties of its manifestations?".

When interviewed, architect A, a practicing architect. had thoughts on this question. In their projects they work with materials often chosen for their temporal properties. In their view, houses should grow into, and become a part of the environment where they are built. Rarely do materials have these properties and appearances at the time of construction, they need to age into the desired appearance. Wooden façades need time to turn grey, metals loose their shine and become dull, concrete changes appearance through algal growth and staining (see for example Figure A.1).

Figure A.1: Wooden panel treated with ferrous sulfate and concrete stained by runoff from the panel. Photo by the author.

This process of patination takes time, but can be controlled. The architect can design with a certain appearance in mind, and make choices in materials and treatments that suit the location, situation, and environmental factors, and design the expression that will unfold over time.

Architect A says that clients often don't want to wait for the changes to take place at their "natural" pace, but want the desired expression when construction ends. There are means and methods to accelerate ageing, but they often come at a price. Treating a wooden façade with ferrous sulfate, for example, will make it grey, but it will be a different, and perhaps less beautiful, appearance, from an untreated, slowly aged façade. The treated wood may also have a shorter time span.

Some desired appearances can not be achieved other than through time. Concrete may be thought of as an unchanging material, but in fact it changes through time, says architect A. Exposed to the elements, and to surrounding materials, it stains and changes colour. The effect can be controlled through the construction process, with for example rougher surfaces providing more surface area for algal growth, that changes the appearance of the material, both over time, but also over seasons and different weathers. Concrete can appear very different in dry and damp conditions, and through the seasons.

Concrete can also be mixed with other materials that will give it different expression over time, one project architect A is aware of mixed copper shavings into the concrete. Copper oxidises and turns turquise, and runs, and it's an ever changing material, says architect A.

What architect A says about staining, and copper in particular, is echoed by Mostafavi and Leatherbarrow:

> *Dirt and staining: can they be anticipated? Certainly they are inevitable, but can they be projected, or envisaged as a likely future occurrence; still further, can they be incorporated into a design project? Staining is often the result of the juxtaposition of two materials, stone and metal for example, as in many nineteenth-century industrial buildings. When copper oxidizes and is washed by rain, a green stain is formed on the surface of the stone directly below. Stains seep into the porous stone, altering and deforming the original surface with these parmanent markings. This may seem to be a deviation from the original intention for the surface color and texture, and it may be construed to have resulted from a fault in the design; but to the degree that stains show a new encounter between previously unrelated materials in one building sited in a particular place, they might also allow for a discussion of its harmony. (Mostafavi and Leatherbarrow 1993, p. 72)*

In addition to weathering, the use of a building also changes it over time. Floors are worn down through and show the most common paths taken through the house by the inhabitants, surfaces accumulate scratches. Architect A notes that "Houses age like wine" and that while the first scratches may detract from the appearance of a surface, eventually as the scratches multiply, they become part of the appearance and adds to its desirability. Similarly Mostafavi and Leatherbarrow (1993, p. 108) rhetorically ask "under [what conditions] a surface marking is experienced as a stain".

It is not only the component materials that can be designed with temporal aspects in mind, but also the building as a whole, the architectural gestalt. Leatherbarrow (2008, p. 111) notes, discussing the ideas of Fredrick Gutheim, that while "[buildings] generally outlive their designers, [they] do not last forever. For Gutheim, this conclusion called for a shift of focus, from preserving the look of the new to understanding the ways that work could remain significant, even graceful, as it aged." Even in ruin, buildings have an expression, and this expression can be designed.

A, perhaps extreme and even macabre, variant of this is the idea of "ruin

value": when buildings are designed in such a way to leave beautiful ruins. This idea has its origins in the romantic period of the 1800's (Leatherbarrow 2008), but is primarily connected to the infamous architect and nazi Albert Speer, who drew up plans for a reimagined Berlin that would last a thousand years, but leave ruins comparable in grandeur to the remains of the greek and roman empires. His view was that to achieve this goal required the use of "natural" material like stone, and not reinforce structures with iron girders or use concrete.

Speer claimed to be the originator of these ideas, but there were earlier examples, like achitect Auguste Perret who said "architecture is what leaves beautiful ruins" (Leatherbarrow 2008, p. 111), and Sir John Sloane, architect of the Bank of England building, who presented the bankś governors with oil pantings showing the building as it would appear when new, as aged and weathered, and as ruins after a thousand years (Spotts 2003, p. 322).

Of course weathering effects, can be unanticipated and unwanted, but when it is not, as in the examples above, it can be considered as time used as a design material.

A.3 Fashion

Fashion, like architecture, deals with physical materials that age, wear, and deteriorate. The time scales are in most cases shorter in fashion, but listening to fashion designer A, who primarily works with leather, you get the impression that such materials are not dissimilar to the materials used in architecture. A well made leather item can last generations, and it's appearance and expression will change over time, as wear turns it soft, and it acquires patina.

The way leather is prepared decides its temporal properties. There are different methods for tanning leather, with the most common two being chrome and vegetable tanning. Fashion designer A says that chrome tanning is popular because it creates a softer material that is easier to colour. Vegetable tanned leather, meanwhile, is harder and more brittle initially, but will last longer and also soften with wear, and develops patina in a way chrome tanned leather does not. Fashion designer A likens chrome tanning to accelerated ageing, it creates a desired state quicker and many times cheaper, but the material will not last, and not develop the same appearance as vegetable tanned leather.

Fashion designers rarely consider the long view of the products they design, and temporal properties like these are not often considered. It is more common in the luxury segment than in couture, though.

A similar story is told by fashion designer B, who works with jeans. Most of the jeans sold are "washed" and "pre-stressed", meaning that after the fabric has been dyed with indigo it has been worked on to create a worn-in look, and then washed to fix the colour and wear in place. In contrast, "jeans connoisseurs" prefer "dry denim", a jeans product that is not washed after dyeing, and which will change over time with use, creating a unique look for each individual use.

The way the dry denim jeans will age can be controlled through choice of cloth, dye, etc. and while most of the time the intention is to create a product that ages in a desirable way, sometimes it is done to create a product that instead

does not appear to age.

One aspect of the work of fashion designer B is creating pre-worn looks for pre-washed models. These designs are often inspired by dry jeans that have been worn sometimes for many years, and have acquired a unique style and patina. Sometimes it's the jeans worn by celebrities or influencers, but many times by jeans aficionados that have turned wearing jeans and creating a specific expression into an art form.

Fashion designer B agrees that their could be seen as a form of co-creation between them, the designer, and the owner of the jeans. They decide the parameters that determine the ageing properties of the jeans, the wearer creates the patterns and patination, and they then uses the result as the blueprint for a new style that wholly or in part replicates the look created by the wearer.

A.4 Horticulture

Another creative discipline that deals with physical materials is horticulture. While the fashion designers interviewed talked about the materials they work with as "living" in a metaphorical sense, horticulturists literally work with living materials.

Horticulturist A says a goal of garden design is to make the garden interesting all year round. For example, trees are chosen not only for their appearance during spring and summer, but for their autumn colours and "winter values", i.e. how they appear in winter when all leaves have fallen and only the trunk and branches remain. Gardening, they says, concerns itself a lot with seasons in this way – but also with age, growing, and how time affects plants, trees, etc. However, time is rarely talked about as a thing in itself, it is the effect of time that is considered.

The materials of gardening are ephemeral, and constantly changing. This is a factor in the design of, for example, flower beds. Horticulturist A says a lot of thought goes into planning around when flowers are flowering. You can employ different strategies, for example plant flowers that flower at different times, so that the flower bed is colourful for a longer time, or you can plant flowers that flower at the same time and complement each other. Either strategy requires careful planning and timing.

The flowering season (at this latitude) is also only measured in weeks, which means that for most of the year a flower plantation needs to be something else. By planting different flowers such that they flower in waves you can make the flower bed last longer, but still, for most of the year there will not be any flowers and you need to design it in such a way that there is still something interesting there to see.

Another example of working with seasons, is something that has become fashionable again, after being out of style for a very long time: saving flowers in the summer, by drying them, and using them as decoration in winter time.

When designing a garden, or for example planting trees in public places, there is what is called an "establishment phase". This is the time between the actual planting and when the tree, shrub, or plant, has reached its desired state. A tree

can take years to grow to the size that was intended for the space it was planted in. In other words, the design can take years to reach its intended expression, and needs to be tended properly to do it. Making the design have a desirable appearance during this phase is a challenge, and not always possible.

Long establishment phases are a challenge in that the effects of time are hard to control, and design decisions also have very long lasting consequences. Trees, for example, take a long time to grow, and are affected by many factors that vary over time, such as weather, climate, pollution, and so on. Horticulturist A says that the job is many times a war with time.

There are, limited, ways to shorten the establishment phase, for example by using pre-grown shrubs and trees. This is not always possible, and always more expensive in terms of initial cost, but it shortens the time before the desired state is reached. In a way it's a form of time travel, or, (metaphorical) accelerated growth, says horticulturist A.

The materials used by gardeners have very different temporal properties, says horticulturist A, some plants only live for a season, while others last for generations. This means you have to think completely differently for different parts of a garden or installation. Some plants also require very little maintenance, while others require constant care to survive.

Something simple as a lawn can be very maintenance heavy. To keep the grass short it needs to be constantly cut, and to keep green it needs watering. Any deviation from a strict maintenance regime can easily be spotted and will make the lawn appear to be unkept. Contrast this, says horticulturist A, with a meadow, where the grass is allowed to grow and you won't see changes even over several weeks.

A.5 Photography

> *The aesthetic discussion of photography is dominated by the concept of time. Photographs appear as devices for stopping time and preserving fragments of the past, like flies in amber. (Wollen 2007)*

Photography is often thought of as capturing a single moment in time. But what a moment is, is not defined. The shutter speed, the time the camera gathers light, is the main factor in this conundrum, and can be used both to freeze motion, when fast, or reveal motion, when slow.

Throughout the history of photography there has been a steady progression of technological advancement that has made shorter and shorter shutter speeds possible. First in the development of more and more light sensitive films, mechanical shutters capable of exact, millisecond operations, lenses capable of capturing more light, and in the last decades digital sensors with light sensitivities that can seem to be able to make a signal out of every single photon available.

Short shutter speeds means being able to capture moving subjects in greater detail. For as long as the shutter is open the photons reaching the sensor affect the final picture. When photographing things in motion, such as sports, wildlife,

or kids, this motion translates to loss of sharpness. The motion is in a way captured, but is often considered a flaw.

> *The fact that images may themselves appear as punctual, virtually without duration, does not mean that the situations that they represent lack any quality of duration. (Wollen 2007)*

Slow shutter speeds have, however, throughout history, been used for creative purposes. There are several photographic techniques that could be considered in terms of time as a design material, such as double exposure, iskiography, and long exposure.

Double, or multiple exposure, is a technique where the shutter of the camera is opened to let in light multiple times without advancing the film (in an analogue/film camera), or digitally superimposing multiple exposures on top of each other[2]. The technique can be used for purely aesthetical purposes, or for fabricating images for both nefarious, and instructional purposes.

> *I take all photographs to be durational, but propose that this is most evident in the long exposure. (Plummer 2012)*

Long exposure is a photographic technique where the camera's shutter is kept open for an extended period of time. Depending on the scene and the desired expression, anything from around a second, to minutes is common. As Plummer (2012) puts it:

> *The long exposure photograph, however, captures the entire duration that unfolds before it. The continuity occurs because the still camera is set to record continuously (since in the case of the long exposure the shutter is left open). In this sense it functions much like the movie camera but it is almost as if the movement of the film through the camera has been disrupted. The cessation of a mechanism to progress the reel of film forward would create a series of shots superimposed onto a single frame. The long exposure presents something akin to a series of still slides projected on top of each other (rather than a roll of film that is in constant movement through an apparatus). While the moving image consists of a reel of stills, the long exposure produces these moments on a single frame. It is as if the frames are accumulating to provide a depth of time on a single image rather than a movement through space and an extension onto a series of successive frames. The long exposure can present a continuity of any-instant-whatevers rather than a selected privileged moment. While not presenting an actual movement in time, the photograph can represent the movement that occurred in its duration. The long exposure traces a continuity of movement (albeit without animation).The long exposure not only extends the time of the photograph, it reveals that time in its image. (Plummer 2012)*

Common scenes in long exposure photography are jetties in water, boulder filled streams, or vistas with skies full of clouds (see Figure A.2 for an example).

[2]many digital cameras have built in double exposure modes, but the sensor is not physically double exposed as such, the technique is very differently executed in analogue and digital photography

Figure A.2: Long exposure photography. Photo by the author.

When exposed for anything from 30 seconds to minutes all movement is smoothed out and water gets a milky and misty appearance, and clouds streak across the sky. In contrast to a short exposure the long exposure captures the movement in the scene. Other themes are roads at dusk or at night, where the white headlights and red rear lights of cars appear like glowing ribbons along the road, or light painting where a person is moving around with a torch or other glowing object while the shutter is open, making light trails in the image, and star trail photography where the movement of the stars in the night sky is captured over tens of minutes or even hours.

The famous photographer Michael Kenna puts it like this:

> *A few elements can evoke a whole world of imagination. A small amount of tangible subject matter has infinite possibilities. Sometimes I make long exposures, either during the day or at night. Film can accumulate light and record events that our eyes are*

> *incapable of seeing. Drama is often increased, deep shadows can appear, light sources may appear surrealistic. (Balthus 2018)*

Less common is views that include people, but photographers like Alexey Titarenko have captured streets that look deserted, with only ghostly shadows suggesting that the places are indeed populated, or queues of people appearing like smoke[3]

When doing long exposure photography during the day, the photographer must ensure that the resulting image is not overexposed. For this purpose "neutral density" filters are used. These are pieces of dark optical glass that cut the amount of light entering the lens. A common filter is the "10 stop" filter, which cuts about 99.9 percent of the light. This might sound like a lot, but a common shutter speeds in daylight is around 1/100th of a second or less, or ten milliseconds, and a 10 stop filter only increases this to about ten seconds. Long exposure photography usually takes place in overcast conditions, or later in the day when the base exposure is slower. There are of course also darker neutral density filters, but there are technical challenges keeping these both neutral in colour (and most neutral density filters are far from neutral), and of a high optical quality (i.e. not affecting the sharpness of the image).

There are also extremes of long exposure, such as "solararography", where the sun's progression over the sky is captured over the course of many months [4].

Similar to long exposure is iskiography. This technique was invented by Lothar Shiffler, but similar techniquess have been used by for example Mike Kelley. It can also be seen as an extreme form of multiple exposure, where tens to hundreds of regular photographs, or frames from video, are combined. The technique was created by Shiffler to get around a problem with regular long exposure photography: you can't capture the movement of a dark object against a bright background. Since photography works by gathering light, and long exposure by adding more and more light as long as the shutter stays open, a moving dark object will be erased by the ligh that comes from the same spot when it has moved – something used for example by Titarenko to make streets appear desserted, as mentioned above. Digitally combining multiple exposures can instead be done subtractively, so that moving dark objects occlude the bright backgrounds they move across.

Shiffler's works feature birds in flight and combines individual frames from digital video to create images where birds in flight have been smeared out to ribbons in the air. The speed of the birds in relation to the frame rate of the video can also create effects where the ribbon is either a smooth line or a where the flapping motion of the birds' wings can be seen in detail.

> *From a photo-technical point-of-view, it is not possible to photograph longer movements of dark objects against a light background. In order to be able to do so, you need the opposite of photography, i.e. iskiography, as I would like to call it. (Shiffler 2019)*

Kelley, meanwhile, in his "Airoportaits" project, takes multiple individual

[3] See for example http://www.nailyaalexandergallery.com/artists/alexey-titarenko

[4] See for example https://www.telegraph.co.uk/news/newstopics/howaboutthat/3496139/Stunning-photographs-of-landmark-captured-over-six-month-period.html

exposures from the same vantage point of planes taking off or landing. He then digitally superimposes these, picking images where the planes don't overlap, and makes a composite that highlights the busy nature of airports and also question things like the economic and environmental impact of air travel.

> *Most photographs work to capture a single decisive moment. Each Airportrait is captured over an extended time period, anywhere from three hours to nearly sixteen hours. Using a stationary camera, every aircraft movement during the given time period is meticulously captured. The hundreds, sometimes thousands, of resulting images are then culled and each departing aircraft is cut, stitched, and assembled onto a background image taken during the same time period. This process creates a temporally expanded composite image of the airport, showing a day's worth of air traffic and activity. (Kelley 2019)*

A.6 Music

Music is an inherently time based medium. The way notes are played, sustained, and muted, the tempo, and pauses, all create different aesthetic expressions to a piece – the same sequence of notes can be given different expression by manipulating temporal aspects during a performance.

One example of how time is used as a design material is through the use of a "loop station". An early practitioner of this technique, and possibly its inventor, is the guitarist Robert Fripp, who rigged reel-to-reel tape recorders in such a way that the first would record him playing the guitar, feed the tape to the other, which would play the just recorded sounds, then feeding the tape back to the first to record new sound. This endless loop of tape made it possible for him to layer sounds on top of each other while playing, and with the right timing act as a one-man orchestra.

The technique has been developed and there exists today many commercial implementations of the idea, and even a competition format. Using loop pedals and other electronic devices that can record multiple separate sequences, performers can create whole performances where they play along with themselves, and in effect fold sequences of events on top of each other.

Musician B, teacher at the Academy of Music and Drama at the University of Gothenburg, describes looping as taking sounds out of time, and that the sound put into the loop are other objects than they were when they were originally played. To them, music is organised time, and looping is a clear example of that.

Musician A says that the hardest aspect of live looping is how it can easily become repetitive. Even as you add new layers to the loops, the initial sounds remain and you can't subtract from the loops. When performing without looping you can often seamlessly move between verse and chorus, but in live looping this is not as easy. When live looping you must almost start over, which introduces a very big change, and is rarely desirable.

Another complication when performing with live looping techniques is that mistakes multiply. As you record new layers to the loops you must either accept

any mistakes you make, or discard what you've recorded. For this reason many performers limit their use of looping and focus on applying effects to sounds when playing live.

Live looping is a form of repetition, and repetition and periodicity is very common in music says musician A. Pop songs, for example, are often built up by many levels of periods, from the basic building blocks of the bars of 4 beats, in the common 4/4 time signature, to chord progressions, to song structures of verse, chorus, verse, etc. In this periodic structure, musician A says, most often you introduce new things, for example instruments, sounds, effects, etc. at the beginning of a period, and very rarely in the middle. This is the moment when the listener expects change, and when it is least disruptive – but breaking this rule can be a way to put extra emphasis on the thing. Music is often a balance between anticipation and tension or release created by unanticipated events.

Musician B describes western music as grid-like. Music is composed by writing notes, and these notes even appear on paper in an actual grid. Notes, however, are not music, continues musician B. The interpreter must add their own expression in the form of tempo, pauses, sounds, etc.

Live performance is another case when new expressions are added, says musician A. When recording songs you often record them at a fixed tempo[5], in part to make it possible to record instruments at different times and still be able to put them together in the same recording, but when playing live you can increase or decrease the tempo as a way of emphasising parts of the song.

Even more freedoms are explored in improvisation, something musician B often performs. They have built their own instruments to support their performances, and many of these have temporal aspects. One of these instruments is like a piano, but with a buffer that records what is being played, and replaying it one minute later. The result is, in a way, that they play along with themselves, and must continuously consider how that which they are currently playing interacts with what they played a minute ago, and what they will play one minute from now.

When listening to recordings of one of these sessions, I'm struck by how hard it is to hear which sounds are from the past and which are from the now, they blend together like they were two performers improvising together.

Musician B has made many other instruments that include delays of different kinds to support their improvisation. Some are meant as creative challenges for himself, and others for multiple performers. Besides the one described above they has also made variations of a piano like instrument with a sound buffer that, instead of being on a fixed delay, is controlled by what is being played. In one, called "Parity Mirror"[6], odd keys are delayed differently from even keys. In another, called "Foldings II", the buffer replay is controlled by what tones are played to replay previous sounds forwards, backwards, quicker, or slower. Finally, in a project called "Dynamic Triads", the instruments of three different

[5]For an example of when this is not the case, see https://www.uncut.co.uk/features/the-making-of-pulp-s-common-people-8632

[6]A recording of this can be found here https://soundcloud.com/palle-dahlstedt/parity-mirror-2016-05-24

performers are connected in such a way that what they play is recorded to a buffer, and the sound level of their instrument controls the sound level of the playback of another instrument's buffer. This way each instrument both produces sounds in itself, but also echoes of sounds of another instrument.

By adding buffers and delays, and ways that the buffer is controlled, musician B have created chaotical systems. The inputs are controlled, and the mechanisms can be known, but it is in practice impossible to predict the outcome. The performer, be it musician B or someone else, cannot reason with the system, there is no time to plan and think, one instead have to create strategies that can be used automatically, and develop an intuition about how to act and react:

> *I have to rely on trial and error, or rather on performance patterns such as probe and react, find and rest, explore and contemplate (what you have before you lose it). Or ponder and vary, discover and exploit, or possibly even: go to the limit and jump ship. (Dahlstedt 2014)*

In improvisation it's important to realise that everything that has happened has happened – you can't decide that it hasn't, says musician B.

A.7 Game design

In game design research, the effect of different ways of using time has been studied by for example Juul (2004) and Zagal and Mateas (2010).

Consider, for example, what happens when a player is logged out in the online multiplayer games "World of Warcraft" and "Eve Online": in the former their avatar is not active in the world, safe from harm, while in the latter the avatar still experiences the flow of time, can travel, and be harmed. These are different aesthetic expressions that, in part, defines these two games and set them apart. Pausing time for the avatar makes sense for the more casual expression of "World of Warcraft", whereas in Eve Online you wouldn't achieve the same level of immersion if there was a way to pause time for your avatar like in "World of Warcraft".

Creative uses of time are also present in single player games like "Sim City", where you can speed up and slow down the speed of the simulation as you please, and "Tetris" where it is used to control difficulty as the game progresses (Juul 2004). The simulation speed control of "Sim City" is not just a practical tool, but one that changes the experience of using the game. It's a release valve for boredom, for example. When money is short, and the city turns a profit, the player can speed up the simulation until enough funds have accumulated for the next investment to be possible.

The way time is expressed in most games is probably incidental, but there are exceptions. For example, the game "Braid" makes it necessary for the player to think about time and alternate paths through time. The player does not only have the traditional spatial controls, but also control time. In different game worlds the player has different ways to control time, from being able to rewind actions to connecting the flow of time with horizontal movement. Some game objects are

not affected by the player's control of time, which creates puzzles where the the player must, for example, rewind time to perform an additional action that would not have been possible to perform had time not been under the player's control (Stamenković and Jaćević 2015). Another game with similar controls is "Prince of Persia: Sands of Time", where a key game mechanic is the ability to rewind time up to ten seconds. This ability can be used to retry actions until they succeed, and among other things replaces the save and restore feature present in many similar games (Zagal and Mateas 2010).

Save and restore is a common feature of computer games, it's present in "Sim City", mentioned above, as well as many first person shooters (FPS), such as "Doom" or "Half Life". It is a form of time travel where the player can restore the game to a previous point in time (where they saved, even though some games also provide automatic check points), and try again. One reason to provide this way of manipulating the game time is to avoid frustration and make games more enjoyable. Having to replay the game from the beginning when you miss a jump and your avatar dies is too frustrating for most (Juul 2004).

Games very often include multiple timelines. First, there's what Juul (2004) calls "play time" (the time it takes to play), and there's the "event time" (the time portrayed in the game world). These two can be though of as analogues to representational and represented time in narratology. The relationship between these is not fixed, and the and experience of a game is dependent on how this is expressed. Zagal and Mateas (2010) explores this in depth and calls the different ways the event time is expressed "temporal frames".

Zagal and Mateas (2010) establish a number of archetypal temporal frames, such as "real-world time", similar to Juul's "play time", "gameworld time", the time portrayed in the game, similar to represented time in narratology, "coordination time", a frame established when, for example, the actions of multiple players, or players and the game AI, are coordinated, and "fictive time", a description of what each moment in the game represents, e.g. a turn can represent a day in the world portrayed by the game.

These temporal frames interact and games often possess multiple temporal frames. The authors use the game "Animal Crossing" as an example, in it the fictive time is is set to match the real-world time. A day in the game is a day in the real world, and it's also the same date, in that for example holidays are represented in the game on the same dates as in the real world. Another example they give is in the game "Grand Theft Auto: San Andreas" you can play an embedded arcade game, a game within a game. While you do this the time in the regular game world is paused.

Temporal frames within temporal frames like this can be coherent in the context of a game, but can also be inconsistent. This is called "temporal anomalies". Like the example with the game within a game, that time does not pass in the regular game world while the arcade game is being played is an anomaly. Similarly, another game in the same series, "Grand Theft Auto III" has a day and night cycle in the main part of the game, but when the player's avatar enters a building this cycle is paused.

The speed of the day and night cycle in that game is also inconsistent with the

time it takes to perform other actions, such as driving. The day can turn to night and to day again while driving a distance that in real life would only take a fraction of an hour. Another example of this is how in a game like "Sim City" a building can be built instantaneously, even though other things take longer to happen (Juul 2004; Zagal and Mateas 2010).

Inconsistencies in temporal frames seem to not bother us as players, on the whole. Like we accept narratives where the story jumps back and forth in time, we on the whole accept temporal anomalies in games (Juul 2004).

B

Appendix B: AESTHEMOS

B.1 The AESTHEMOS questionnaire

Rating instruction: How often did you feel this emotion?
Rating scale: From 1 (never) to 5 (very often)
Instruction: Which emotional effect did _____ have on you?
For each emotion listed below, please mark the response category that best matches your personal experience. Please only indicate how you actually felt. Do not characterize the emotions expressed in _____ if you did not feel them yourself.

1. I found it beautiful
2. Challenged me intellectually
3. Delighted me
4. Calmed me
5. Made me curious
6. Liked it
7. Fascinated me
8. Felt something wonderful
9. Invigorated me
10. Was mentally engaged
11. Baffled me
12. I found it ugly
13. Sensed a deeper meaning
14. Felt deeply moved
15. Made me feel melancholic
16. Energized me
17. Made me angry
18. Was enchanted
19. Bored me
20. Relaxed me
21. Felt a sudden insight
22. Amused me
23. Made me sad
24. Felt confused
25. Made me aggressive
26. Made me feel sentimental
27. Worried me

28. Made me feel nostalgic
29. Surprised me
30. Felt oppressive
31. I found it sublime
32. Spurred me on
33. Felt indifferent
34. Was impressed
35. I found it distasteful
36. Touched me
37. Was unsettling to me
38. Sparked my interest
39. Made me happy
40. Felt awe
41. Motivated me to act
42. Was funny to me

B.2 Aesthetic emotional scales

The following table shows the relationship between the 42 questions in the AESTHEMOS questionnaire (see appendix B) and the 21 emotional scales.

Question	Emotional scale (question number)
Anger	Made me angry (17)
Anger	Made me aggressive (25)
Awe	I found it sublime (31)
Awe	Felt awe (40)
Being moved	Felt deeply moved (14)
Being moved	Touched me (36)
Boredom	Bored me (19)
Boredom	Felt indifferent (33)
Confusion	Felt confused (24)
Confusion	Was unsettling to me (37)
Enchantment	Felt something wonderful (8)
Enchantment	Was enchanted (18)
Energy	Energized me (16)
Energy	Motivated me to act (41)
Fascination	Fascinated me (7)
Fascination	Was impressed (34)
Feeling of beauty/liking	I found it beautiful (1)
Feeling of beauty/liking	Liked it (6)
Feeling of ugliness	I found it ugly (12)
Feeling of ugliness	I found it distasteful (35)
Humor	Amused me (22)
Humor	Was funny to me (42)
Insight	Sensed a deeper meaning (13)
Insight	Felt a sudden insight (21)
Intellectual challenge	Challenged me intellectually (2)
Intellectual challenge	Was mentally engaged (10)
Interest	Made me curious (5)
Interest	Sparked my interest (38)
Joy	Delighted me (3)
Joy	Made me happy (39)
Nostalgia	Made me feel sentimental (26)
Nostalgia	Made me feel nostalgic (28)
Relaxation	Calmed me (4)
Relaxation	Relaxed me (20)
Sadness	Made me feel melancholic (15)
Sadness	Made me sad (23)
Subtype	Emotional feeling (Q)
Surprise	Baffled me (11)
Surprise	Surprised me (29)
Uneasiness	Worried me (27)
Uneasiness	Felt oppressive (30)
Vitality	Invigorated me (9)
Vitality	Spurred me on (32)

B.3 Subclasses of aesthetic emotions

The emotional scales can also more broadly be grouped into the following subclasses.

Subclass of aesthetic emotion	**Emotional scale**
Amusement	Humor Joy
Animation	Enchantment Energy Vitality
Epistemic emotions	Insight Intellectual challenge Interest
Negative emotions	Anger Boredom Confusion Feeling of ugliness Uneasiness
Nostalgia/relaxation	Nostalgia Relaxation
Prototypical aestheticsl emotions	Awe Being moved Fascination Feeling of beauty/liking Surprise
Sadness	Sadness

C

Appendix C: Planning

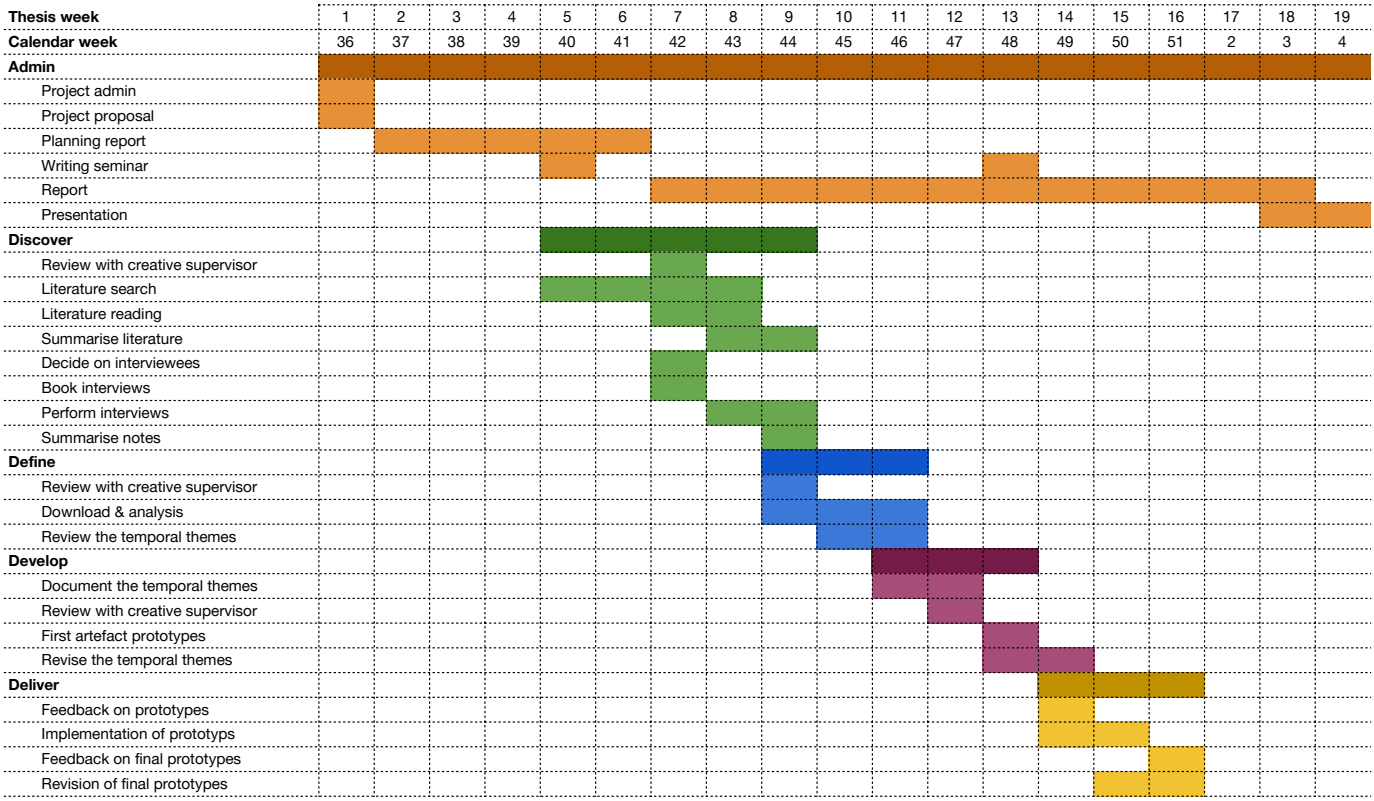

Figure C.1: A breakdown of the project into its major tasks and activities, and their sequence in time.

C.1 Planning

The work on this thesis was performed from September, 2019 through January, 2020. Figure C.1 gives an overview of the tasks and activities over time. Below is the same information presented as milestones, and on a weekly basis.

C.2 Milestones & important events

Week 37 Proposal submitted
Week 41 Planning report submitted
Week 44 Interviews and research finished
Week 45 Temporal themes defined
Week 49 Feedback on artefact prototypes
Week 50 Artefacts finished
Week 51 Revision of the report
Week 52-1 Christmas break
Week 4 Project presentation

C.3 Weekly breakdown

Week 36 Pre-project admin
- Initial admin, course registration, etc.
- Write and submit project proposal

Week 37 Project startup
- More admin, course registration, etc.
- First meeting with academic & creative supervisors

Week 38 Start planning
- Outline of planning report

Week 39 Planning & preparations
- Work on Planning Report
- Theory research on the aesthetics of Interaction Design

Week 40 Planning & preparations
- Finish Planning Report
- Revise Planning Report based on supervisor feedback
- Attend CSE writing seminar
- Theory research on systematisation of knowledge

Week 41 Start of Discovery phase
- Finish the project schedule and do last Planning Report revisions
- Submit Planning Report
- Start searching for examples of the use of time as a design material

Week 42 Research & interview preparations
- Continue searching for, and documenting examples of the use of time as a design material
- Review academic literature on considerations of time in Interaction Design
- Meet with creative supervisor to discuss literature review, and interviews
- Decide what creatives to interviews, and book interviews

Week 43 Interviews, research, and summary
- Book interviews (if not complete)
- Continue searching for, and documenting examples

- Summarise examples found so far, and academic literature findings, for the report
- Perform interviews

Week 44 Define phase starts
- Perform interviews (continued)
- Summarise examples, academic literature, and interviews for the report
- Do a first download & analysis of the findings
- Meet with creative supervisor to discuss the outcome of the research and interviews

Week 45 Download, analyse, define
- Download & analyse the findings from the research and interviews
- Relate the findings to the temporal themes, and determine if new themes should be added

Week 46 Develop phase starts
- Write descriptions of the themes for the report
- Revise project plan

Week 47 Describe the found temporal themes, prototype
- Continue developing the the themes
- Ideate on what to prototype to show the results from the analysis in action
- Meet with creative supervisor to review the themes and discuss prototypes for the artefacts

Week 48 Prototyping
- Prototype artefacts that demonstrate time as a design material
- Update the temporal themes with insights from the prototypes

Week 49 Deliver phase starts
- Gather feedback on the first prototype(s)
- Continue prototyping
- Select prototypes to evaluate
- Perform the first evaluations

Week 50 Evaluation
- Complete the final evaluations
- Analyse the results of the evaluations

Week 51 Documentation
- Document the evaluations
- Revise the project report

Week 52 Christmas break

Week 1 Christmas break

Week 2 Finalisation of the project
- Revise the project report based on supervisor feedback

Week 3 Finalisation of the project
- Revise the project report based on supervisor feedback
- Submit draft report to the examiner
- Prepare the project presentation

Week 3 Project presentation

- Prepare the project presentation

Week 4+ Project presentation

- Attend other master thesis presentations
- Be opponent at a master's thesis presentation
- Submit the final report