Data—Informed Design Experiments

Assessing the effectiveness and appropriateness of design for behaviour change

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The curves on the cover of this thesis were generated with actual data from the study

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Master thesis

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"Experience is never at fault; it is only your judgment that is in error in promising itself such results from experience as are not caused by our experiments."

— Leonardo da Vinci

The Literary Works of Leonardo da Vinci (1977)
Vol. 2, p. 240

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Executive summary

Our society is facing a number of great challenges which will require all of us to significantly change our lifestyle in the coming years. To support people in those transitions, next to systemic changes, new design interventions have to be crafted that intentionally aim to redirect behaviour for the common good. As changing behaviour intentionally comes with great responsibility, social and behavioural design calls for sound and deliberate design and evaluation. However, changing behaviour is something that takes a long time to materialise durably and thus conventional qualitative user-centered approaches to evaluation may not be the most suitable. On the other hand, quantitative approaches measuring only the outcomes of the behaviour do not provide detailed insight into the performance of the intervention.

This thesis investigated how integrating various sources of qualitative and quantitative data on a behavioural situation during evaluation contributes to critically assessing and anticipating the effectiveness and appropriateness of an intervention aimed at changing behaviour.

Studies that investigate the effectiveness of interventions often find that the effects induced in the short-term were not sustained (Abrahamse et al., 2005). A theoretical model was developed that conceptualises the underlying mechanism of this observation as the transition of the design being efficacious (works when people receive an intervention) to being effective (works when people are offered an

intervention), which is influenced by the appropriateness of the intervention to its context. This appropriateness can be further operationalised into three types: aesthetic, moral and systemic appropriateness.

The relations between the effectiveness and appropriateness were experimentally explored through deploying research artefacts in the context of the end-user. In this experiment an interactive bedlight and a chatbot were evaluated on their effectiveness and appropriateness in achieving the intended effect, 'adopting regular sleep and wake times', while at the same time understanding their performance in relation to 'sleeping better' and 'balancing sleep and other practices'. In the study several perspectives on the situation were collected and integrated: sensor data from an ecology of instrumented things, data from interviews with the participant before and after using the intervention, and data generated through the interaction with the interventions.

Integrating these perspectives resulted in concurrent insight into the performance of the intervention as it is now and potential elements for improvement. Although some perspectives are more attuned to the efficacy, and others more to the appropriateness—in general the integration of perspectives contribute to a holistic understanding of the situation as the individual perspectives filled in each other's blind spots. Through assessing the efficacy and appropriateness of the intervention the long-term effectiveness can be anticipated. This could nurture new methods for evaluation where data is informing the design process in order to assess how the mechanism in the intervention performs to decide what the right level of persuasive influence of the intervention is and assess whether the intervention is proportionate.

Acknowledgements

This thesis marks the conclusion of the seven years that I roamed the hall of the faculty of Industrial Design Engineering. It is quite surreal to write this final part not from there but from the place where I spent the past months. Although this work puts forward the argument that designers should anticipate the consequences of their design, I concede that as recent times have shown the future is something that you can never fully predict.

The work in front of you is very much a product of the multitude of brilliant people who I encountered during the past seven years at the faculty, and all the experiences I had at other places. Without doing injustice to all those that will go unnamed, there are a few people who I would like to specifically thank for their contribution to this project.

First and foremost, Nynke and Elisa, thank you for all the support, your flexibility and your belief in my work. Although we had to readjust along the process, I loved the many inspiring discussions we had that forced me to rethink and focus every element of my research.

Nynke, thanks for always trying to keep my eyes on the ball and for your support when things were not really going as planned. I especially enjoyed the sessions where we tried to make sense of a numerous concepts to find the coherent whole in the chaos.

Elisa, thank you for the very inspiring conversations that we had that ranged from the super concrete to the very abstract—and your positive and supportive stance towards my work.

I would like to thank the many people in the ID-StudioLab who I encountered in the past years for your thoughts, inspiration and help. Aadjan, thanks for offering me the opportunity to get to know Studio Make and Do so well that I knew exactly what I could rely on for this project. Martin, thanks for helping me out with some of the technological challenges I had during this project.

Special thanks to the participants in the study for accepting being spied upon in your bed- and bathroom by strange white objects with loads of cables attached.

I would like thank all my friends who made my student life in Delft an amazing time! To my roommates over at the Poppesteeg, thanks for being there, and not being there in the past months.

Finally, and most importantly, I would like to thank my family for supporting and believing in me throughout the past years to even be able to finish my studies.

Then all that rests me to say is: enjoy the read!

Thomas

A Introduction

Our society is facing a number of pressing challenges that need to be addressed in the coming decade, such as climate change, poverty and obesity to name a few. Tackling these challenges requires concerted action of governments, organisations *and* individuals; all of us will have to significantly change our lifestyles in the coming years. This will involve changing existing and adopting new behaviours that may not seem as appealing or attractive when comparing them to our current way of living. To support people in those transitions, next to systemic changes, new design interventions have to be crafted that intentionally aim to redirect our behaviour for the common good.

Changing behaviour intentionally comes with great responsibility. Findeli (2010) argued that a design project constitutes of two parts: the conception of a design, "and the reception part being the other". Thus, "the design act is incomplete if we do not address what happens to the project's output once it starts its life in the social world". In the first place, design that specifically intents to alter people's interactions and behaviour should at least have the effect that it claims to have once it is out in the social world. Designs that do not live up to their promises can nurture false beliefs that people are doing good, or could (potentially) do more harm than they do good.

Next to understanding the performance of the design in terms of its intended effect, designers should also anticipate the (unintended) consequences that the design can have. In line with Jelsma (2006), designers should take moral responsibility for the actions that result from interactions between people and things. Although we can anticipate some of those actions during design time, the consequences that we did not foresee will only manifest themselves once the concepts we design are confronted with the social world at large. Hence social and behavioural design calls for sound and deliberate design **and** evaluation.

We could do so by adhering to Mark Zuckerberg's motto of 'move fast and break things'— rush unfinished designs to the market while dealing with the fallout later. However, given the moral responsibility that comes with changing behaviour intentionally, experimenting on the populace at large may not be the most ethical thing do. Instead, social and behavioural design calls for supervised experimentation where designers structurally and continuously assess the performance of their work.

Coinciding with our increased understanding of the impact of products and services on people, society and our planet, numerous tools, methods, frameworks and techniques were developed that support designers in designing an intended social or environmental effect in areas like design for emotion, design for behavioural change and design for wellbeing—or so called methods for effect-driven design (Fokkinga et al., 2014). From descriptive accounts and analyses of the effect that artefacts have, scholars are gradually developing more normative methods and approaches, such as Social Implication Design (Tromp & Hekkert, 2019), Positive Design (Desmet & Pohlmeyer, 2013) and Design with Intent (Lockton et al., 2010), that are inherently anticipatory and prescriptive in the way that the designs produced affect the social world.

When anticipating and prescribing effects through design there are two major implications on the design process. First, achieving and maximising the intended effect has priority above all other concerns and should determine the eventual design, not the other way around (Tromp & Hekkert, 2019). Second, when intending to achieve an effect it is important to take responsibility for the design, by evaluating whether the design brings about that effect while weighing the consequences that the introduction of the design has on the social world.

This thesis explored how designers can take responsibility for their designs by investigating how they can anticipate the effectiveness and appropriateness of their designs. The argument put forth in this work is that when designers integrate various heterogeneous perspectives on the situation during the evaluation of designs for behaviour change, they can critically examine and anticipate the effectiveness and appropriateness of their designs. In the remainder of this introduction we will first examine the state of the art in how design can generate an effect on behaviour. Then we will discuss how designs for behaviour change are evaluated to account for their effect.

Designing for behaviour change

Given that design is so closely related to both change and human behaviour a common misconception is that design always concerns behaviour change. While it is true that almost every artefact designed has an effect on human behaviour, designs for behaviour change are intentional and explicit in the change in behaviour that they want to bring about (Niedderer et al., 2017). Another key differentiator with other types of design is that a 'design for behaviour change' approach is employed specifically to address societal and environmental challenges.

Relation to other fields

We cannot discuss the field of design for behaviour change without positioning it within the larger field of behaviour change. This is the field that is populated by scholars from academic disciplines like social, cognitive, organisation and environmental psychology, behavioural economics, communication sciences and sociology. Given this wide range of disciplines that focus their attention on understanding human behaviour, it is no surprise that the contributions of these fields to our understanding of human behaviour differ on varying levels. In general we can see the contributions to human behaviour on a continuum between individual—social context—environment (Clark, 2010; Niedderer et al., 2016), where each field often contributes to their own level.

There are two predominant views on why people act as they do: that people act rationally or act irrationally. The basic premise behind viewing people as rational actors is that people act based on a rational appraisal of the information that they receive. Theories like the theory of planned behaviour (Ajzen, 2011) and stages of change (Prochaska et al., 1992) build on the fact that people want to maximise their gains and minimise their losses. However, the idea that providing people with adequate information is enough to change their behaviour is clearly invalidated by the fact that many people have difficulty quitting smoking and losing weight even though they know something should change.

On the other hand of the spectrum behaviour is often conceptualised as an instinctive response to heuristics in the environment (Dijksterhuis & Smith, 2005; Kahneman, 2011), which can be addressed through making small *nudges* in the environment that influence people to change their behaviour (Thaler & Sunstein, 2008). Apart from having questionable morality given their overt influence, it is also arguable whether people act on their environment only as were they primitive animals. For example, do we drink too much alcohol because the environment of a bar influences us to do so, or is it the social context of the events that take place there?

Both stances share that they stem primarily from the domain of psychology. Hence they place emphasis on the individual and sometimes interpersonal variables as opposed to broader social and contextual variables (Glanz & Bishop, 2010). Here is an opportunity for design practice as designers are capable of gaining insight into the social context surrounding a behaviour and translate those to interactions on the individual level through the development of artefacts. Second, given their origin from the field of psychology, communication, persuasion and marketing they do not provide guidance in how to design artefacts. General theories like the six principles of persuasion (Cialdini, 2007) may lend themselves well to develop communication designs such as posters and stickers, but do not guide how to steer behaviour through design—suggesting that additional theory or skills are required for developing artefacts that redirect behaviour.

The role of the artefact

The key differentiator between the field of behaviour change and the field of design for behaviour change is the focus on the role of the artefact. Designers were not the first to consider the role of the artefact in changing behaviour, as social scientist and philosophers were the first to turn to describing the role that artefacts play in shaping human behaviour, such as Akrich (1992) and Latour (1992).

One of the earliest contributions from the design field to the design theory underlying our understanding of how things affect behaviour was the introduction of the concept of *affordance* by Norman (1988), drawing on earlier work from the field of ecological psychology (Gibson, 1979). This also demonstrates a common approach in the development of methods for designing for behaviour change —the appropriation of various theories from the fields of for instance psychology, sociology, and behavioural economics for a design context. Other examples are practice theory (Kuijer, 2014; Shove & Pantzar, 2016), and scripts (Jelsma, 2006). Scholars started to embrace a single theory in their method as a frame for understanding behavioural design situations.

Tromp and Hekkert (2017) state that this appropriation of theory from a single area of study results in seemingly opposing stances and incompatible worldviews, where design actually benefits from a holistic view. As social problems are inherently complex there is no single theory that is likely to explain the full extent of the social issue. As designers have the ability to integrate various (seemingly opposing) perspectives (Dorst, 2006; Tromp & Hekkert, 2010), design theories and methodologies should support the use of various theories (for instance the ones in (Tromp & Hekkert, 2012)).

Anticipating the effect

In line with this stance design theories that conceptualised product influence from an experiential viewpoint were developed (Tromp et al., 2011; Tromp & Hekkert, 2017) in order to understand how the (hidden) influence of artefacts can be used in ways that are beneficial to society. This eventually resulted in the Social Implication Design method (Tromp & Hekkert, 2019), which is in part based on the Vision in Product Design method (Hekkert

& van Dijk, 2011). These methods anticipate the future by developing a carefully constructed future context from which a behaviour that the designer wishes to elicit in their design is derived. Other than philosophical approaches like moralising technology (Verbeek, 2011), which take an existing artefact and alter its consequential effects, these methods reason from the outcome to an intervention.

An important element of critique to both these methods is that through the careful anticipation and prescription of the effect it is assumed that the desired effect is likely to be induced. Although Tromp and Hekkert (2019) stress the need for evaluating designs on their respective effectiveness and appropriateness, they leave open what exactly is meant with those concepts. Second, these methods give little guidance in how design interventions should be conceptualised in terms of their formgiving in relation to the aspects of the behaviour that needs to be changed, as the design theory underlying the relation between formgiving and resultant behaviour is rather underdeveloped. Given these two issues we will now dive deeper into the evaluation of behavioural design interventions.

Evaluating design

An integral part of effect-driven design is to assess the impact of a designed intervention. When designers are explicit and intentional in the effect that they want to achieve, it is essential that they evaluate such interventions on the effectiveness and appropriateness.

In relation to the effect, the evaluation of a design serves mainly two purposes:

1 To gain insight into the effectiveness and appropriateness of the design as it is now
2 To distinguish the aspects that need to change in order to improve said effectiveness and appropriateness

To illustrate some of the issues with evaluating design interventions we first introduce an example from a behavioural science approach.

Two approaches

First we will introduce an example from a behavioural science approach. Dijksterhuis and van Baaren & Design Innovation Group (2019) describe a case where they deployed several interventions on a floor in an office building to motivate people to separate their waste. Plenty of available single use cups were used as containers for various waste collected during the day such as banana peels and tea bags, which were discarded unsorted at the end of the day. To address this they installed signs on computer screens, placed signs with prompts near routes to toilets and exits, placed informative signs near coffee machines and improved the signage near the bins; all meant to motivate people to go more often to the waste bins to recycle during the day. This is a prime example of what they themselves call a *behavioural cocktail*, where many small changes in the environment aim to change behaviour. The percentage of correctly separated waste increased from 67,5% to 81,3%, and it even had a similar effect on floors where the intervention was not implemented.

Instead of proving that the intervention was effective, these result show that the attention induced by bombarding the situation with signs and posters made people think twice the next time they were at the recycling bins—and moreover is highly likely that they discussed this with colleagues on other floors. It would be curious if that did not happen when every step you take in the office confronts you with the fact that you have to recycle. What is the contribution of the individual elements on changing behaviour? Do people still notice these signs after a month or three? And besides, what if management decides that next to waste recycling another important

thing is to stand more during the day—are we going to hang additional signs next to the recycling signs? Or will people relapse in old habits once you replace the signs?

In this example we see a conventional quantitative approach to evaluations which is predominant in the behavioural sciences. These types of evaluations primarily fulfil the first purpose of evaluations by quantifying the effect of the intervention as it is now. There are multiple issues with such an approach that cannot solely be attributed to the simplistic nature of the specific evaluation in this example.

First, the evaluation measures the outcome of the behaviour without taking the values and social structures surrounding that behaviour. Hence a change in behaviour is observed, but there is no insight into the specific mechanism that achieved that change and whether the working principle of the intervention was even induced by the intervention itself. Additionally, what was the effect of the individual components of the intervention, and which ones could potentially be left out? In more rigorous evaluations with between-group designs this issue holds as well, as the measured level across participants obscures the effects on individuals (McDonald et al., 2017).

As behaviour is something that takes a long time and effort to change, there is a high chance that if it is not done durably people will relapse into their old behaviour (Ludden & Hekkert, 2014). It is arguable whether in this case the observed change in behaviour is likely to be durable as except for the signs and posters the environment still affords to doing the old behaviour. Thus the behaviour measured at point T1 in time may not be the same as at point T2.

So what if we take a design approach to evaluation? Contemporary design practice is firmly rooted in the user-centered design tradition (Norman & Draper, 1986) where explicit attention is given to end-users during every stage of the design process in order to take their needs, values and concerns into consideration, as ultimately designs should be useful, usable and desirable to users. Hence in design practice we observe that designs are often evaluated through product usability or concept evaluations (van Boeijen et al., 2020), where ideas are validated by employing user tests in which (prototypes of) a product or service are used to elicit user response in a qualitative manner. As contemporary methods and tools for evaluating design concepts are rooted in usability research, the primary mode of evaluation in practice is on the identification of improvements, thus focusing primarily on the second purpose of evaluations.

An important assumption underlying this focus on user response is that "the user is an expert of their own experience" (Stappers & Sanders, 2012). While that maybe true when trying to gain access to latent needs and values, it is arguable whether that is the case for behaviour as well. Behaviour can be something that people are ashamed of to discuss honestly resulting in them turning towards socially-desirable answers. Besides, behaviour can also be something that simply falls outside people's sense of perception and relevance. For example, it is quite hard replicate the exact amount someone picked up their phone in the last hour. And given the longitudinal nature of behaviour this task will become even harder the more time passes. In order to fully grasp the situation of a behaviour we need more than just the user's version of events.

Experimentation

In general we see that in the behavioural sciences there is a quantitative approach to the evaluation of interventions, whereas in design practice methods are more attuned to gaining qualitative insight into the intervention

(although we do acknowledge that, with for instance mixed methods approaches, practice is not as black and white as presented here). An important first step is to recognise that in every way that we can probe the situation the resulting data is a *perspective*, or viewpoint, on the situation; a particular attitude towards or way of regarding something (Oxford Dictionary of English, 2019). In order to gain insight into the behaviour of we person we have to attain multiple perspectives of a different nature in order to triangulate what really happened (Giaccardi & Nicenboim, 2018; Ventrella et al., 2020).

This coincides with new views and understandings that challenge and complicate the traditional user-centered approaches. For instance, Desmet et al. (2019) describe how people experience a design may vary from moment to moment based on their momentary mode state. Giaccardi (2020) suggest the integration of a thing perspective as a means to problematise our inherent biases and beliefs. In the case of design for behaviour change we could see a similar complication waiting to occur.

Ideally we would like to combine the quantitative approach of the behavioural sciences with a qualitative approach of the design sciences. Building on Pragmatist philosophy, Ansell and Bartenberger (2016) differentiate between three different *logics of experimentation*: controlled experimentation, Darwinian experimentation and generative experimentation. Controlled experimentation is primarily concerned with finding cause for effect through isolating variables in controlled settings. In Darwinian experimentation a multitude of experiments are performed concurrently; successful interventions will surface through large-scale trial-and-error. Generative experimentation aims to iteratively refine a prototype in order to arrive at success. Hence our ideal version of a design experiment would be a generative experiment infused with elements of a controlled experiment.

Data in the design process

An important part of an evaluation is the collection of 'evidence' in the form of data, discrete values for objective facts and observations gathered through some kind of measurement tool or method. Designers already have quite the repertoire for the collection of data, ranging from traditional ethnographic methods such as user observations (Abrams, 2000) and interviews (Byrne, 2001); as well as more designerly methods such as cultural probes (Gaver et al., 1999) and context mapping (Stappers & Sanders, 2012).

Advances in the domain of computing increase the availability of data, the variety of different sources and present new opportunities for designers to gather data while doing user research—which could help to support design experimentation in practice by providing more perspectives on the situation.

Examples of this integration and use of new types of data in doing research for design are a set of tools that can be deployed as digital probes (Boucher et al., 2019), widgets that can be used while co-creating smart products (Verweij et al., 2019), data-collecting prototypes for doing design enquiry (Bogers et al., 2016) or by outfitting everyday objects with cameras and sensors in order for them to act as co-ethnographers (Giaccardi et al., 2016; Giaccardi & Nicenboim, 2018). These show the value data can have in the design process, especially in the (re)framing of design problems and situations in the front-end of the design process, or even in identification of new design problems (Kun, 2020).

However, in the evaluation of design ideas the use of data has not yet really been applied to aid designers in learning about the effect of ideas and steer their course of action in a way that suits their situated needs as designers. Traditional quantitative approaches in data-driven design include the use of A/B-testing (King et al., 2017) to statistically

test design variations, and usage analytics (Klein et al., 2019) to gain insight into actual usage and interaction with products. These methods provide insight into the performance of the product design, however, they rarely expose the reasons and values underlying the observed behaviour. Their intention is more centred around the traditional interpretation of data-driven design where the data is used to optimise product performance to predefined performance metrics (Gorkovenko et al., 2020). Besides, it is arguable whether interaction with a product only can provide with enough insight to understand rich behavioural patterns that may not always be influenced by the intervention.

In line with Gorkovenko et al. (2020) there is a need to find more nuanced ways to bring data in the design process in order to understand less quantifiable phenomena. Here the performance of artefacts in the wild can inform design decisions at design time. Although there are already excellent examples of similar approaches as in Bogers et al. (2016) and Kurze et al. (2020), for development of these types of research diversity of approaches can be beneficial.

There are three key issues that will be explored further in this work. First, for the evaluation of behavioural design intervention the use of sensor data is under explored. Many approaches as listed before apply camera's (Giaccardi et al., 2016; Boucher et al., 2019) in order to collect data. However, that may not be the most suitable method when trying to gain insight into the behaviour at hand—for instance when doing research in private environments such as the connected toilet roll holder in Speed and Luger (2019) where even the collection of sensor data imposed privacy concerns.

The use of sensor data poses a second issue, mainly surrounding visualisation of data, where there is an interesting opportunity to explore ways to visualise sensor data in such a way that it still affords sensemaking instead of providing with definitive answer (Gorkovenko et al., 2020), as by visualising only the end results "but not the process by which it was created, we risk propagating false, misleading, or unreproducible findings" (Correll, 2019).

The final issue concerns the involvement of users in the sensemaking process. Previous work navigate the problem of contextualising sensor data by applying collective sense making activities with participants (Amram, 2016; Fischer et al., 2017; Kurze et al., 2020). However, in line with the characteristics of behavioural design where people may not be the expert of their own experience it is arguable whether that is desirable as well.

Outline of this thesis

When designing for effect—especially when the intent is to change behaviour in a way that is beneficial to society—it is vital to understand the degree to which that effect manifests itself and what the consequences of introducing that effect are. However, changing behaviour is something that takes a long time to materialise durably and thus conventional qualitative user-centered approaches to evaluation may not be the most suitable. On the other hand, quantitative approaches measuring only the outcomes of the behaviour similarly do not provide detailed insight into the performance of the intervention. This thesis explores how a combination of quantitative and qualitative perspectives on the situation can improve the evaluation of design interventions on their effectiveness and appropriateness in four chapters:

Chapter A, the current chapter, introduced the topic of this thesis by giving an introduction to the field of design for behaviour change—sketching the state of the art in terms of designing and evaluating designs that specifically aim to change behaviour. After

this outline, the chapter concludes with the research setup which details the aim of this work, research questions and the approach that was taken during the execution of this project.

The rest of this thesis is divided into three chapters. *Chapter B* provides a detailed account of the mechanics of designing for behaviour change by going through all stages of the behavioural design process. The chapter details the process of specifying the behaviour addressed and provides a structural overview of design interventions, in order to arrive at implications for the evaluation of design interventions. Furthermore, the concepts of effectiveness and appropriateness will be operationalised into a theoretical model. The chapter concludes by posing three additional research questions that inform the experimental setup in the next chapter.

Chapter C outlines the experimental part of this work in which the theory developed in the previous chapter is explored in practice by evaluating two design concepts in the context of the end user. This chapter details the study design, methods, intervention development and data analysis. The chapter ends by examining the results of the two experiments in terms of how they contribute to assessing the effectiveness and appropriateness of the intervention.

Finally, *chapter D* takes a step back by placing the results from the design experiments in perspective to the greater context of this thesis. The chapter starts by examining the results and discussing them in relation to the research questions. Additionally, the limitations of the work present will be discussed as well as directions for further research and development. Given the practical approach in this work we will also provide with implications of this work for design practice. The chapter concludes with a final conclusion of the contributions of this work as well as a personal reflection on this graduation project.

Research setup

Aim and research questions

This thesis investigated how during design experiments integrating various sources of qualitative and quantitative data on a behavioural situation contributes to critically assessing and anticipating the effectiveness and appropriateness of an intervention aimed at changing behaviour. The work thereby mainly contributes to the domain of evaluating design for behaviour change. Other contributions are to the interaction between designers and data, tools for facilitating design experimentation, and theory for design for behaviour change. Through the planning and execution of two design experiments we investigate the barriers and opportunities of using quantitative and qualitative data during an evaluation. Driving the research is the following design goal:

DG How can behavioural designers be supported in critically evaluating design ideas on their effectiveness and appropriateness through the use of collecting and harnessing various sources of data.

Derived from this design goal is the following research question:

RQ1 How can the dimensions of effectiveness and appropriateness be operationalised?

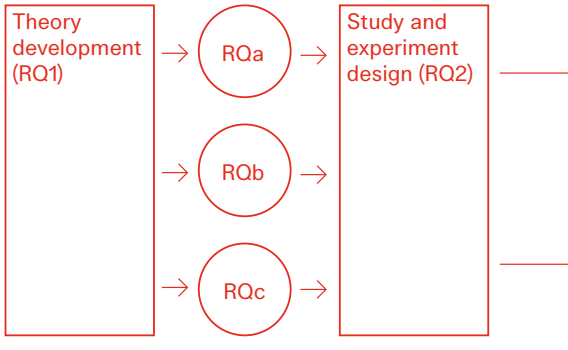
RQ2 How can the integration of multiple perspectives on the situation improve the critical evaluation of design ideas in terms of their effectiveness and appropriateness?

Research approach

The research focused on design for behaviour change, a specific type of design for effect where collecting data from various sources could potentially serve well to enhance and/or challenge the perspectives gained through a traditional user-centered approach. Most importantly, we chose to explore the use of sensor data collected through instrumenting an ecology of things related to the behaviour targeted. The use of sensor data served two purposes: to investigate how behavioural interventions can be evaluated on a longitudinal scale, and to explore how designers can harness sensor data during design evaluations.

This last element of the setup had additional interesting implications for the research. As sensor data is a material that designers are not able to handle as intuitively as for instance interview data, the process of turning it into usable knowledge was more considerate. Through this process of handling the data we expected to obtain insights that can reflect back on how more familiar sources of data are handled.

The research consisted of two parts, a theory development phase which developed a theoretical model that was evaluated in the consecutive research through design



phase. The theory development phase investigated how design can play a role in changing behaviour, and what the respective repercussions are for the evaluation of such a design. In this phase we investigated the first research question by operationalising the effectiveness and the appropriateness of design interventions. Additionally, during this phase the second research question was further detailed by posing three additional research questions.

In the second phase we addressed the second research question through adopting a research through design approach (Stappers & Giaccardi, 2017). Taking the hypotheses that followed from the first phase we developed a study in which a design process was simulated resulting in two research artefacts that were deployed and evaluated in the context of the end-user. During that evaluation we gathered multiple perspectives on the situation: through interviews with the user, obtaining data generated through the interaction of the user intervention, and through attaching sensors to other relevant things in the context.

The results of those studies were visually analysed as were they actual evaluations of design interventions. Based on those conclusions we reflected back on the design goal and research questions to discuss the results and limitations, examine the implications for design practice and discuss directions for future research and tool development. An overview of the research process can be found in Fig. 1.

In research through design projects where the object of study is a design method itself the interrelations between actors can easily become quite confusing (Stappers & Giaccardi, 2017). Therefore it is helpful to discern between the different levels and respective roles that are co-existing within the project (Stappers & Sleeswijk Visser, 2014). In this project the main roles of interest are:

1 the *researcher* focused on understanding the role of a data-informed perspective in behavioural evaluation
2 the *behavioural designer* of design interventions
3 the *developer* of an infrastructure to gather thing-centered data

Where role 3 is supportive to the primary roles 1 and 2.

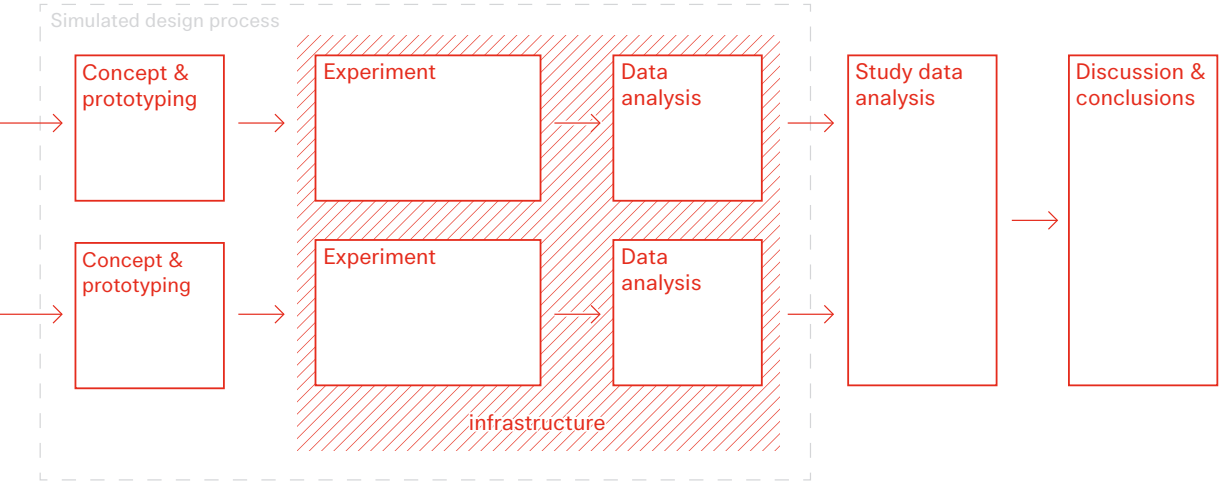


Fig. 1 Overview of the research process

Core concepts

Throughout this thesis a number of core concepts will be used frequently. In order to avoid misunderstandings due to different understandings of the terms, these concepts are introduced and defined below in Table 1.

Appropriateness	The quality of being suitable or proper in the circumstances (Oxford Dictionary of English, 2019)
Artefact	Any designed entity—such as products, services, platforms and systems (Erlhoff & Marshall, 2008)—in its straight materiality
Behaviour	People's actions in response to other people, things, environments and context, for the purpose of negotiating external factors and internal goals (Niedderer et al., 2017)
Data	Unorganised and unprocessed sets of set of values for variables that collect objective facts and/or observations gathered through some form of measurement.
Design intervention	An artefact that intentionally aims to change behaviour through exerting influence
Designer	A trained practitioner, either through education or practice, who has a structured process and systemic approach to the development of interventions aimed at effectuating change.
Effectiveness	The degree to which an intervention is useful in producing the desired effect, when an intervention is offered to a user
Efficacy	The degree to which an intervention is useful in producing the desired effect, when a user receives an intervention.
Experiment	A process undertaken for the purpose of discovering something unknown or testing a hypothesis.
Manifestation	The specific chosen artefact form and its respective qualities that embodies the selected mechanism of the design intervention.
Mechanism	The specific characteristics of the design intervention that address specific characteristics of the behaviour
Practice	A routinized type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know- how, states of emotion and motivational knowledge (Reckwitz, 2002)
Situation	All the elements that are relevant to a practice, activity or (in this work) behaviour—the environing experienced world (Dewey, 1938)
Thing	The designed artefact, plus the people or other artefacts that relate to it and how they relate to it (Giaccardi, 2019).

Table 1 Core concepts used throughout this thesis

B

Changing behaviour through design

As established in the introduction of this thesis design for behaviour change has certain distinct qualities that differentiates it from traditional product and service design. This chapter explores the mechanics behind developing design interventions aimed at changing behaviour. During this chapter we will roughly follow the behavioural design process from the specification of behaviour until the evaluation of the design intervention. Every section in this chapter will conclude with several implications on the evaluation of design interventions. The first section sets forth the implications of the specification of the behaviour to be elicited through the design in relation to the conceptualisation and eventual evaluation.

We will provide an overview of the breadth of design interventions that aim to change behaviour, and define the scope of the type of interventions addressed in this work. Then we will structurally examine design interventions and their conceptualisation by discussing the intervention's mechanism and manifestation of design.

Finally we will continue with operationalising the aspects that constitute the assessment of the effect of behavioural design interventions. The concepts of effectiveness and appropriateness will be operationalised into a theoretical model, where we will show that the long-term effectiveness of an intervention is linked to the appropriateness of the intervention.

We end this chapter with a short summary of the findings up to this point and complement our research setup with three additional research questions based on this theoretical exploration that were used to guide the experimental part of this research.

Specifying behaviour

Design processes alternate between divergent and convergent activities (Roozenburg & Eekels, 1995, p. 109). One of those convergent steps in the front-end of the design process of effect-driven design methods is the definition or framing of the problem behaviour through for instance a behavioural problem statement (Cash et al., 2017), a statement (Hekkert & van Dijk, 2011; Tromp & Hekkert, 2019) or a design goal. That 'framing' of the problem is the process of creating a novel standpoint from which a problem can be adressed (Dorst, 2011). By demarcating the intended effect that the designer wishes to elicit this formulation of the behaviour is key to the eventual evaluation of an intervention.

Framing behaviour

In behavioural design the framing of the problem primarily concerns the articulation and specification of the behaviour that the designer wishes to address. In behavioural design we can distinguish between two ways of framing the effect, as *discouragement* of undesired behaviour or as *encouragement* of desired behaviour (Tromp et al., 2011). Behavioural design is inherently concerned with changing behaviour, and often that motivation to change the situation stems from an observed undesired behaviour or social phenomenon. This behaviour is often reflected in the initial design brief and marks the entry point into the situation.

As we will show in the remainder of this chapter behaviour can be specified on a continuum from abstract to specific, allowing the designer to traverse varying levels of abstraction in order to frame and reframe behaviour. However, to do so effectively it is helpful as a first step to frame the behaviour in a positive way instead of a negative one. Framing behaviour in a negative way often focuses attention on addressing that single behaviour in a traditional problem-solving way, leading to interventions that can be characterised as behavioural fixes. If we frame the problem as what people *should* do instead of what they *should not*, we open up the space for far more ideas that in the end might be more effective and appropriate. For instance we can design an intervention that makes people stop littering—or we could design an intervention that stimulates people to bring their waste home, make people reinterpret their waste as a resource or even make sure that people do not have any waste to begin with.

Means-end laddering

The previous example also shows that when framing the desired behaviour in a positive way, that behaviour can be expressed on a variety of abstraction levels. The specification of a behaviour can be captured through a means-end ladder which shows the relationship *between* behaviours;

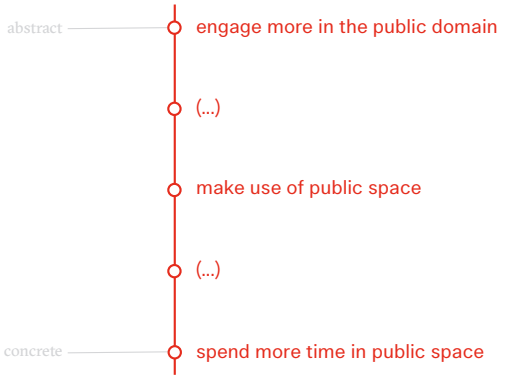


Fig. 2 Example of a behavioural laddering, after Tromp and Hekkert (2019, p. 82)

ranging from abstract behaviours with wide social implications to concrete, 'designable' behaviours (Tromp & Hekkert, 2019). An example of a behaviour laddering can be found in Fig. 2.

Through laddering we establish a relationship between behaviours, serving as stepping stones to higher abstraction behaviours and implications (Tromp & Hekkert, 2019). This allows the designer to traverse varying levels of abstraction throughout the design process; ultimately leading up to a design situation that might *reframe* the initial brief/target behaviour.

Reframing behaviour

When reframing behavioural problems designers address the underlying reasons for the behaviour instead of the symptomatic outcomes. For instance, people often place their garbage bags next to a fully loaded waste collection point instead of taking it back home or walking an extra distance to the next container. One approach to this could be to address this behaviour directly by motivating people to walk to the next container or temporarily store their garbage bag at home. However, does such an intervention address *why* people exhibit this behaviour in the first place?

By doing research into the situation designers can cross varying levels of abstraction and identify causal relationships between behaviours. It could be that in this case people are not separating their waste at all—resulting in too many garbage bags of the same type—which could lead to an intervention that addresses the waste produced. Or the collection times of the containers do not match the rate at which people produce waste, which could lead to the realisation that we might not need an intervention to change people's behaviour but rather adapt the collection times to people's behaviour. This reframes the problem behaviour into something that might result in an intervention that is more effective and appropriate.

In this example of behaviour we see that designers establish a relation between the behaviour that was the entry point of enquiry and the behaviour that is going to be designed for. When changing the reframed behaviour it is assumed that the target behaviour will be resolved. However we have only established a relationship and have not yet gained insight into the strength of that relationship.

Additionally, it is important to note that there is no single laddering that can fully describe the causal relationship between specific and abstract behaviours alone—as behaviours can be specified in several different, more specific behaviours that each contribute to a certain extent to the same more abstract behaviour.

Dealing with complexity

Traversing between specific and abstract levels is particularly helpful for the act of reframing, however it is vital to end these moves on a rather specific level. Specifying the behaviour is an essential step in order to develop an intervention; for too abstract behaviours the complexity of the situation is likely to exceed the limits of bounded rationality and thus overwhelm our ability

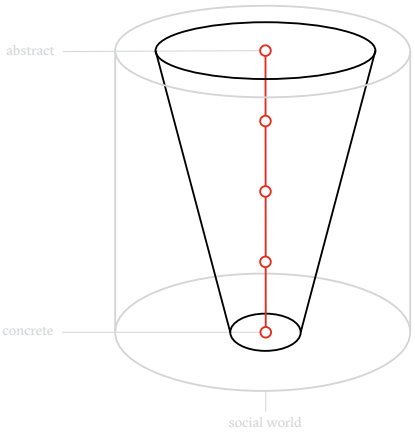


Fig. 3 Through specifying the behaviour the complexity of the social world is reduced step by step as fewer things and events are relevant to the behaviour

to do anything about the problem at hand (Sweeney & Sterman, 2001; Weick, 1984). Reducing the complexity of the situation is inevitable in order to effectively develop interventions. As such we can visualise our ladder as an inverted cone, where through each level of specification the part of the social world that is actively considered at design time is further reduced (Fig. 3).

Establishing the design situation

At every specified level of behaviour we can take a slice of the inverted cone, which provides us with a *situation*[1]. Dewey (1938) states that we "never experience or form judgment about objects and events in isolation, but only in connection with a contextual whole", hence he defines the situation as an 'environing experienced world'. It is *environing* as it forms the environment or background to an activity or practice, that is *experienced* as certain organisms interact with their environment and forms a coherent whole or unity, a *world*. Especially this environing element is of interest here, as the situation is not constrained by distance in time, space or causal connection, but in terms of its relevance to the behaviour at consideration. Thereby the situation is not an environment in a spatiotemporal but an ecological sense.

As we started this section, in design processes an important step is the transition from contextual research to design activities by focusing the problem in a statement. Following Schön (1983, p. 40):

> When we set the problem, we select what we will treat as the "things" of the situation, we set the boundaries of our attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situation needs to be changed.

Thus through articulating the behaviour in a statement the designer establishes their design situation; limiting the part of the

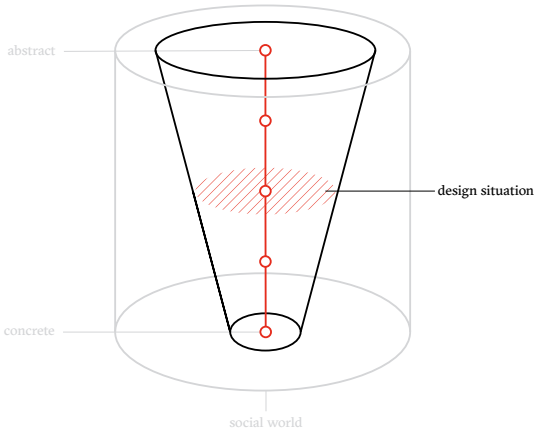


Fig. 4 By defining their behavioural statement designers create a slice of the social world that they consider at design time: the design situation

context they actively consider during design time (Fig. 4). It is through this *naming* of the things that will be considered and *framing* the context in which those will be addressed (Schön, 1983, p. 40) that designers set their problem.

The artificial construction of the design situation functions as the lense through which the situation is observed. It does not filter out the interactions with other elements but rather focuses the attention on the elements of concern at design time; leaving other elements and interactions in the peripheral vision of the designer.

Unpacking the design situation

Up to this point we have considered the behaviour as an opaque entity. Yet to fully understand the relation between behaviour and the context we have to decompose it into constituent elements. When looking at the social world we see an infinite amount of elements that all interact with each other at varying levels of criticality and intensity (Nelson & Stolterman, 2012, p. 75). The main premise underlying this work is the notion that a significant part of our behaviour arises from our interactions with things[2] in the world. Behaviour thus is the product of multiple interactions between people and things;

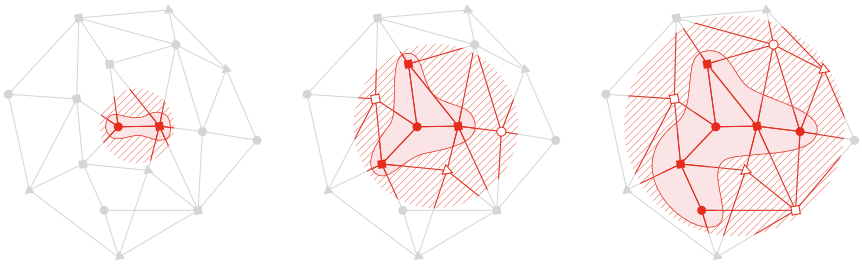


Fig. 5 When expanding the situation the number of things and relations that are relevant increases—encompassing things and relation that directly contribute to the behaviour (pink), affect the behaviour indirectly (hatched) or affect the behaviour tacitly (grey)

The more abstract the behaviour, the more elements and respective interactions that behaviour encompasses (Fig. 5).

However, the fact that those elements are present in the situation does not mean the designer has full control over them. Generally speaking the designer crafts an artefact over which they exert full control, while other interactions and elements are merely influenced indirectly (or by employing multiple interventions).

Implications for evaluations

> Means-end laddering and reframing result in relations between behaviours that are assumed to be causally related, however, there is no insight into the strength of those relations. Additionally, this could mean that multiple behaviours have to be considered during an evaluation (in the case of reframing).

> The specification of the behaviour implicates the elements that are relevant to that behaviour, establishing an ecology of things and events that contribute to the behaviour.

> Designers limit themselves during design time to a narrower design situation established by the target behaviour specified for the effective development of an intervention—which may not necessarily contain all elements that influence the eventual effectiveness and appropriateness.

1 This argument was developed based on an interpretation of Dewey's work in a working paper by Brown (2017).

2 Another significant portion of our (social) behaviour stems from interactions with other people within the social constructs present in our world, such as for instance bullying behaviour.

Fig. 6 Cards that are part of the infrastructure of the 'introduction dinner' which aims to establish common ground between participants in order to nurture more social cohesion in residential buildings for elderly people

Fig. 7 A situation in an IKEA restaurant showing several intervention elements on top of the bins, on the sides of the bins, the colours of the bins and on the trays

Design interventions

After outlining the process of specifying the behaviour to target, it is now time to examine the vehicle for effectuating that change. First we will discuss general properties of design interventions by providing examples in order to scope the kind of design interventions that this research is concerned with before moving over to conceptualisation of design interventions in the next section.

The focus of this research is on the evaluation of design interventions for behavioural change. The key distinguishing factor between a design intervention and a 'traditional' artefact is the intentionality to effect change in behaviour. Given their mediative role, all things will influence our interaction with the world—yet design interventions aim to alter this human-world relationship in a deliberate way.

When viewing designing for behaviour change through the lense of practice theory, behaviour change can be conceptualised as the reconfiguration of the elements and links that make up the practice (Kuijer, 2017), which occurs when new elements are introduced into the situation (or existing are combined in new ways) (Shove et al., 2012). A behavioural design intervention is in this case the vehicle for introducing those new elements.

How those elements are introduced can vary from intervention to intervention. Interventions can manifest in many different ways, and as such can either introduce themselves as an element (thing) or through interaction with them introduce elements (skills and images). In the latter case the intervention can also be of a temporary nature—as it can be retracted from the situation when the practice has reconfigured and the elements are integrated in the practice-as-entity. For instance, the cards in Fig. 6 are part of an infrastructure to organise an 'introduction dinner' for elderly people in a residential building. Here the intervention aims to establish common ground between participants in order to stimulate feelings of connectedness and reduce feelings of solitude. Here the physical intervention, or even the dinner itself, are not meant to be permanently integrated as it is intended as an event to kickstart new relations between residents.

As discussed in the previous section, more abstract behaviour encompass several interactions with multiple related things instead. Thus design interventions are not confined to the limits of a single artefact but can also consist of several components deployed at various places or touchpoints in the context. An example of this is can be found in Dijksterhuis en van Baaren & Design Innovation Group (2019) where they describe a case at IKEA on stimulating waste separation by detailing a design intervention comprised of several elements in the context of the restaurant that influence people to separate their waste (Fig. 7).

Classifying behavioural design interventions

Given the wide array of behavioural design interventions, a classification of behavioural design interventions was made in order to be able to scope the type of intervention that would suit our proposed approach. It provides a shared vocabulary for discussing design interventions further on in this thesis. Starting point for the classification was the work of Bay Brix Nielsen et al. (2018) who

Manifestation type	In line with Simon (1996), any intervention that changes an existing situation into a preferred situation is a manifestation of design. This dimension is a non-exhaustive list of categories of different ways that behavioural design interventions can manifest themselves.
Manifestation level	The level at which the intervention manifests itself, on a specific *part*, the *product* level or through the introduction of multiple elements in a *system* (Andreasen et al., 2015 in Bay Brix Nielsen et al., 2018)
Moment of intervention	The moment that the intervention is mainly active, before the behaviour (*antecedent*), during the behaviour or after the *behaviour* (*consequence*) (Miltenberger, 2008 in Bay Brix Nielsen et al., 2018)
Intervention influence type	The experienced salience and force of influence, which can be described as *decisive* (hidden and strong influence), *coercive* (apparent and strong influence), *seductive* (hidden and weak influence) and *persuasive* (apparent and weak influence) (Tromp et al., 2011)
Intervention strategy type	The way that the social dilemma in every behavioural intervention is overcome, by *resolving* the conflict, *bypassing* the conflict or *transforming* long-term concerns into short-term ones (Tromp & Hekkert, 2019).
Point of intervention	The level of specificity of the target behaviour that is targeted (related to the concept of laddering as in (Tromp & Hekkert, 2019)). It can focus on *behaviour* in isolation, on the *practice* that makes up the behaviour or on the *systemic* context of the behaviour—where the latter ones have wider social implications.

Table 2 Overview of the dimensions of behavioural design interventions

proposed three dimensions for describing the solution space for behavioural design interventions—the intervention form, the time of active intervention and the intervention strategy. Based on those three dimensions and complementary dimensions from other literature the following six dimensions where drafted, which are further detailed in Table 2. A set of aggregated examples was mapped along those dimensions, as can be seen in Fig. 8 on page 26.

Scope of this work

Given the breadth of the field of behavioural design, what is the scope of interventions for behaviour change that this study is concerned with? When we consider the manifestation types according to the definition of an artefact—any designed entity—such as products, services, platforms and systems (Erlhoff & Marshall, 2008), one could argue that all of them are indeed artefacts. However this study will not explore communications, campaigns, infrastructures and policies—as the relation between the artefact and the change in behaviour is implicit and diffuse. Hence a key distinguishing property of design interventions that are considered in this work is that they afford action (Gibson, 1979; Norman, 1988).

An important part of this work is to understand behaviour holistically, thus focusing on interventions that aim to 'fix' people through small changes in the environment are not the focus of this work. Hence we did not focus on interventions that aim to intervene in a specific behaviour but rather interventions that target the behaviour at the level of different practices.

Although the manifestation level of a system (for instance through developing and evaluating a service) could be interesting to explore, for the limited timespan of this work having that as the object of study is not within reach.

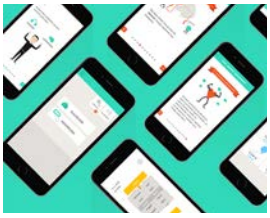
Finally, the focus in this work is on the introduction of a singular design intervention into the situation, instead of an intervention that is composed of several parts as the example we discussed in the introduction of this section. Additionally we focused on interventions that are intended to become a permanent part of the situation, as opposed to the example provided in the beginning of this section.

Manifestation type

communication
product
app
service
campaign
infrastructure
policy

Manifestation level

part
product
system



Moment of intervention

antecedent
behaviour
consequence

Intervention influence type

decisive
seductive
coercive
persuasive

Intervention strategy

resolve
bypass
transform

Point of intervention

behaviour
practice
system

Fig. 8 Typology of behavioural design interventions along the dimension as defined in Table 2. A description of the examples can be found in appendix II

Conceptualising design interventions

While the previous section expanded on the breadth of design interventions, this section will examine the mechanics of conceptualising design interventions. The focal point of a design experiment is the evaluation of a design concept. Here we see a design concept as the proposition of a manifestation and a mechanism. As such it is an embodied hypothesis of an effective means to achieve the intended effect; together they aspire to achieve that intended effect or value. This highlights an important characteristic of design, the concurrent development of the artefact and the working principle (Dorst, 2011; Roozenburg & Eekels, 1995). From the onset of a design project only the aspired value is known, and consequently there are likely to be many mechanism–manifestation pairs that could achieve the specified behaviour.

Mechanism

The mechanism[1] is *how* the intervention aims to achieve the aspired value. The mechanisms and thereby describes the relationship between the intervention and the behaviour. Tromp and Hekkert (2017) decompose the mechanism into two constituent parts, the strategy and the style. The strategy describes which characteristics of the design target which specific characteristics of the user, whereas the style describes how that is achieved through this specific intervention. The latter is thus more closely associated to the formgiving of the selected manifestation of design.

Applying theory

The strategy should ideally be informed by theory[2] derived from the body of work in the behavioural and social sciences. Theory is "a set of concepts and/or statements with specification of how phenomena relate to each other. Theory provides an organising description of a system that accounts for what is known, and explains and predicts phenomena" (Davis et al., 2015, p. 327). Thus theory can be used to identify the elements[3] that are hypothesised to be causally related to the behaviour, which when addressed should lead to the desired change in behaviour (Michie & Prestwich, 2010). As a consequence, theory can help during an evaluation in explaining why an intervention was effective or not, as either the intervention did not induce the mechanism as desired or the applied mechanism did not lead to a change in behaviour (Davis et al., 2015).

Despite these benefits theory often does not end up as the central element of design's mechanism[4]. Most theories do not provide guidance in how to develop an intervention (Michie et al., 2008), resulting in interventions that are more inspired by a theory than based on them. Also, for effective integration of theory it is imperative to select the most appropriate theory for the problem at hand (Cash et al., 2017), which requires an understanding of a wide range of theories. In practice we see that a small amount of theories are applied over and over again (Davis et al., 2015, p. 327), where those might not be most appropriate for the specific situation. Finally, many theories, especially those concerning public health, place emphasis on the individual and sometimes interpersonal variables as opposed to broader social and contextual variables (Glanz & Bishop, 2010), which contradicts with a more holistic approach.

The chosen mechanism in a design project more often is the result of a synthesis of various sources—findings from interviews and observations in the context of the end-user, literature studies, expert interviews etc. Nevertheless theory provides yet another (important) perspective on the situation, which could help to explain the phenomena observed in the experiment. Therefore it serves it purpose both for the conception and the evaluation of the intervention. For the conception of design interventions our focus is more directed towards the translation of a mechanism into a concrete intervention as opposed to the selection of the mechanism. Here we will work from the assumption that when the selection of the mechanism is done in a sound academic manner the chosen mechanism is an effective strategy for achieving the intended goal.

Manifestation of design

Mechanisms are of an amorphous nature; hypothetically speaking they could manifest themselves in any conceivable way. In the development of interventions for behavioural change designers embody a mechanism into a manifestation of design, solidifying that working principle into a specific type of artefact. In that process a designer is "searching for some kind of harmony between two intangibles: a form which we have not yet designed, and a context which we cannot properly describe" (Alexander, 1964, p. 26).

The manifestation is not merely a neutral carrier of the mechanism as it has qualities of its own. "The [manifestation] and the [mechanism] should be fully integrated and strengthen each other's purpose" (Hekkert & van Dijk, 2011, pp. 244-245). Thus the designer should strive for an internal fit between the mechanism and the manifestation. However there is also an external relation between the artefact and its context, as Simon (1996, p. 6) states:

> An artefact can be thought of as a meeting point, an "interface" in today's terms, between an "inner" environment, the substance and organisation of the artefact itself, and an "outer" environment, the surroundings in which it operates. If the inner environment is appropriate to the outer environment, or vice versa, the artefact will serve its intended purpose.

That interface can be seen as the human-artefact interaction (Hekkert & van Dijk, 2011, p. 280). However, here it would be too simplistic to equate the artefact to the manifestation and the human-artefact interaction to the mechanism. Although the mechanism concerns the style, the exact choices made during formgiving is largely dependent on the manifestation of design. The choice of using a card set or a smartphone application directly influences the type of interactions that present themselves.

An important element to consider when giving form to the manifestation of design is the artefact's 'fitness' or suitability to the context for which it is designed. So when designing the manifestation of design, "the real discussion is not the form alone, but the ensemble comprising the form and its context. Good fit is a desired property of this ensemble which relates to some particular division of the ensemble into form and context." (Alexander, 1964, p. 16). Through the formgiving of the intervention we are able to either amplify or diminish the effect of the mechanism as selected.

Selecting the medium

The choice of manifestation is not always based on an optimal fit between manifestation and mechanism. For instance many researchers with a background in the behavioural sciences develop interventions through textual and communicative means like posters and campaigns. Given that these kinds of manifestations do not afford action

(Gibson, 1979; Norman, 1988) they may not always provide the best fit with the context and thus may not be the most appropriate medium for the intervention.

Given the ability of designers to translate abstract concepts into concrete interventions they are better equipped to select the right manifestation for the best fit to the context. However, even designers are not always as deliberate in selecting the right manifestation for their intervention. For instance, designers opt for a certain manifestation based on their familiarity with the medium's 'material' or because it fits the profile of their studio (e.g. building an app as a digital design agency). Another reason might be the economic implications of developing such a manifestation (e.g. a card set is less expensive to develop than an app). Finally designers often operate in multi-stakeholder environments where the client might have fixated on a certain manifestation beforehand.

Describing fitness

Achieving good fit is largely something that has to be achieved through the formgiving of the intervention as "the form is a part of the world over which we have control, and which we decide to shape while leaving the rest of the world as it is. The context is that part of the world which puts demands on this form; anything in the world that makes demands of the form is context" (Alexander, 1964, p. 18). Describing good fit usually happens through pointing out the elements that failed in achieving good fit. In the words of Alexander (1964, pp. 23-24): "it seems as though in practice the concept of good fit, describing only the absence of such failures and hence leaving us nothing concrete to refer to in explanation, can only be explained indirectly; it is, in practice, as it were, the disjunction of all possible misfits" . Alexander sees the process of achieving fit as a process of neutralising the forces that cause misfit, where the ones that demand the most attention should be addressed.

Although we see this process of negating the most prominent opposing forces as an important part of the process while developing an individual intervention—it would also make sense to have a shared vocabulary to discuss the 'fitness' of manifestation in relation to its context. Therefore we propose an initial set of qualities that will be used to discuss the design concepts later in the work, which is by no means intended to be a definitive and conclusive list.

Presence

Artefacts have a varying level of presence in the situation. Physical objects can have a constant presence by physically being there. However presence can also be a mental construct, as for instance a water kettle may be present on your mind even when you are not in the same room. Generally things slowly recede into the background, although for objects that are meaningful to a person that might not be the case (Lehtonen, 2003). Things that have a high presence in the situation often signify a state of 'potential use', like being instantly at the users disposal such as a standby modus, or only when required for a specific action such as a tool. For digital artefacts the notion of presence changes as they alter on the spatial and temporal dimensions (Löwgren & Stolterman, 2004). Instead of transitioning from a state of 'potential use' to 'in use', they merely present themselves once they are required, disappearing afterwards.

Directionality

Manifestations can be directional (Boon et al., 2018) as they convey *clarity*, the specific interpretation of manifestation's purpose or message, and provide *guidance*, engage the user in specific course of action. Textual cues, in manifestations such as posters and chat messages, often are very directional in the sense that they are explicit in their message

and course of action. In artefacts that feature a high level of directionality the interactions that can be performed with that artefact are limited and restricted, bending the user to the 'will' of the thing. There are cases where such a quality is desired yet it can also lead to obstructing the ability for the user to engage with the thing.

Coordination

This factor concerns the level in which a thing unites different practices (Shove et al., 2012). Things that are highly coordinative often fulfil a very important (but not meaningful per se) role in the life of people, such as mobile phones. Things that are highly coordinative often fulfil a very important—but not meaningful per se—role in the life of people, such as mobile phones. As these artefacts tap into various ecosystems, they can be used to change or adapt behaviour across a variety of situations. As they are used in many different practices, there is also a high likelihood that these artefacts will be in relative close proximity to the user while performing these practices. At the same time, this can also mean that trying to attention has to be shared with other practices.

Essential

Some artefacts are essential for performing certain interactions. For instance in the case of sleeping, the bed is a very essential thing (although not exclusively) in the practice of sleeping. Intervening in an essential artefact means that there is a high chance that the user will interact with the intervention, which also implicates that the user will be exhibited to its influence during every interaction.

Implications for evaluations

> Understanding the mechanism, and the theory on which it is based, in relation to the observed change in behaviour can help to explain whether the intervention was effective (when it induces the mechanism) or that this mechanism simply was not effective, either as it does not lead to the desired change in behaviour or because the intervention needs improvement.

> Properties of fit can help to establish a shared vocabulary in discussing whether the manifestation of design is an appropriate match for the design situation in relation to both the context and mechanism.

1 Complex design interventions can make use of several mechanisms, which can be evaluated both integratively or in separate tests (Tromp & Hekkert, 2019).

2 Apart from the benefits for the design to be developed, the application of theory also has the benefit of strengthening the validity of the theory itself; it accumulates evidence for the theory across different contexts, populations and behaviours (Michie & Prestwich, 2010). When adapting the theory according to it's applications this has the potential to turn into a positive reinforcing loop.

3 In the behavioural sciences these are described as the mechanism of action, or mediator, and the moderator of change (Davis et al., 2015). Mediator variables describe how two variables are related, while moderator variables describe the conditions under which, or for whom, those two variables relate.

4 This phenomenon is not exclusive to design practice, as also in the behavioural sciences many published studies report on the evaluation of interventions without making an explicit link to the theory that they are based on (Prestwich et al., 2013).

Assessment of effect

One important characteristic of design for behaviour change is the intentionality with which the designer wants to effectuate a certain *change* in *behaviour*. Hence the effect of a behavioural design is generally measured in terms of its effectiveness. Behavioural interventions can produce long-term effects like a reduction of water use and electricity consumption, however, in follow-up studies the positive effect often is not sustained (Abrahamse et al., 2005). This suggests that even though the interventions may seem to be effective in the short run, there is another factor at play that influences the effect an intervention eventually has.

Generally speaking we can distinguish between two phases within the development of designs, design time and use time[1]. During design-time designers anticipate their design at use-time, which in the case of behavioural design means inscribing features in the design that aim for an intended change in behaviour. Once the design transitions to use time the effect that the intervention has will gradually become apparent as it manifests itself in the social world. As mentioned before, that manifested effect is often not the same as the intended effect. There are other factors at play that influence the actual effectiveness of a design intervention over time.

One of the factors that we deem as essential when assessing the effect of a design intervention is the *appropriateness*. For instance in creativity research scholars discern between the novelty and appropriateness of ideas (Paletz & Peng, 2008), where the latter relates to the 'product' usefulness, correctness and value (Amabile, 1983). Yet for a design to be appropriate it needs to be more than instrumental in fulfilling a value. It also needs to fit with the demands of the situation (Brown, 1989).

According to Simon (1996) "fulfilment of purpose or adaptation to a goal involves a relation among three terms: the purpose or goal, the character of the artefact, and the environment in which the artefact performs". Thus for a design to be effective in achieving a certain outcome it has to be appropriate in the context in which it operates. Hekkert and van Dijk (2011, p. 72) build on that by stating that "the term 'appropriate' is ideally used to describe the relationship between a product and the context from and for it is designed". This touches upon the concept of adaptation, the artefact's 'fitness' or suitability to the context for which it is designed. Throughout their book on the Vision in Product design method they stress the importance of reflecting on whether the design is appropriate in its context[2]. When there is a 'fit' between the artefact and its context it is highly likely to fulfil its purpose.

Hence we see the appropriateness of an intervention as inherently linked to the resultant manifested effect.

Operationalising effectiveness and appropriateness

In order to assess behavioural design interventions in terms of their effectiveness and appropriateness we have to further operationalise these terms. In the preceding section we lightly touched upon what effectiveness is. The *effectiveness* of a design intervention can be described as the degree to which the intended effect manifests itself into the social world, and the long-term consolidation of that manifested effect. In

Fig. 9 An intervention that reduces the number of displaced garbage bag by placing fake grass and flowers around the container

Fig. 10 An intervention that reduces the number of displaced garbage bag by placing a planter with real plants and flowers around the container

behavioural design the intended effect is the behaviour that the designer wishes to elicit, and the effectiveness is the measure to quantify the degree to which that behaviour is evoked.

When discussing the effectiveness it is important to distinguish between the *effectiveness* and *efficacy* of an intervention. An intervention is efficacious when it works for people who receive the intervention, while it is effective when it works for people to whom the intervention has been offered (Courneya, 2010). Thus it involves a certain anticipation of the adherence of people to the intervention.

The term *appropriateness* is defined as "the quality of being suitable or proper in the circumstances" (Oxford Dictionary of English, 2019), and as such is a *relational* concept. Within design, it is a qualitative description of the relationship between the intervention and the design situation. However the way that an intervention relates to the situation has different facets. Here—in the context of behavioural design—we differentiate between three types of appropriateness, *aesthetic*, *moral* and *systemic* appropriateness.

Aesthetic appropriateness

A first factor to consider when assessing the appropriateness of an intervention is its aesthetics. However, aesthetics does not only entail an appreciation of an intervention purely based on its material qualities—such as texture and colour contrast—but also on the relationship between the artefact and the effect that it has. This appreciation of the way that an artefact achieves an effect involves a sensory appreciation of the artefact itself (da Silva et al., 2016). This is then judged according to the principle of maximum effect for minimum, which stems from the evolutionary principle that our sensory systems want to function as economically as possible (Hekkert, 2006).

Take for instance the two interventions shown in Fig. 9 and Fig. 10. Both aim to reduce the number of displaced garbage bags by tapping into the principle that people do not want to trash spaces that are neat and well-cared for. In their embodiment different choices were made which influence the appreciation of the design intervention. The intervention in Fig. 9 places fake flowers and grass around the container, while the one in Fig. 10 uses planters with real flowers and plants. The intervention

Fig. 11 The Camden bench, a concrete piece of street furniture designed specifically to prevent anti-social and criminal behaviour

Fig. 12 Photo from the Uninvited Guest design fiction video that shows one of the (placeholder) smart products that aim to improve the elderly man's lifestyle

with flowers achieves the intended effect by also introducing preferable side-effects such as aiding in climate adaptation, boosting civic engagement and social cohesion—while the intervention with fake flowers introduces even more plastic 'garbage' into the situation.

This example also shows a second important principle when considering the aesthetic appropriateness of an intervention—the principle of most advanced, yet acceptable. This principle states that people appreciate an optimal balance between the notions of novelty and typicality (Hekkert, 2006). In this case the intervention with planters resembles much closer what one would encounter normally in the urban sphere than the intervention with fake grass and flowers which seems rather out of touch with its context.

Moral appropriateness

The influence that people experience by a design can be expressed on the dimensions of salience and force (Tromp & Hekkert, 2019). When discussing the design in terms of its moral appropriateness we consider the alignment between that experienced influence as exerted by the intervention in relation to the user's personal values. People can accept designs that coerce them into a desired behaviour by limiting their individual freedom when the collective concern is of grave importance—such as preventing road accidents near schools or mitigating a pandemic outbreak. Yet design generally does not deal with matters of life and death, and in those cases the experience of the salience and force of influence can both differ from person to person as well as from time to time (Tromp et al., 2011).

One instance where we see this is in designs labeled as hostile architecture; design that intentionally restricts behaviour in urban spaces for the purpose of maintaining public order. A prime example of this type of design is the Camden Bench (Fig. 11), a piece of street furniture that was primarily designed in order to prevent anti-social and criminal behaviour such as sleeping, littering, skateboarding and drug dealing by making sitting the only possible behaviour (Factory Furniture, 2017). This decisive strategy makes people either conform to the norms as imposed by society, or pushes them further away towards the fringes of that society (such as the homeless who are now unable to sleep on these benches). These interventions heavily rely on the fact that the salience of influence is implicit. Once people become aware of the influence it often results in public outcry. The experienced salience and force of influence conflicts with the user's value set[3], resulting in for instance petitions to remove these kinds of interventions (Long, 2019). This in the end undermines the overall effectiveness of interventions as people either start rebelling against the intervention or depriving from the use of the intervention.

In Uninvited Guests[4], a design fiction video (Fig. 12), we see the interplay between an elderly man and the smart home products that aim to improve his lifestyle. As can be seen in the video, although the man is initially willing to give it try, through the overly paternalistic and coercive influence of the devices he very quickly deters from intended use. Although this is a video that aims to trigger reflection on the role of technology and elderly, these types of mechanisms are not very far-fetched compared to similar products on the market.

Both examples show that when there is a mismatch between the values of the user and the influence as exerted by the intervention, acceptance will be hindered. This can be accredited to the style and strategy as employed by the intervention, but also to the origin of and the reasons for influence (Tromp & Hekkert, 2017). For the bench, once the reasons for influence became apparent it resulted in increased feelings of discomfort with that influence. And for the smart products, the fact that they were given to the elderly man by his children might have initially made him more willing to comply.

Fig. 13 An Apple Watch giving a notification that it is time to stand up—aiming to persuade the user to stand up and move around for at least a minute

Systemic appropriateness

A design intervention is not introduced into a vacuum, but instead in an existing system of other elements. In the words of Buchanan (2019, p. 97) we must recognise that:

> a system is an organic whole, a functioning relationship of elements that seeks to fulfil particular needs and aspirations, and it is apparent that the forms and wholes around us are nested in a larger and larger wholes that must be understood for design to be successful.

In other words we need to consider the fit between the 'subsystem' of the design and its relation to the greater whole—as well as account for the (unexpected) consequences that the introduction of the design has on the greater whole—in order for the design to be appropriate on a systemic level. As the intervention "will become networked into complex causal entanglements" (Nelson & Stolterman, 2012), the resultant effect can be beneficial or detrimental to the system as a whole. For instance, a balancing heuristic leads people to believe that they can compensate behaviour that has a large negative environmental impact (e.g. eating red meat) with sustainable behaviour that has a significantly smaller positive impact (e.g. showering for a shorter period of time); resulting in people doing more harm to the environment while they believe they are doing good (Sörqvist & Langeborg, 2019).

As the intervention is introduced in the system world at large it interacts with elements as inserted by 'others'. For instance, notifications by a smartwatch (Fig. 13) that remind people to stand up every once so often might be very appropriate when you are at home. However, when receiving those notifications during a long meeting it is unlikely that they can be followed up given the social conventions during meetings.

Coming back to Uninvited Guests (Fig. 12), an element of interest here is the fact that it was not the user's own choice to use these interventions but he was coerced into using them by his concerned children. The way the products are applied in a social context influences their use and therefore their

effectiveness. In this case they are applied as a tool for remote monitoring and surveillance of the health status of a relative which, next to privacy concerns, can also result in less frequent visits to that relative which increases feelings of loneliness.

The previous example also shows consequences of the introduction of an intervention into a system. Here two key concepts can help in understanding the consequential effects of design, *mediation* and *appropriation*.

Products and systems *mediate* how we experience the world, and thereby influence both our perception as our actions in that world (Verbeek, 2011). The mediative role of artefacts is often illustrated through the use of mundane objects such as the microwave (Tromp & Hekkert, 2019; Verbeek, 2005). Through its functionality of (re)heating meals, the time for meal preparation was significantly shortened. Yet over time other, more consequential effects started to materialise. Reheating individual portions allowed family to eat their meals at their leisure, adapting it to their own individual schedules. While this can account for substantial contribution to the emancipation of women, it also affected the cohesive bonds within a family as an important moment of quality time was slowly disappearing. Next to that the microwave also sparked the rise of pre-cooked meals which, given their low nutritional and high fat and salt levels, have had adversarial effects on public health.

Appropriation is the process of making a thing one's own. When people appropriate a product that generally is considered as a positive development, as they adapt the product to their own practices and lifeworld. However, appropriation is inherently a deviation from intended use which in the case of an influential agent could result in reduced effectiveness.

Variance in effectiveness and appropriateness

The effectiveness of an intervention is not a static measure as it changes over time; the effectiveness varies on a temporal dimension. This can explain why interventions seem to be effective in an initial experimental study, but are not in a follow-up study. We can approach the overall effectiveness of an intervention on a curve as shown in Fig. 14.

Design interventions disrupt the situation at hand; observed behaviour just after introduction is likely to be very different as opposed to when the situation has settled in. A design has to be integrated into one's life first. Lehtonen (2003) conceptualises

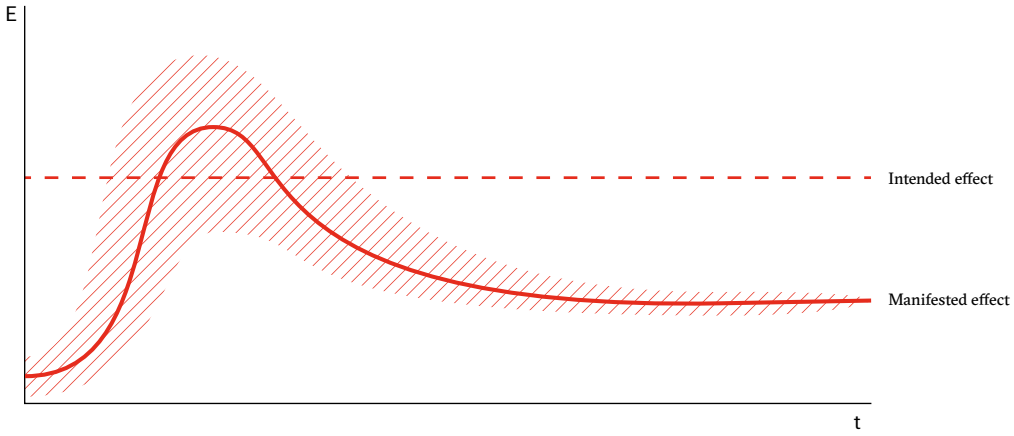


Fig. 14 A generic effectiveness curve, showing an initial overshooting with high uncertainty about the actual effect, gradually moving towards the actual effect with a stabilising effect

this process, domestication, as a series of trials where things and people reciprocally influence each other. Over time these trials, in the form of negotiations between different types of influence, form a more or less stable attachment to a thing. Similarly, when viewing the situation through the lense of practice theory behaviour change can be conceptualised as the reconfiguration of the elements and links that make up the practice (Kuijer, 2017), which occurs when new elements are introduced into the situation (or existing are combined in new ways) (Shove et al., 2012). This reconfiguration takes time and many performances before the elements are integrated in the practice-as-entity.

In the beginning performances are likely to show behaviour close to the intended effect, or even an effect that is overshooting the intended effect. Positive and negative effects may surface more prominently in the beginning, increasing the uncertainty about the actual effect induced. People may be more motivated to change their behaviour upon receiving the intervention, or may not fully understand the capabilities of the design intervention. But once those initial feelings fade away we get closer to the actual manifested effect.

Through the examples in the preceding section we have established that a level of inappropriateness influences the overall effectiveness of the intervention. Interventions can be efficacious after introduction due to variety of reasons, for instance an increased motivation to change behaviour or novelty of the intervention in the situation. However, over time the appropriateness of the intervention influences the actual effectiveness through the adherence of the user to the intervention. If the intervention is inappropriate to its context it is likely to result in non-usage attrition (Kelders et al., 2012)—leading to an intervention that demonstrates minimal effectiveness. So for understanding and anticipating the long-term effectiveness of an intervention we have to understand the appropriateness of the intervention (see Fig. 15).

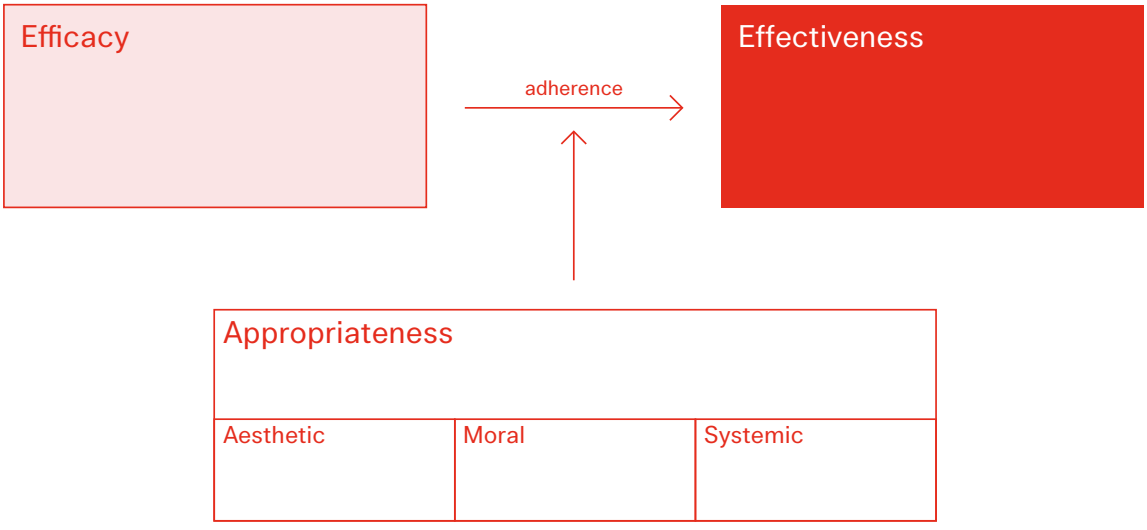


Fig. 15 The difference in efficacy and effectiveness can be attributed to the adherence to the intervention, which is influenced by the appropriateness of the intervention

In order to do that thoroughly we have to acknowledge the *relational* aspect of appropriateness. As defined at the beginning of this section appropriateness is a qualitative description of the relationship between the intervention and the situation. However, which situation is meant here? At the beginning of this chapter we explored the design situation as an artificial construction to focus attention on the elements of concern at design time. This results in design interventions that can be effective and appropriate in achieving the desired change in behaviour for that specific situation. However, we also have to acknowledge the elements and relations that were shifted to the fringes of the situation during design time can play a role when the design interventions is deployed in the 'real' world.

It is thus important to not only evaluate the appropriateness in relation to the design situation but also in relation to situations demarcated by more abstract, yet related behaviours. There are two reasons for doing such a thing. As the appropriateness is a qualitative description of the relation between an intervention and the situation, and that the situation is dependent on the specificity of the behaviour, the respective appropriateness is likely to vary from level to level. Appraisals of the appropriateness of the intervention co-exist in time, meaning that what is appropriate at one level of specificity might be inappropriate at another level. Second, when discussing the laddering of behaviour we noted that other behaviours may also influence a higher abstraction behaviour. This could reinforce or hinder the change that the designer is trying to accomplish.

Thus for the evaluation of effectiveness and appropriateness we propose that the evaluation should be two-tiered. First, the designer should assess the intervention in relation to the *design situation*; followed by assessing it to a *extended situation*, where the extended situation is established by picking the highest abstraction of the behaviour that has relevancy to the target behaviour.

Implications for evaluations

> Behaviour change takes a long time to settle in, thus the change in behaviour observed during an evaluation study may be different from the effect at a later point in time.
> This difference in long-term effectiveness can be attributed of the appropriateness of the intervention to the situation. Gaining insight into the aesthetic, moral and systemic appropriateness of the intervention can contribute to anticipating the actual effectiveness.
> An intervention needs to be evaluated not only in terms of its performance in the design situation, but also in relation to the extended situation where other factors may influence the appropriateness and effectiveness.

1 We acknowledge that the boundaries between these two phases are gradually becoming more and more blurry (Giaccardi, 2020), but for the purpose of this argument we will treat them in their traditional dichotomous way.

2 It is however important to note that they see the context as a construct of designer, in which their values and beliefs are deeply embedded. Assessing the appropriateness in relation to this context—even though it is tremendously well-considered—is still just an enquiry into the designer's own version of reality.

3 Although this is a personal experience it does not have to concern the individual itself but can also concern others as in this case.

4 A project by Superflux and commissioned by the ThingTank project. A video of this project can be found at https://vimeo.com/128873380.

Conclusion

In the introduction chapter we sketched the state of the art in designing and evaluating designs for behaviour change. In this chapter we followed up by exploring the mechanics of changing behaviour through design. While examining the behavioural design process in this chapter several interesting directions for further inquiry emerged that complement the initial research questions. Hence we will briefly summarise the findings from the previous two chapters and how those relate to the additional research questions.

Designs for behaviour change are intentional in that they way want to effectuate *change* in *behaviour*. Thus the evaluation of concepts for those designs serves mainly two purposes: to gain insight into the effectiveness and appropriateness of the intervention, and to identify the elements that need to change in order to improve said effectiveness and appropriateness. We discerned two approaches to evaluation, a quantitative approach from the behavioural sciences and a qualitative approach from design practice.

In quantitative approaches often the outcomes of behaviour are measured, obscuring the contribution of the design intervention to the change in behaviour in the individual. Besides, data from for instance usage analytics will provide an 'objective' baseline, yet they miss the contextual richness of an interview. Additionally, these methods only deliver results in terms of the intervention's performance without providing courses of action for improving the effectiveness. Finally, given the longitudinal nature of behaviour and the often observed relapse into old behaviour (Ludden & Hekkert, 2014) it is arguable whether the results of a study will remain after the evaluation has ended.

A qualitative designerly approach has its limitations as well when it concerns behaviour change. Contemporary methods and tools for evaluating design concepts are rooted in usability research, where the primary mode of evaluation is on the identification of improvements. An implication of this is that evaluations often focus on improving the interaction between the user and the product in a momentary setting, thereby neglecting whether the intervention is actually instrumental in changing behaviour. Many qualitative design methods depart from the notion that the 'user is the expert of his own experience' (Stappers & Sanders, 2012), yet for their own behaviour it is arguable whether that is the case as well. Given the distributed nature of (higher abstraction) behaviours, our behaviour may simply not be attainable to human perception, or we turn towards socially-desirable answers when asked about how we behave. A further complication is that through means-end laddering and reframing behaviour, the behaviour that the designer is aiming to elicit through their design might be far-related to the behaviour that was the entry point to the situation and it is unknown what the strength of the relationship between the two behaviours is.

Therefore in order to critically evaluate behavioural design interventions, evaluations need to incorporate multiple perspectives on the situation, such as a longitudinal data perspective, that are analysed in conjunction. Hence the following additional research question:

RQa How do different sources of knowledge relate to each other while integrating them during evaluation?

Studies that investigate the effectiveness of interventions after a longer period of time often find that the effects induced in the short-term were not sustained (Abrahamse et al., 2005). For a design to be effective it has to satisfy the relation between the goal, the character of the artefact and the context in which the artefact operates (Simon, 1996)—thus the intervention needs to be appropriate in its context. Hence there is an assumed relation between the appropriateness of the intervention and the transition of the design being *efficacious* (works when people receive an intervention) to being *effective* (works when people are offered an intervention).

When evaluating an intervention we can discern between three types of appropriateness. *Aesthetic* appropriateness concerns the aesthetic appreciation of the intervention in relation to its effect. *Moral* appropriateness entails the tolerance of the user towards the exerted influence by the intervention. *Systemic* appropriateness relates to the fit between the intervention and the greater whole—as well as the (unexpected) consequences caused by the introduction of the intervention.

Introducing a design intervention disrupts the situation at hand which takes time to settle back in. This process can be conceptualised as a series of trials where things and people reciprocally influence each other. Over time these trials, in the form of negotiations between different types of influence, form a more or less stable attachment to a thing. During these trials elements of the intervention that are inappropriate to the situation of the user influence whether the user will adhere to the use of the intervention, which will influence the long-term effectiveness.

Analysing the appropriateness of an intervention helps in identifying the factors that might lead to obstructions to forming this stable attachment to the intervention at a later point in time—allowing the designer to anticipate the effectiveness at design time. Hence we complemented the research questions with the following:

RQb How can the effectiveness of an intervention be anticipated through assessing the appropriateness and efficacy?

Design interventions are conceptualised by concurrently developing the intervention's mechanism and manifestation. The mechanism explains *how* the intervention aims to achieve the aspired change in behaviour, the manifestation is the *what*, the artefact that is introduced into the situation. The main task of a designer is to achieve fitness between the artefact and its context, as then when it is appropriate it will achieve its purpose. When a mechanism is embodied in a medium that does not achieve this fitness, it is likely not to induce the behaviour as intended. Thus the last additional research question is:

RQc What is the relation between the selection and formgiving of the manifestation of design and the appropriateness of an intervention?

The following chapter will turn these research questions into an experimental design in which we will evaluate two design interventions on their effectiveness and appropriateness.

C

Experimentation in practice

In the previous chapter the process of designing and evaluating design interventions for behaviour change was examined, resulting in a theoretical model that operationalises the dimensions of effectiveness and appropriateness and sketches the relations between these concepts. In this chapter those relationships will be explored experimentally by evaluating two research artefacts in the context of the end user. Here the main focus is on the second research question complemented with the additional research questions formulated in the conclusion of the previous chapter.

Based on those additional questions several directives for the experiment design are discussed including the experiment design, the choice of variables in the study and the specific choice of perspectives on the situation.

Then we will discuss the choice of context and development of corresponding interventions. Here the theory related to specifying behaviour and the manifestation of design of the previous chapter will be applied during the conceptualisation of two design interventions. A structural overview of the two prototypes and their interaction will be delivered—explicating the assumptions underlying the design. Afterwards the specific experiment design and methods is detailed, describing how the two design experiments were carried out and the resultant data was analysed. We end this chapter with the results and conclusions based on the two experiments in relation to the research questions of the study.

Study setup

In the previous chapters we concluded that designers could anticipate the effectiveness of their intervention through assessing the efficacy and appropriateness of their intervention. The following study will examine how such an assessment would be executed in practice by providing an instantiation of two behavioural design processes[1] where the concepts were evaluated experimentally.

We will describe the study design, methods, intervention development and analysis. Parallel to the experiment design a custom infrastructure for collecting sensor data was developed for the collection of a thing-perspective, an overview of that process can be found in appendix III.

Research questions

The focus in this part of the project was on answering the second research question:

RQ2 How can the integration of multiple perspectives on the situation improve the critical evaluation of design ideas in terms of their effectiveness and appropriateness?

This research question is complemented by the following subquestions which stem from the previous chapter:

RQa How do different sources of knowledge relate to each other while integrating them during evaluation?

RQb How can the effectiveness of an intervention be anticipated through assessing the appropriateness and efficacy?

RQc What is the relation between the selection and the formgiving of the manifestation of design and the appropriateness of an intervention?

Experiment design

While discussing the role that experiments play in the design field we encountered differing conceptions of the term 'experiment'. Hence it is important to clarify the interpretation of experiment used in this work. Returning to the logics of experimentation, our approach to design experiments would taking *generative experiments* as a starting point while taking some elements from *controlled experiments*, such as the introduction of control.

In the previous chapter we encountered the notions of effectiveness and efficacy. Experimental designs for evaluating interventions can contain a mix of efficacy and effectiveness elements (Courneya, 2010). In most usability or observational studies the intervention is mostly tested for efficacy in a qualitative way. Although this a suitable approach for testing assumptions and validating concepts early on in the process—truly evaluating the efficacy also requires quantitative data to measure success. Crucial for that is the introduction of a control situation where no intervention was administered.

For the evaluation of medical interventions the golden standard is the randomised-control trial; yet at the same time scholars are looking for alternative ways to evaluate their interventions given the long and resource intensive nature of RCTs. Especially in the evaluation of health technologies new ways are explored as randomised-control trials are simply too costly and time-intensive. One promising avenue is the use of single case or n-of-1 designs (Dallery et al., 2013; McDonald et al., 2017), in which participants serve as their own control. In that case there is no need to recruit double the amount of participants. Single case design are more flexible in the

way that they can be carried out as they allow the experimenter to tailor the experiment to the lifeworld of the participant. Additionally, in between-participant designs individual effects are averaged out at the group level which could misrepresent individual effects or obscure those effects, while by studying an individual we can obtain information about the process of behaviour change (McDonald et al., 2017).

For RQa, to anticipate the effectiveness it is likely that we need to obtain an accurate understanding of the effectiveness which requires the introduction of control. However, we want do such a thing in a designerly way. Hence the experiments in this study were carried out as single-case reversal designs. Here data is measured across three stages: first an initial period of data-collection to establish a baseline, then an intervention is introduced and eventually the intervention is retracted again while data collection continues in order to rule out other factors of influence (Dallery et al., 2013).

Object of study

In a design experiment that evaluates a concept on its effectiveness and appropriateness the primary interest of the evaluation would be the mechanism, as the mechanism explains the specific characteristics of the design intervention that address specific characteristics of the behaviour. However, the interest of this study lies in exploring the relations between the appropriateness, efficacy and effectiveness instead of the actual efficacy or effectiveness of the intervention. Therefore the mechanism itself is not the most suitable element to use as a variable in the study.

In line with RQc we expect the manifestation of design to be a more important factor in influencing the appropriateness of the intervention. Hence the study varies the manifestation of design in two concepts while keeping the mechanism constant; thereby differentiating between the two concepts in a controlled manner.

Thing perspective

In the previous chapter we discussed the concept of a situation as an 'environed experienced world', where the things and events in that situation are not bound to the behaviour by spatiotemporal or causal relationship but in terms of their relevancy to the behaviour. The ecological nature of this relation can be used when trying to understand and observe behaviour. The ecology of things that is defined by the situation at hand can be an interesting departure for the collection of other sources of knowledge (for RQa and RQ2), as we can harness these things as partners in the design process (Giaccardi, 2020). This might complicate and enhance the views that we obtain through other sources of knowledge.

Hence a vital part of the experiment will be to collect data through instrumenting an ecology of things in the situation. It is important to note that we do not constrain ourselves to the design situation here, but rather that we take the extended situation as the level of abstraction at which we select the things to instrument.

1 Although there are two behavioural design processes present in this work, due to limited resources we cut some corners in the conceptualisation in order to focus our attention primarily on the evaluation of the concepts.

Conceptualisation and prototyping

This section outlines the conceptualisation, development and prototyping of the stimuli used in the study. First the choice of context will be discussed, resulting in the respective design brief that was drafted for the purpose of this study. Then we will discuss the development of the two research artefacts that were deployed in the context of the end user, comparing and contrasting them in terms of their manifestation of design.

Context and design brief

The first step was to draft a fictitious design brief which defines the context of the study. Based on earlier explorations we decided to investigate rich everyday environments where many practices intersect. One of those contexts is that of the home, where many different practices take place. At the same time the home is also a relatively private space, which lends itself to the approach in this work. Within the context of the home we decided to focus on the practice of sleeping, as here many practices intersect and we assumed that there was tension between those practices. Additionally, sleeping happens in for many people a private area of their home, the bedroom, which provides with interesting challenges for the research.

Design brief

Sleeping well is essential for functioning well in today's society. Sleep is often seen as an individual problem, yet it also has its respective social consequences. Sleep deprivation has been suggested to influence multiple health issues such as obesity (Watanabe et al., 2010) and diabetes (Spiegel et al., 2005) and sleeping issues are said to have other behavioural consequences such as cognitive slowing, automatic behaviour and performance degradation, errors and accidents (Czeisler, 2011).

Although exactly how sleep works remains elusive, research suggest that sleeping well is a way for our bodies to prune, encode and consolidate our memories (Walker & Stickgold, 2006), freeing up brainpower for the next day. Not being able to do that results in less cognitive power to be productive in our day jobs and potentially leads to respective workplace stress, which we again bring home and subsequently causes restlessness in bed (Burgard & Ailshire, 2009). A truly vicious cycle.

In today's society there are many different things vying for our attention. That new episode on Netflix that is still awaiting, the endless list of posts on Facebook, the emails that you weren't able to respond to during the day. With all these interruptions it is not surprising that sleeping well is not our first priority. How can we defend ourselves against all these intrusions in order to sleep more and better?

Design question

Design an intervention that motivates people to be more aware of and attentive to their sleeping behaviour—in order for them to take charge of their bed time routines.

Reframing and behavioural specification

Sleep hygiene is the encompassing term for all the conditions and practices that are consistent with good-quality sleep (Thorpy, 2012), such as regular sleep- and wake times, limiting substance use such as caffeine, nicotine and alcohol before going to bed,

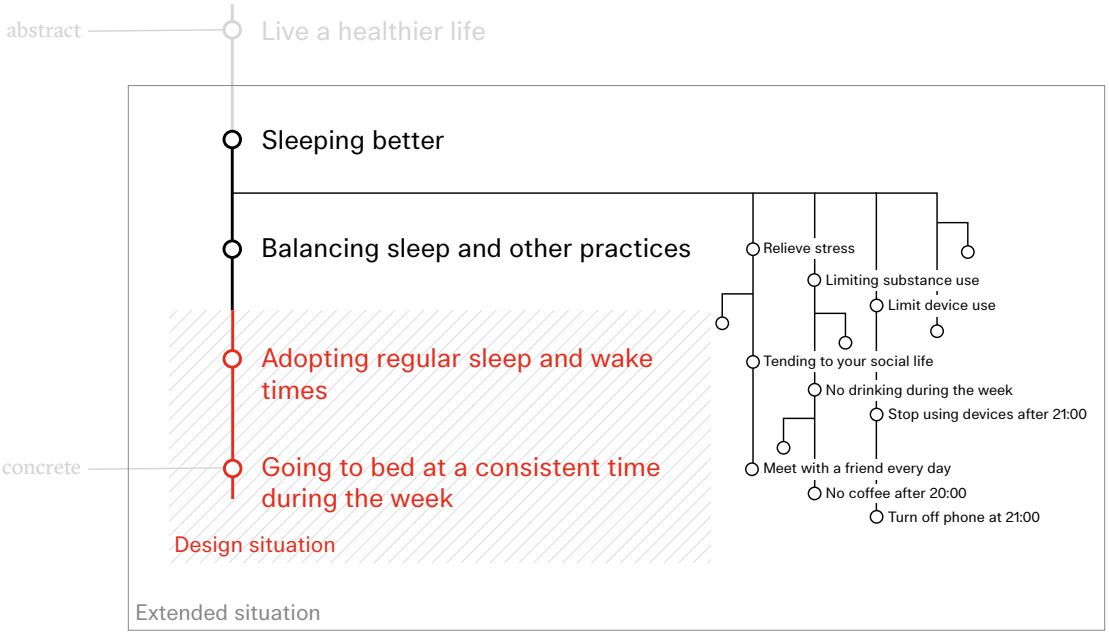


Fig. 16 Overview of the behavioural specification showing the main laddering that ends up in the design situation (red), and some examples of related behaviour that are part of the extended situation

reducing disturbing environmental factors and doing stress relief. Changing the underlying practices is assumed to be beneficial to overall sleep quality, as awareness only does not seem to influence sleep quality (Brown et al., 2002). However, most evidence for the recommendations that improve sleep quality are based on studying—often extreme—sleep behaviours in laboratory studies instead of observations in a natural environment (Irish et al., 2015).

Nonetheless we consider that a combination of those recommendations for changing behaviour could help in sleeping better. The aim is not so much to sleep more or go to bed earlier, but to be more consistent in when to go to bed and utilise our time in bed more effectively. Ultimately it is about finding the right balance between sleeping enough and doing activities that help put our minds at ease by incorporating those in the bedtime routine. As such the behaviour can be further specified through the behavioural laddering as in Fig. 16, with some related behaviours For the design phase the chosen level of specificity for the design situation is established by the behaviour 'adopting regular sleep and wake times', where the extended situation is established by 'sleeping better' (focusing on 'balancing sleep and other practices').

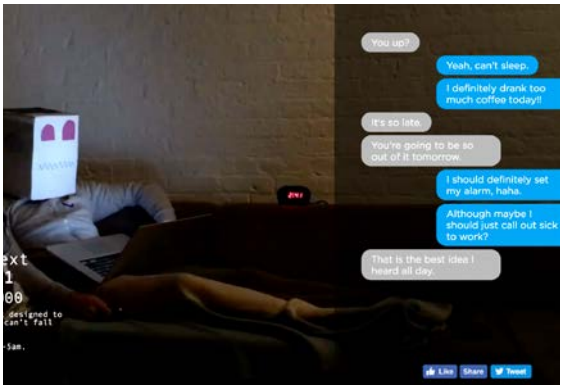


Fig. 17 SleepCycle is an mobile app that tracks your sleep quality during the night

Fig. 18 insomnobot-3000 is a chatbot that you can text during the night when you cannot sleep

Fig. 19 Casper Glow is an interactive bed light that helps to naturally unwind for better sleep

Fig. 20 Google bedtime feature that also has a sunrise function that mimics a wake-up light experience through turning on the device's screen

Conceptualisation

Along with the quantified self movement, a great many products and services focus on improving sleep quality through a various different strategies. In line with the proliferation of the quantified self and health trackers, initial strategies mostly focused on the consequences of behaviour, by feeding information about sleep during the night back to the user (Fig. 17). The interventions in Fig. 18, Fig. 19 and Fig. 20 show other types of interventions that try to intervene more on the antecedents of the behaviour and during the behaviour itself.

Mechanism

In order to adopt a regular sleep and wake rhythm we developed two designs that both embody a mechanism inspired by the parental nudge to go to bed. The mechanism of the concepts comprises of two parts. First, we focus on the antedecent of the behaviour by motivating the user to set their bedtime a specified amount of time earlier in order to create time to unwind before falling asleep. Second, we remind the user when it is time to go to bed and support them in taking the time to unwind.

Manifestation of design

In this study two research artefacts were developed, SleepyLight and SleepyBot, that aim to induce the mechanism as described above while varying the manifestation of design. Given the limited amount of time available in this graduation project we decided to appropriate two concepts for this study. This means that we took the real products and their respective interactions as inspiration for developing two prototypes, which differed on their manifestation of design. On the one hand we developed an interactive bed light that was inspired by the Casper Glow (Fig. 19), serving as a physical product in the study. The other concept was a chatbot inspired by the Google and Apple bedtime functionality combined with the chatbot in Fig. 18, serving as a digital phone application in the study.

Both prototypes were developed as an experiential prototype, meaning that they primarily convey the aspects of the concept that are needed for participants to envision what it might be like to use the concepts. (Buchenau & Suri, 2000). That means that:

1 Only the most salient aspects of the design that produce the experience were implemented
2 Only sensor modalities were used that were required for the desired interaction, thereby producing data that was only relevant to the intervention-user interaction.

The remainder of this section will describe both concepts and their prototypes as developed for this study. We will conclude by comparing and contrasting both interventions on their manifestation of design.

Interactive bed light

The first concept is an interactive bed light—SleepyLight—that stimulates users to go to bed at consistent times during the week and take some time to unwind before going to sleep. By equipping the bed light with a wakeup function the bed light is able to replace both a non-interactive bed light as well as a smartphone used for alarm purposes.

The bed light consists of two components: the bed light and a configuration app. The bed light is a portable cilinder shaped lamp (Fig. 21 on page 49) that can be interacted with through several movements like shaking and turning. Given that interaction with the lamp happened intuitively through the use of movements, another component was required in order to configure the various settings of the lamp. That is why the lamp is complemented by a configuration app (Fig. 22 on page 51)

Fig. 21 The interactive bed light prototype SleepyLight within the context of use

in which the bed and wake times next to other settings could be set.

Interaction

We will now briefly explain the interaction with the prototype[1]. In general the interactive bed light aims to help users keep track of the right time to go to bed by externalising thinking about that to the lamp through setting a schedule beforehand.

The first step of using the bed light is to configure it through the dedicated configuration app. Here the user is able to set their desired bed- and waketimes and other settings of the lamp. Subtle influence is exerted to persuade the user to set the same bed and wake times by only being allowed to set a single time for all selected days (Fig. 22 on page 51). If the user desires to vary their bed- and waketimes per day, then the alarm has to be set on a daily basis after the alarm went off. Other influential elements are for instance standard values that suggest to the user that they should take 30 minutes to unwind. After setting up the light, ideally the user should take it with them during the day, but in practice we hope it is brought from the bedroom to the living room in the morning, and vice versa in the evening.

When it is time to go to bed the light will give visual and auditory feedback for one minute. If the user picks up the bed light then the notification stops, otherwise it will stop after that one minute has passed.

In bed, turning the lamp will start the countdown of the predefined time for unwinding as configured in the application. In that time the light will gradually become redder and less bright until it eventually fades in the last minutes, gradually easing the user into sleep. Here influence is exerted as there is no way to turn the bed light off before the predefined period has ran out, forcing the user to take that moment to unwind.

If the user wakes up during the night, for instance to go to the toilet, the bed light can be shaken to give a faint red light for a short amount of time before fading back.

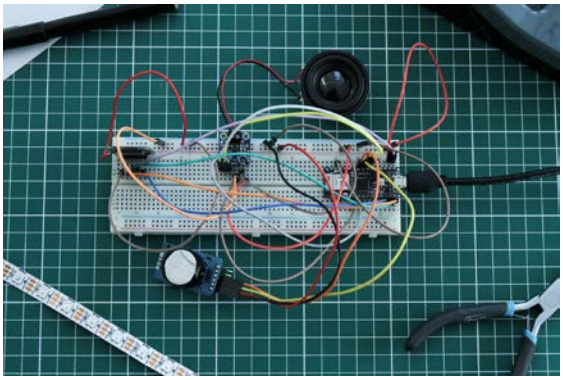
Before the alarm goes off the alarm the bed light will gradually turn itself on, gently easing the user into the morning by simulating a sunrise. When it is time to wake up the user can either shake the bed light to snooze for a predefined period, or turn the lamp around when it is time to get out of the bed. Ideally this is the moment where the lamp is taken back downstairs.

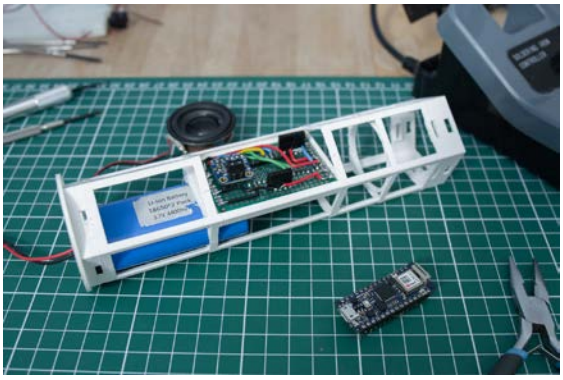
Prototype

The prototype[2] consists out of two parts, the interactive bed light and a configuration app. The bed light prototype consisted of a 3D-printed embodiment in which several components including a battery were fastened. On the five sides of the 3D-printed core of the lamp LED strips were placed. Around that 3D-printed core a matte acrylic tube was placed to diffuse the LED lights. As the bed light was intended to be a full replacement of a phone or other wake up light a speaker was also included in the prototype. The hardware of the prototype was developed in several iterations (see Fig. 22 on page 51).

The configuration app was a React-based web application hosted online, which communicated with the light prototype over a MQTT connection. In order to limit people accessing the configuration app who did not participate in the study the credentials for the MQTT connection had to be provided on each load of the application.

Given that the data of the prototype was processed on a different location than where the study data was stored a small connector script was developed that turned the prototype-interaction data into the right format and fed it into the study database for analysis. This connector script ran on a Raspberry Pi at the researcher's location.





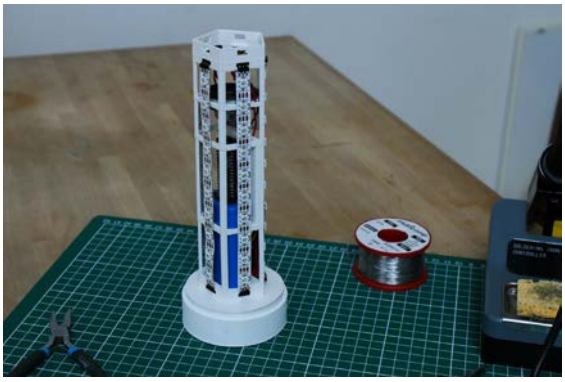


Fig. 22 The configuration app prototype showing the screen that enables the user to schedule their bedtime alarm

Fig. 23 Overview of the prototyping process of the bed light

Chatbot

The second concept is a chatbot—SleepyBot—that reminds people of their bedtime at consistent times during the week and take some time to do some activities before going to bed. The bot consist of a conversational interface within the Telegram chat application (Fig. 27 on page 53).

Interaction

We will now briefly explain the interaction with the prototype[3]. Similar to the interactive bed light the chatbot is used to help users keep track of the right time to go to bed by externalising thinking about that to chatbot through setting the desired schedule beforehand.

The first step to using the chatbot is through finding its user handle in Telegram and giving the '/start' command. The bot will ask the user to provide with their name to personalise the experience. Then the configuration procedure is initiated. The chatbot explains its function and goals, and then asks the user to provide with the desired bed and waketimes. Additionally it will ask for the amount of time that the user wants to be reminded of before their bedtime. Here subtle influence is exerted by stressing the need for unwinding. The bot will also ask on which days the bed and waketimes should be set. Here influence is exerted by allowing only a single time to be set across all days that the notifications are set (Fig. 24). After finishing the setup the bot will explain that the user is able to change settings through giving a command at any time, and that the bot will keep quiet until it is time to go to bed.

When it is time to go to bed the bot will send a message, which will be delivered to the user as a native push notification on their phone. The first message will tell the user that it is time to go to bed. Then a follow-up message will check whether the user is already in their bed. The user can respond to this message through predefined options (Fig. 25), as the chatbot cannot handle natural language. If the user responds negatively, the bot will continue to remind the user every three minutes until they are in bed. In general the bot does this by communicating in an overly positive, light-hearted and supportive way, using for instance emojis and GIFs (Fig. 26).

If the user responds positively to being in bed, the bot will provide with an example activity that can be performed to unwind. Once it is time to really go to sleep, the bot will provide with one final message to wish the user goodnight.

Fig. 24 Part of the chatbot conversation where the user is coerced into setting a single bedtime across all days

Fig. 25 Custom keyboard with fixed responses to the questions of the chatbot

Fig. 26 Example of the tone of voice of the chatbot, using positive language, emoji and GIFs

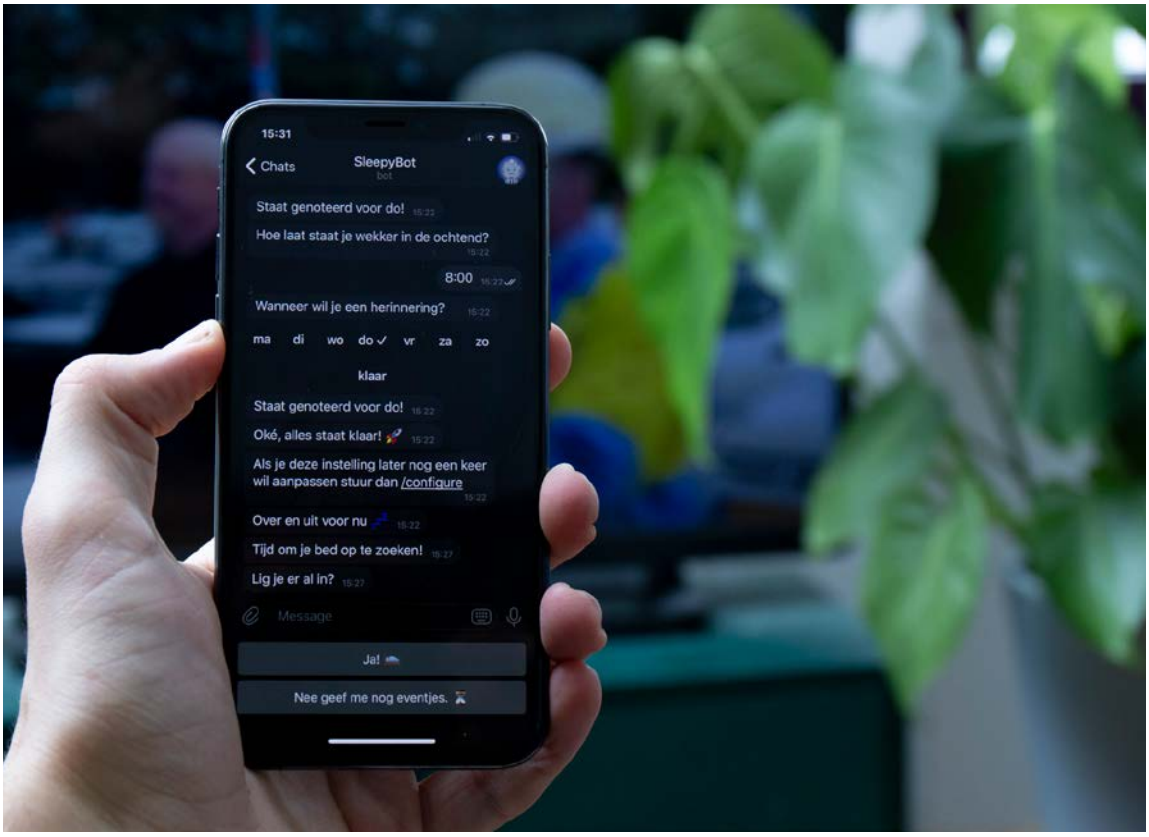


Fig. 27 The chatbot prototype SleepyBot within the context of use

In the morning a similar sequence as in the evening is initiated to check whether the user has left their bed on time.

Prototype

The bot was prototyped[4] through means of a Telegram bot, where a specific script was built that ran on a local Raspberry Pi at the researchers location. In order to limit people who did not participate in the study a access code had to be provided upon initialisation. By using a Telegram bot we could harness the full infrastructure of the iOS platform including push notifications, meaning that scheduled timers on the Raspberry Pi were triggered to send push notifications on the participant's device via Telegram. The prototype made use of a state machine and several predefined keyboards, meaning that no actual language of the participant (except in some cases yes and no, and times) were processed. This way it was the simplest implementation of an 'agent'.

Compare and contrast

To conclude this section we will examine the differences in manifestation between the two concepts in order to explicate assumptions of what is likely to occur during the study. In general, we chose two manifestations of design for the prototypes where we assume that the chatbot will be less appropriate given that it relies on a mobile phone, an intrusion in the bedroom, while the bed light fits better into the context that context of the bedroom.

To discuss several other differences we will mostly rely on discussing the properties of fitness as described in the previous chapter.

The interactive bed light is a physical artefact which has a high degree of presence in the situation. However that presence is limited to its physical location, which may be a different location than the user is in—which could lead to the influential event of the bedtime reminder being missed. The chatbot on the other hand resides in a smartphone, which given its coordinative role is often close to the user. At the same time the chatbot is 'physically' only present when a notification is presented or the app is on screen, while the lamp may reinforce and remind of intentions to change behaviour through its physical presence.

Further zooming in on the coordinative aspect of the intervention, it may be both beneficial and detrimental to the use of the chatbot that it resides in a highly coordinative device. The benefit is that it is likely to be close to the participant, while on the other hand it can also be a reason to easily dismiss the notifications and continue with the other practices during which a smartphone is used. The smartphone could very well be the device on which the activity is performed that is the hardest to balance with going to bed on time. Here the fact that the bed light is external to the activity at hand might make it more appropriate.

In terms of its directionality the chatbot is highly directional as through textual means it conveys high levels of clarity and purpose. The bed light on the other hand is less directional, as at the core it is still a lamp which has a few added functionalities such as the bedtime reminder. However, it is also much harder to convey clarity through the bed light. For instance, the light will gradually dim as a suggestion that it is time to unwind yet that is something that one has to know in advance as otherwise one could think that it is broken. The specific courses of action are implied, but can be interpreted at the user's leisure.

We conceptualised the lamp as being able to replace at least a bed light or a wake-up light, and potentially a smartphone. Through this process of replacement we made the intervention more essential than the chatbot, as a bed light is often the last thing that is turned off before going to sleep (although another lamp could fulfil that function as well), whereas the smartphone should ideally not be used right before going to bed.

Even though the two concepts apply the same mechanism, the features that make up their functionality differ significantly. For instance the interactive bed light has an alarm functionality, whereas the chatbot merely asks several questions in the morning (which are not likely to wake the user). However, we can attribute these differences to the respective properties of their manifestation that they vary on. In this case the alarm is necessary for the interactive lamp to replace the previous thing that the user used to wake up—ideally limiting the use of for instance phones and tablets in the bedroom.

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1 A video showing the interactive behaviour of the lamp can be found in the digital repository entry of this thesis, at https://repository.tudelft.nl, and on YouTube at https://youtu.be/QtJ7RsAqDhg

2 A repository containing all resources for the prototype can be found at https://github.com/thvanarkel/SleepyLight

3 A video showing the interactive behaviour of the lamp can be found in the digital repository entry of this thesis, at https://repository.tudelft.nl, and on YouTube at https://youtu.be/dFJ3phMxQ-8

4 A repository containing the resources for the prototype can be found at https://github.com/thvanarkel/SleepyBot

Design experiment

This section outlines the method and setup of the design experiment as developed from the perspective of a behavioural designer—taking the elements as discussed in the study setup as a starting point for the development of the experiment.

Goal

The goal of the experiment was to evaluate the two concepts developed on their effectiveness and appropriateness in achieving the intended effect, 'adopting regular sleep and wake times', while at the same time understanding their performance in relation to 'sleeping better' and 'balancing sleep and other practices'.

Hypothesis and indicators

The hypothesis is that the two concepts induce the mechanism which causes the desired change in behaviour. Thus by reminding people just before they will be stimulated to adopt regular sleep and wake times.

For assessing the efficacy of the intervention we operationalise the behaviour into indicators (see page 117 in appendix III). The indicators of this behaviour in terms of its effectiveness are:

1 duration of activities in the evening before falling asleep
2 consistency of bed times between different days

Operationalisation

We used activity in the zone of control of things that are central to practices as a proxy for the participant performing that practice (Fig. 28). Through combining different sensor streams we differentiated between activities that were performed with the same central thing. Through this we inferred the activities that were likely to occur at that point in time.

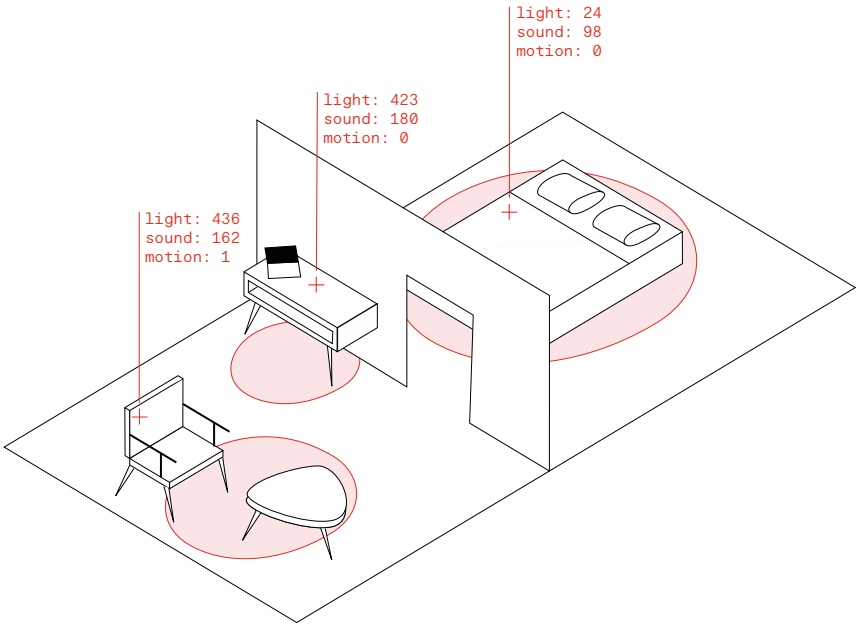


Fig. 28 Zones of control and central things

Setup

The experiment used a single-case reversal design for the evaluation of the concepts, in which participants serve as their own control. This means that the evaluation will divided into three phases, where the second phase is the period of active intervention. Given the nature of sleeping rhythms the phases were set to a weekly interval during a three week period.

During the study several perspectives on the situation were gathered:

1 A longitudinal *thing*-perspective comprising of the sensor data from the instrumented things showing activity near the selected central things
2 A *reflective user*-perspective of the participant reflecting on their sleep behaviour, both before, during and after the deployment of the intervention
3 An *intervention*-perspective comprising of the data generated through the product-user interaction by intervention during its deployment in the context

In order to evaluate the design on its performance in the design situation and in the extended situation, the *thing*-perspective and the *reflective user*-perspective were gained on the extended situation instead of only on the level of the design situation.

To keep the study as 'minimal' as possible for the participant we opted to not use an experience sampling method (e.g. a sleep diary) to gather a *momentary user*-perspective during the study.

Procedure

The experiment consisted of several contact moments with the participant as denoted with the lines in Fig. 29, which also shows the corresponding steps that are executed at that particular moment in time. Only if it was inevitable to visit the participant then the activity was performed in-person, otherwise the activity took place remotely.

0. Recruitment

Participants for the experiment were recruited through convenience sampling. The main criterion for recruitment was recognition and experience of the problem of a tension between sleeping enough and other activities. Another criterion for recruitment was that participants had to be in active employment at the time of the study. Participants were assigned randomly to one of two cases, the use of an interactive bed light or a chatbot. Details of the participants can be found in Table 3.

	P1	P2
Gender	Female	Male
Age	25	27
Occupation	Project-management consultant	Architect
Living situation	Alone, in a city apartment in Rotterdam	With two housemates, in a city apartment in Rotterdam
Assigned case	Interactive bed light	Chatbot

Table 3 Overview of the participants, characteristics and assigned case

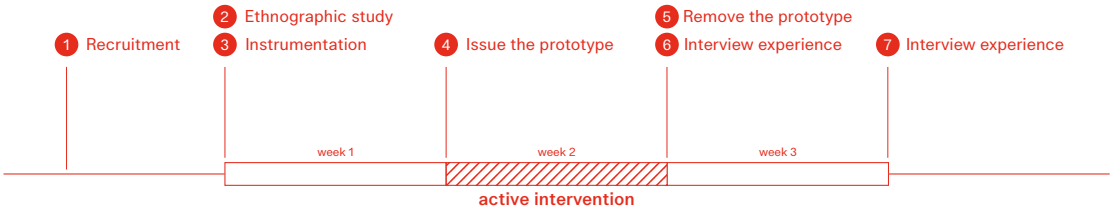


Fig. 29 An overview of the experiment timeline

Fig. 30 The sensitisation package that was sent to participants before the first interview, including the information sheet, informed consent

Fig. 31 Setting during the thing ethnography interview, showing the workbook being used as the basis for the discussion

1. Sensitisation

After recruitment participants were sent a sensitisation package (see Fig. 30). This package aimed to both inform them about the study they were about to participate in as well as sensitise them on the subjects under investigation in the experiment.

As the informed consent form explicitly asked for giving permission to the physical presence of the researcher, both the information sheet (appendix IV) and the informed consent form (appendix V) were sent with the sensitisation workbook in advance.

The workbook (appendix VI) mainly served two purposes: to sensitise the participants to thinking about their evening routines as well as considering the things that play a central role within those activities.

2. Thing ethnography interview

As the informed consent procedure took place remotely the interview started with a review of the information sheet and consent form to clarify any remaining issues the participant had, and to double check whether the participant was willing to give consent. After giving consent—and the consent form being signed by—the interview started.

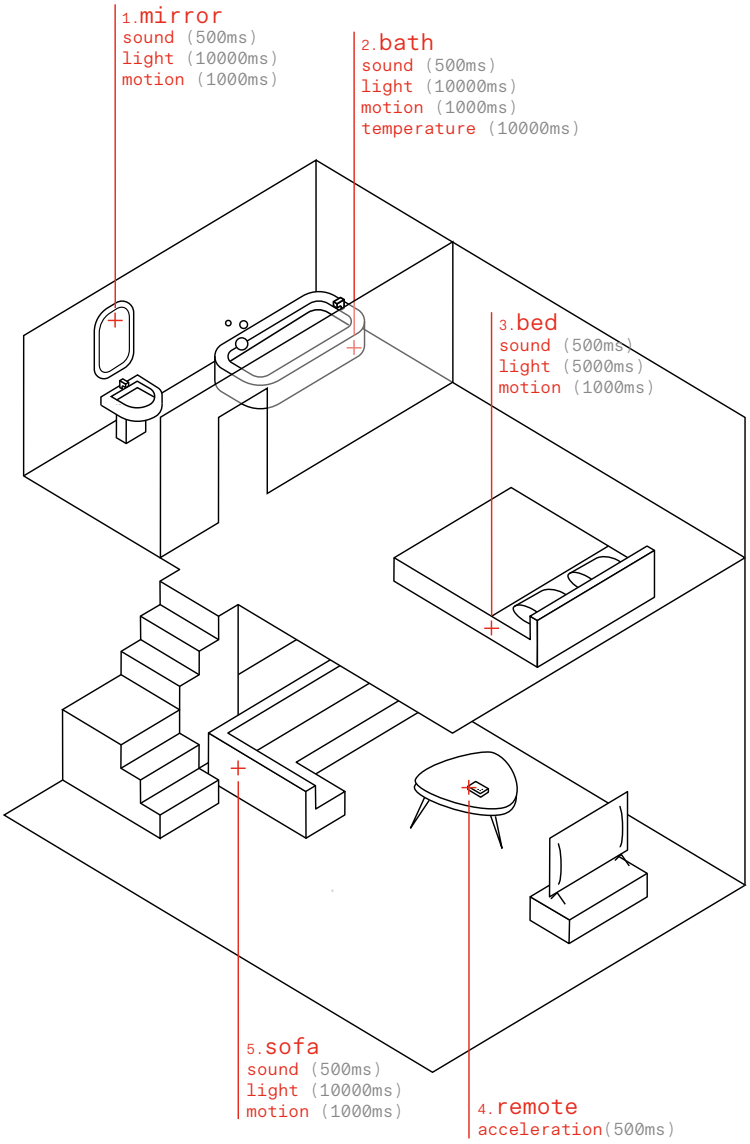
The interview (see appendix VIII for the protocol) consisted of four parts, starting with a general exploration on the topic of sleep and then discussing the three main topics of the workbook in reverse order: sleep rhythm, evening rhythm and evening activities (Fig. 31). The primary goal of the interview was to gain insight into the participant's perspective on their baseline behaviour, and their values associated with it. This served as a baseline for statements made in later interviews and in reference to the sensor data collected. The interview questions were directed at various level of abstraction concerning the behaviour at hand—from the very concrete to more abstract levels.

One task during the sensitisation assignment was to put a sticker on the objects that a participant used during their evening (Fig. 32). Hence we concluded the interview with a short tour through the house showing those things and discussing them in relation to the participants sleep behaviour. This also provided an opportunity to see the context of the things and understand how the participant uses them.

3. Instrumentation

After touring the participant's home the selected things were mapped on the table, including any additional things that surfaced during the tour[1]. The things were mapped on their consistency and duration of use in order to identify the things that would be most insightful for the study. Due to the fidelity of the infrastructure (see appendix III) there were unfortunately cases where the thing of interest was not suitable for instrumentation, such as in the case of P1's fitness mat (see Fig. 32, first picture). Based on the researcher's experience the right sensors and their respective sampling intervals were determined after selecting the things (see Fig. 35 on page 60). An overview of the instrumentation can be found in Fig. 33 on page 59 and Fig. 34 on page 60.

Fig. 32 Stickers on the things that a participant labeled during the sensitisation assignment.



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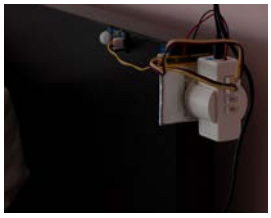

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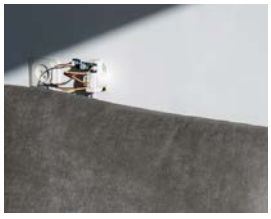
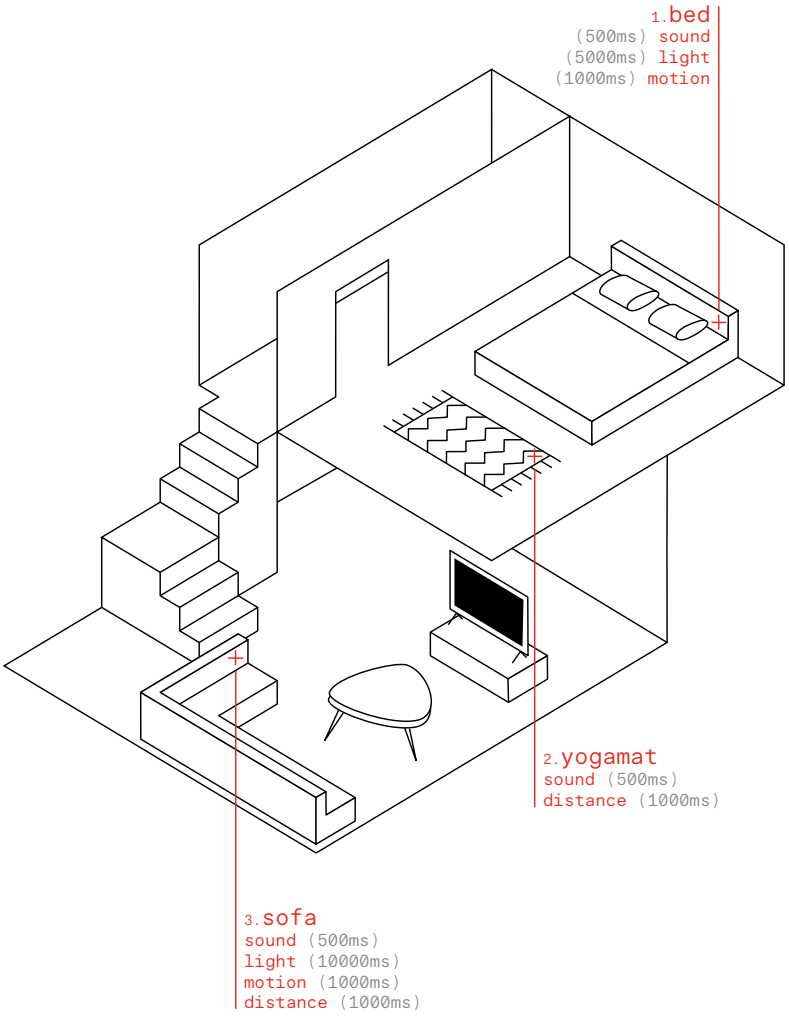


Fig. 33 Overview of the instrumentation in the context of P1 showing positioning and sampling rate and (top to bottom) the bed, the sofa, the bath, the remote and the mirror



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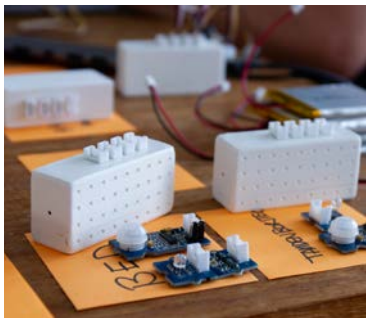


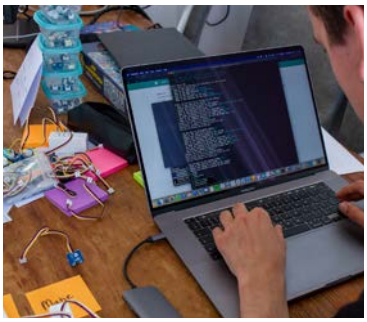


Fig. 34 Overview of the instrumentation in the context of P2 showing positioning and sampling rate and (top to bottom) the bed, the sofa, the yogamat

Fig. 35 Instrumentation process showing the ranking of the things (left), selecting the right sensors per thing (middle), and flashing the sampling configuration on the probe using a custom script (right)

4. Deploy prototype

On the 8th day of the experiment users were issued the prototype. Both prototypes were complemented with a 'manual' (see appendix VII) explaining their core functionality, and provide an illustration of an example bedtime routine.

Due to issues during the prototyping process both prototypes were deployed at a later stage than initially planned. The interactive bed light was deployed after 14 days, and the chatbot was deployed after 22 days. To limit the amount of face-to-face interactions with the participant the chatbot was deployed remotely. Given the nature of the interactive bed light the prototype could not be deployed remotely and had to be handed over in person.

5. Remove prototype

After using the prototype for seven days the prototype was retracted—in this case by asking the participant to either turn off the device or remove the app from their phone.

6. Experience interview

Participants were interviewed on their experience with the prototype after the prototype was removed from the context. The interview questions (see appendix XI) were directed at providing answers on the user's experience of the efficacy of the intervention as well as the aesthetic, moral and systemic appropriateness of the prototype. Apart from several general questions, some questions were attuned to elicit a response on a specific types of appropriateness.

7. Remove instrumentation

After the 21st day of the experiment participants were instructed to remove the sensor boxes and the data collection was stopped.

Data collection

The majority of the data collected is the sensor data as provided by the instrumented things. In Table 4 the uptime values of each individual thing is displayed. Uptime was calculated by taking the period of interest between 18:30 and 10:00 (P1) and 19:00 and 11:00 (P2), and then totalling the time that there was an interval longer than 45 seconds between two individual data points.

The data from the sensors was complemented with data from the design intervention that was produced through the interaction between the user and the prototype. Interviews were recorded and partially transcribed to text. Observations during the ethnographic part of the study were recorded through capturing photos.

P1	wk 1	wk 2	wk 3	total
Sofa	99.9%	100%	99.9%	99.9%
Remote	99.9%	100%	85.7%	95.2%
Bath	99.4%	100%	100%	99.8%
Mirror	99.2%	100%	100%	99.7%
Bed[2]	98.5%	70.9%	28.4%	65.9%
P2	wk 1	wk 2	wk 3	total
Sofa[3]	99.4%	56.9%	99.1%	85.1%
Yoga mat	99.9%	97.1%	89.1%	95.4%
Bed[2]	93.4%	36%	95.7%	75%

Table 4 Uptime values for each individual thing per week during the study, in percentage of total time

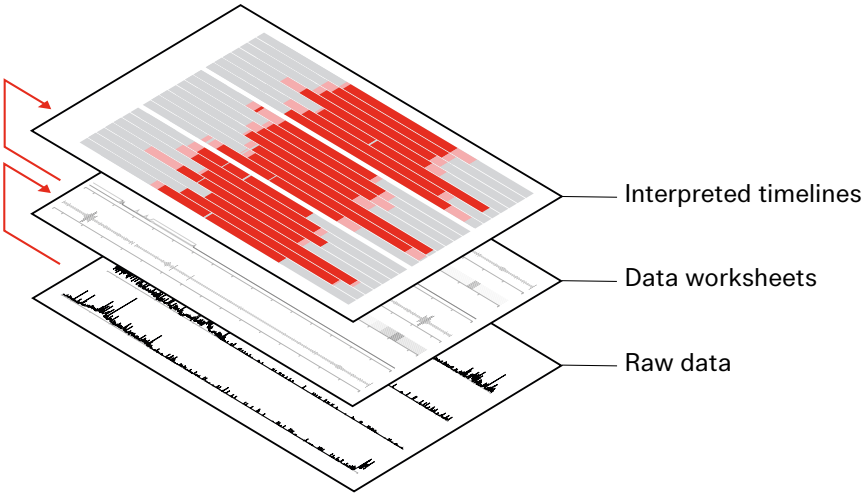


Fig. 36 The three stages of the sensor data, from raw data to data worksheets to interpreted timelines

Data analysis

The approach adopted in this study requires the collection of various sources of raw data. For using that during analysis an important first step is to turn the data into *information*, which is data that is processed and organised in such a way that it is useful (Ackoff, 1989). This is an important step where the data is interpreted and given meaning (Stappers & Sanders, 2012) by framing it into a context.

In this study data analysis was performed in two cycles. First each individual source of data was processed and organised into information. Then the information altogether was synthesised by looking for patterns that give insight into the performance of the intervention. In the first step each individual source of data was handled differently. That is why we will now briefly outline how the the data was processed and organised into information.

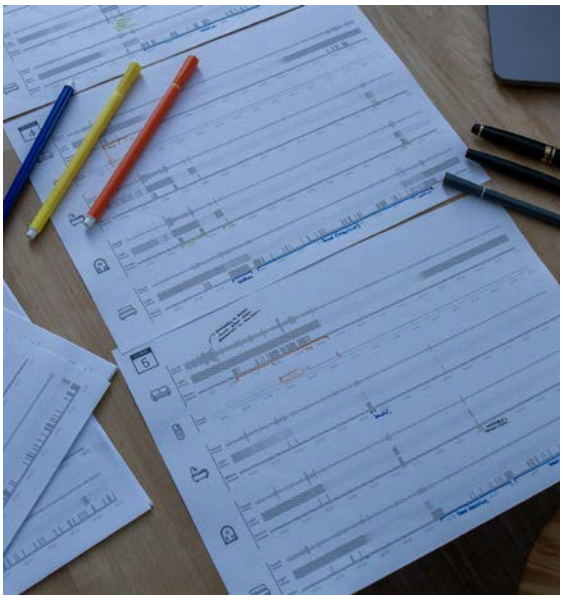
Thing ethnography interview

The transcripts from the thing ethnography interviews were first re-read and interesting quotes were underlined in the text. Those quotations were turned into statement cards (Stappers, 2012) on which for each underlined quotation an interpretation of the quote was made. Then those statement cards were clustered to see if meaningful themes emerged.

Sensor data

Due to issues during the prototyping process data was collected for 29 days (P1) and 37 days (P2), instead of the 21 days initially planned. In order to limit the interference from other factors, such as the increasing number of relaxations in the measures to spread the outbreak of the Covid-19 pandemic, 21 consecutive days were selected for use in the study. In practice this meant that the time period for analysis was selected by taking the seven days where the prototype was deployed and taking the seven days before and after that period. As a result there was a gap of at least eight days between the instrumentation and the start of data analysis.

For processing the raw data from the sensors into information we had to take an intermediate step. Instead of immediately turning them into a visualisation, the data was first turned into a data worksheets. Those data worksheets then function as an intermediate



Efficacy	> Segments that give insight into the user's perspective on changes in their behaviour > Segments related to the mechanism of the design intervention > Segments related to the use of the design intervention
Aesthetic appropriateness	> Segments that show an aesthetic appreciation of the artefact > Segments that relate the effect to the aesthetic qualities of the artefact (memm) > Segments that relate to the fit within their lifeworld in terms of its aesthetic qualities (maya)
Moral appropriateness	> Segments that indicate friction between the user's values and the influence as exerted by the artefact
Systemic appropriateness	> Segments that explain the fit between the artefact and the user's daily life. > Segments that indicate how the artefact changed elements in the user's life

Fig. 37 Steps in the data annotation process showing the activities being labeled on individual days while keeping tabs on other days (left), comparisons with the data as produced by the intervention (right)

Table 5 Coding scheme operationalising the theory derived from the model for anticipating the effectiveness of an intervention

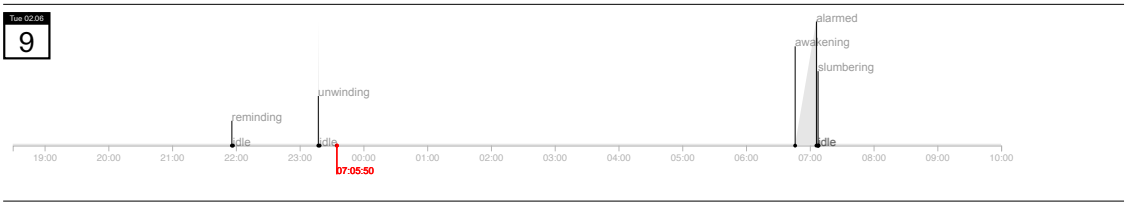


Fig. 38 Timeline showing the interaction data with the lamp, including the state of the lamp, the light level, and when a alarm was set

level between the raw data and the interpreted visualisation by reducing enough complexity so that the sensor data was easier to interpret (Fig. 36 on page 62).

The sensor data was processed in the experiment studio application from which individual graphics were exported and compiled into data worksheets. In this application the choices were made in order to make the graphics the most informative. For all graphics the choice was made to take a window of 3 minutes, and then select the most suitable aggregate function for that specific sensor (for some background on this process see page 118 in appendix III).

Using these data worksheets the activities that were likely to happen at that specific point in time were inferred (Fig. 37). During the labeling of activities patterns started to emerge which served as heuristics for labeling the rest of the activities, similar to open coding of qualitative research data. After labeling the activities the durations of those activities were distilled from the worksheets and fed back in the application which generated the interpreted timelines.

Intervention data

The data generated by the interactive bed light was handled in a similar manner as the sensor data, however, instead of using a data worksheets as an intermediate this data was immediately turned into a timeline. Given that the data produced through interaction with the prototype was already contextualised, events could automatically be labeled on the timelines. An example of a timeline can be found in Fig. 38.

These timelines were appended to the worksheets generated with the sensor data and analysed in conjunction.

Experience interview

Based on the theoretical model as proposed in Fig. 15 on page 37 a coding scheme was developed that operationalised the theory, as can be found in Table 5. Using this coding scheme the transcripts were coded on the occurrence of the respective elements in the statements by the participants. Elements were aggregated to provide total counts for the efficacy and appropriateness, and a breakdown per type of appropriateness. Additionally, elements that indicated a positive or a negative influence on the respective efficacy or type of appropriateness were counted.

1 For instance, none of the participants identified their bed as being a central thing within their bedtime routine.

2 Both the bed sensor boxes started to hang and malfunction after roughly two to three weeks of deployment. That could be attributed to the fact that those were the boards where the power LEDs were desoldered in order for them to emit less light during the night.

3 Other members of the household accidentally unplugged the power cable in week 2, which was noticed only after a few days by the researcher.

Results

In the two experiments three perspectives on the situation were gathered, a longitudinal *thing*-perspective using sensor data, a *reflective user*-perspective through two interviews and an *intervention*-perspective composed of interaction data. During analysis of the data the interaction data generated by the intervention was used to fill in the blind spots of the sensor data resulting in one integrated thing-perspective on the situation. Hence we will discuss the results by comparing and contrasting those two perspectives on the situation. First we will discuss on a process level how the perspectives were handled during analysis and how they relate to each other. Then we will proceed by discussing how the perspectives were used to gain insight into the efficacy and appropriateness of the intervention in order to conclude with how the effectiveness of the intervention can be anticipated.

Thing perspective

The main output of the process handling the sensor data as described in the data analysis section were the timelines derived from the data worksheets (appendix XIV and appendix XV) showing a rough overview of the activities performed during an evening, as can be found in Fig. 39 and Fig. 40, larger versions of the figures in this section can be found in appendix XVI.

Through instrumenting an ecology of things in the extended situation we were generally able to discern the activities that the participant performed during an evening. This approach yielded labeled activities during 89.2% (P1) and 63.6% (P2) of the evening1. Moreover, when comparing Fig. 39 to Fig. 40 we see that in the case of P1 the activities were labeled in a more fine-grained way than for P2.

Instrumenting more things allowed to differentiate in a more fine-grained way the different activities performed. In the case of P1 five things encompassing 13 sensor streams were used whereas for P2 three things were instrumented with nine sensor streams which impacted the range of activities that we were able to label.

The heuristics that emerged during the labeling of the activities helped to label similar patterns for other activities, and limited activity at other things. For instance, in P1 certain combinations in motion, sound and light could helped to infer activity near the mirror that thereby narrowed the time spent in bed. Not only did the quantity of instrumented things impact the results as several well-placed probes proved to be more informative than less fortunate choices. For P1, the activity near the mirror was able to fill many of the gaps left by the malfunctioning instrumentation of the bed—while the activity with the remote did not provide additional insights complementing what was already obtained from the sofa.

Apart from comparing and contrasting activity near things we could also use the individual sensor streams of a thing to distinguish between sub-activities. In the case of P1 it was possible to use variations in different sensor streams to differentiate between sub-activities performed with the same central thing, such as watching tv or socialising with friends on the sofa. The shared nature of the sofa in case of P2 hindered applying the same strategy, as there were no clear deviations between people talking while watching tv or socialising. Similarly, this shared nature also hindered labeling the

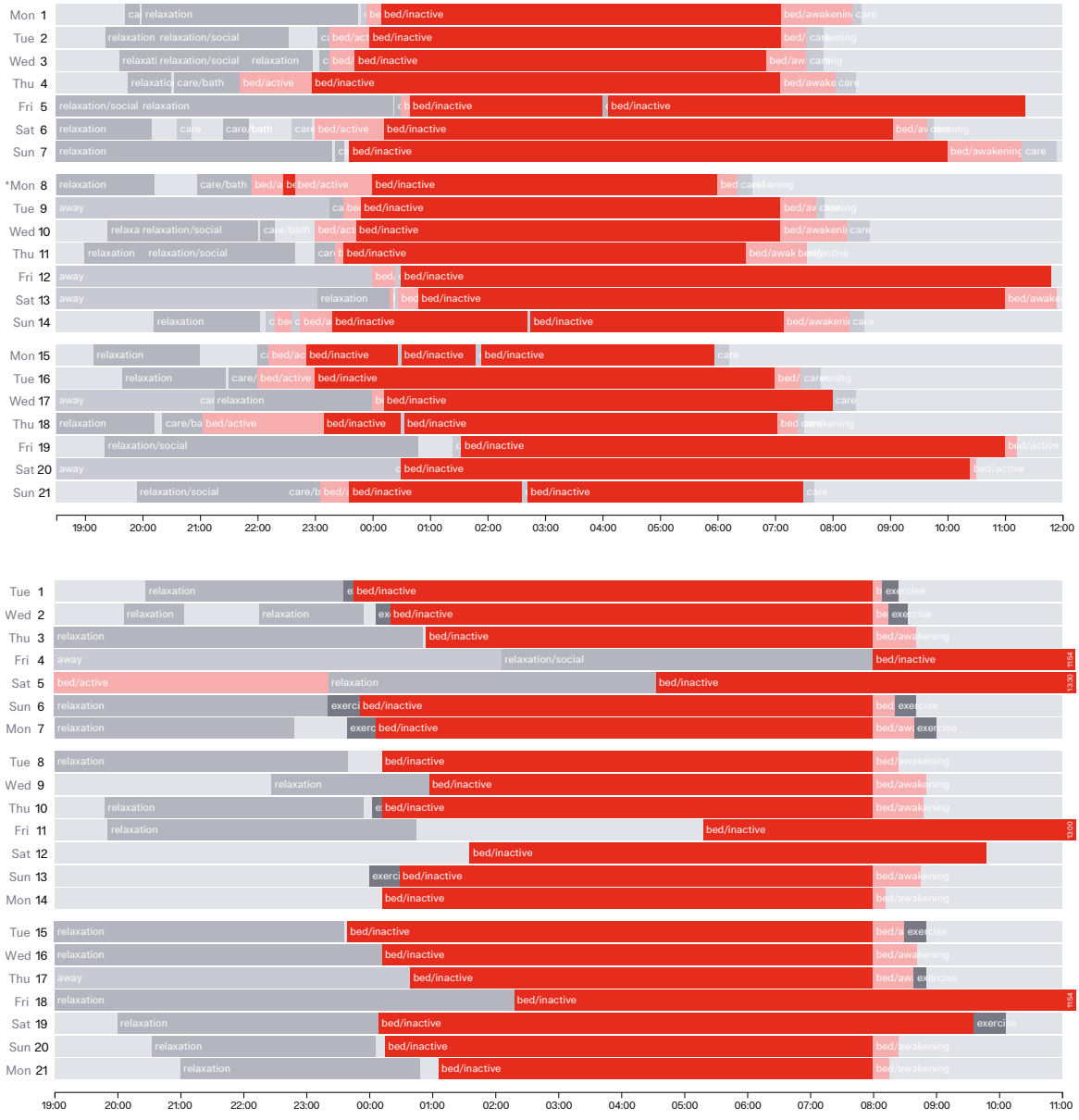


Fig. 39 Interpreted timeline of inferred activities for P1, showing the time in bed in red/pink and the other activities in grey. Note that only the evening routine was analysed during this experiment

Fig. 40 Interpreted timeline of inferred activities for P2, showing the time in bed in red/pink and the other activities in grey. Note that only the evening routine was analysed during this experiment, and for the weekend days when the bar would exceed the edge of the graph the end time is provided at the end

'away' activity as in case of P2 all housemates had to be absent whereas in case of P1 it was already possible to discern that activity when she left the house.

The labeling of activities was largely driven by assumptions based on common sense, as for instance when there are high light levels in a bathroom during the night we can assume that the participant was awake for a while. At the same time labeling cannot and should not be done only through relying on personal common sense. Statements from the interviews helped to understand patterns in behaviour and fill in for some of the blind spots of the sensors. For instance, based on the data it was hard to exactly see when the alarm went off in case of P2 as there were no evident peaks in sound and light levels. However, based on the ethnographic interview and the intervention data we could determine that it was kept constant at 8:00 every day. This also shows a certain level of ambiguity in the beginning and end of an activity which is not well reflected in the timelines as they show clear boundaries of activities.

Indicators of efficacy

The thing perspective proved to be the prime source for gaining insight into the efficacy of the intervention as it gave insight into the situation on a longitudinal scale, by providing the assumed sleep and wake times and the activities during the evening. For assessing the efficacy of the intervention two indicators were formulated:

1 duration of activities in the evening before falling asleep
2 consistency of bed times between different days

Although the timelines are useful to gain an overview over the situation of the two experiments, they do not provide enough information to visually assess the efficacy in terms of the formulated indicators. Additionally, given the relative short duration of the experiments and the respective limited number of data points a purely statistical approach did not yield meaningful results. Hence some combination of statistical and visual analysis was required in order to examine the efficacy of the intervention.

Balance in activities

The first indicator is related to the higher abstract behaviour in the extended situation of 'balancing sleep with other practices'. To assess this indicator the activities during the evening were aggregated and plotted in figure Fig. 41. For P1 and P2 the absolute values were plotted, and for P1 also the relative values. Due to the limited number of activities that could be labeled in the case of P2 relative values did not provide additional insight than the absolute values. Moreover, even the absolute values do not provide with results that allow for meaningful interpretation of balance as there are simply not enough activities to compare. One observation that can be made is that the activity that was supposed to be stimulated through the intervention—doing some meditative exercises before going to bed—was actually performed less often than in the baseline week. This corresponds with some of the statements in the experience interview:

> Yet the part before going to sleep that doesn't always happen. It often changes whether I'm quickly get into my bed, or whether I do some exercises. (P2.exp.5-6)[2]

The more fine-grained labeling of activities in the case of P1 helped to gain more insight into the balance in activities. For instance, we can see that there is a smaller contribution of the 'relaxation' activity, which includes watching TV or Netflix, in the intervention week than in the other weeks. This suggests that the intervention helped in ending that activity earlier by stimulating to go to bed. This

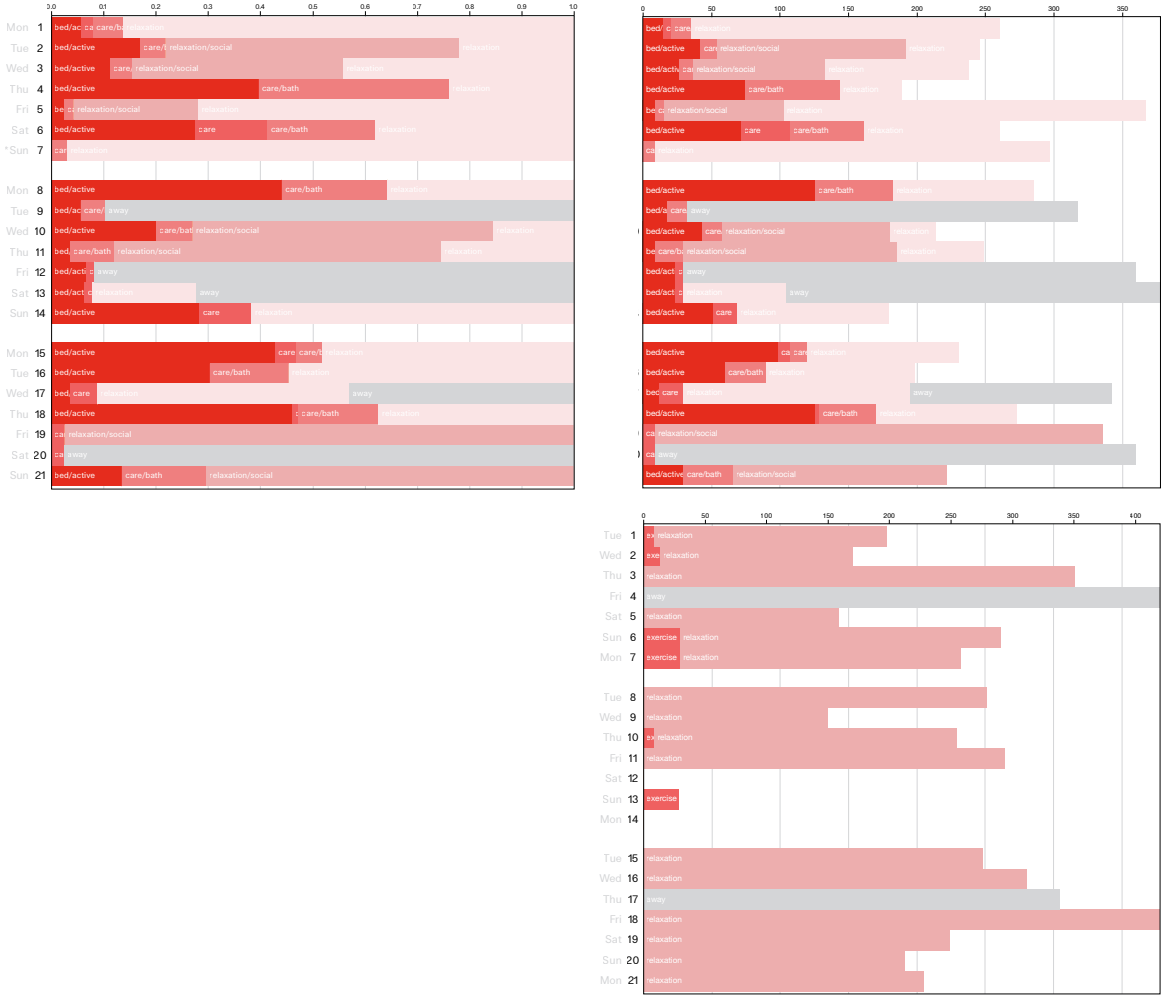


Fig. 41 Graphs showing the absolute durations of activities during the evening for P1 (top right) and P2 (bottom), and the relative durations for P1 (top left)

corresponds with the ethnographic interview which indicated that going to bed on time is largely depends motivation:

> I know that when I'm on the sofa, that it is a lot of effort to get myself to go to bed. (P1.ethn.78)

> Normally I have a bit more motivation because I know what the consequences are if I do not do it. But I am quite a difficult person to get myself to bed even though I think about it the whole day that I have to go to bed early (P1. ethn.84-85)

Although we see balance in that regard, we also observe that when she is 'away' the balance between sleep and evening activities skews more towards the evening than to sleep. This corresponds with the fact that during those social activities it is hard to leave on time:

> I'm not the best in leaving anyway, thus when I'm at a party or at someone's place than I find that really hard. Even though I want to be the one saying 'I'm leaving now', I wait until someones else says that they leave, as my cue to leave as well (P1.ethn.171-172)

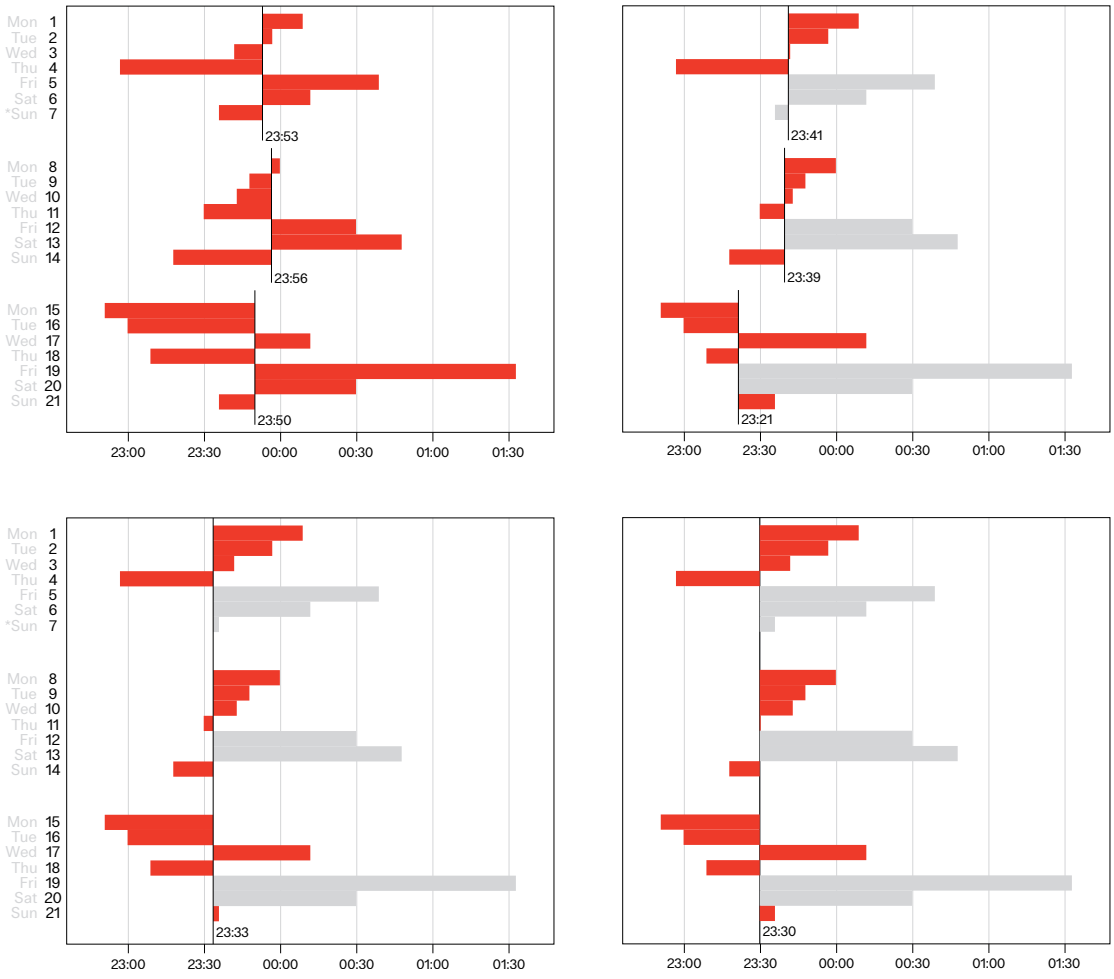


Fig. 42 Graphs showing the deviation between the bedtimes of P1 and the average per week including the weekend (top left) , the average per week excluding the weekend (top right), the average across the three weeks (bottom left) and the intended bedtime (bottom right)

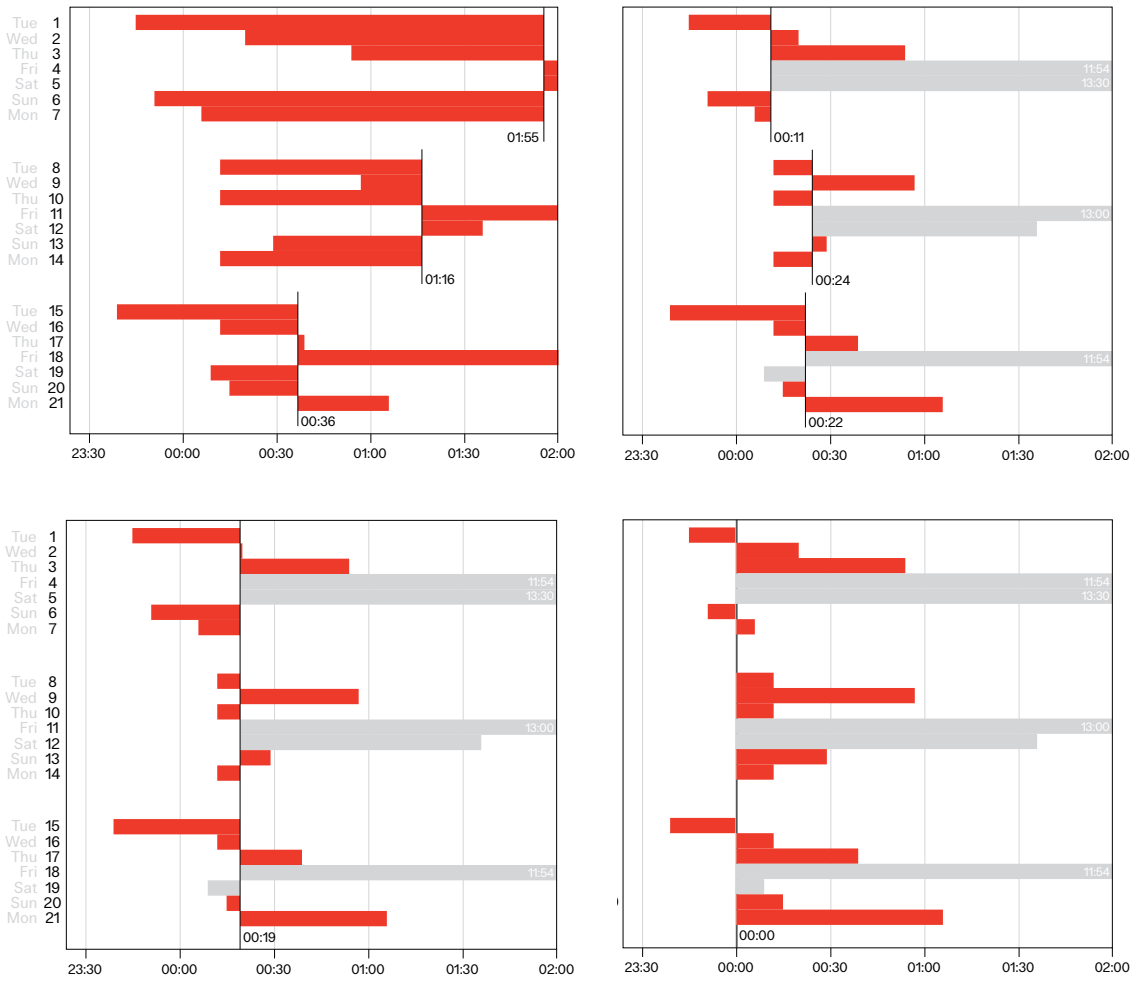


Fig. 43 Graphs showing the deviation between the bedtimes of P2 and the average per week including the weekend (top left) , the average per week excluding the weekend (top right), the average across the three weeks (bottom left) and the intended bedtime (bottom right). For clarity the weekend bars are cut off at the end of the graphs

Although this influences the behaviour at consideration in this experiment it cannot be addressed through the intervention as is, and is potentially undesirable to address through this intervention. This would probably require the development of another intervention.

Finally, the graphs of P1 do not show a longer period of time spent in bed before falling asleep. Although the participant suggests in the interview that she used the unwinding period for reading (P1.exp.31) that is not fully reflected in the data. When introspecting the data worksheets we also see co-usages with other things such as the bath and even her smartphone during the unwinding period of the lamp, which suggests that that period is not used as intended.

Consistency of bedtimes

For assessing the consistency in bed times additional graphs were generated that show the assumed bedtimes (Fig. 42 on page 69 and Fig. 43 on page 70). Given that the exact definition of consistency in this indicator is ambiguous, several statistical measures were used to compare the bed times to.

First the deviations between the bedtime and the average bed time during that week were plotted. These gave mixed results as in both cases the bedtimes during the weekend significantly differed from those during the week. In line with the interviews during both the ethnographic and experience interview those weekend days were excluded as the bedtime component of the intervention was not used on those days during the experiment and is likely not to be used on those days in real life situations.

After excluding the weekend days the bedtimes were compared to the average bed times per week, the average bed time across the three weeks and the intended bedtime of the user. The last measure was determined by combining statements from the ethnographic study (including the sensitising workbook), the experience interview and the set bedtime in both interventions.

When examining the consistency of P1 (Fig. 42 on page 69) we see that the average bed time was roughly similar in the first week and second week, and earlier in the third week. However, the bedtimes in the second week are closer to the average bed time and there are less outliers, indicating a more consistent bed time. This same observation can be made when relating it to the average bedtime across the three weeks, and when relating it to the intended bed time. In the case of P2 (Fig. 43 on page 70) we see a similar effect except for one outlier during the week of the intervention, although the effect is less pronounced. Besides, the average bedtimes during the week of the intervention and the week after are later than during the first week. This suggests that the effect of the intervention was minimal.

Evaluating the mechanism

Both indicators provided insight into the efficacy of the intervention yet, as the measures in this study provided insight into the outcomes of the behaviour, it is arguable whether assessing the efficacy of intervention solely through those indicators only provides the full picture.

Several statements during the interviews indicated that the introduction of the design intervention reminded the participant of the intention to do something about their behaviour:

> Well, not a lot better. But I guess that I have been more aware of it (P1.exp.5-6)

> But also the fact that you see it, that makes you associate it... by seeing the physical thing you know that you want to make a change and that you should do something. (P1.exp.120)

> I started to think more actively about these kinds of things, the intention of such a product. If you download such a thing then you have the intention to do something about it, so already 'owning' such a thing has influence in that regard. (P2.exp.44-45)

Intentions to change behaviour are likely to influence the behaviour itself, yet as discussed in the theoretical explorations of this work are fuelled by the introduction of the intervention and are likely to fade over time. When measuring outcomes only it is impossible to distinguish the effect of those intentions from the effect of the intervention. Hence to understand the efficacy it was also important to 'qualitatively' inquire into the situation in order to see whether the mechanism of the intervention was induced.

The design interventions embodied a mechanism that comprises of two parts: motivating users to take the time to unwind by planning consistent bedtimes beforehand, and then reminding the user to go to bed and support them in taking the time to unwind. For understanding whether these components were induced we went back to the level of the data worksheets in order to see the effect of the intervention on the observed patterns in the data. When examining the data worksheets we could see how these elements manifested themselves.

For instance, for P1 clear responses to the bedtime notifications can be found on several days where the activity at the sofa stops within six minutes after the notification (P1.data.10,14); demonstrating that the reminding part of the mechanism was effectively induced. At the same time we also saw that the bed- and waketimes were altered on a daily basis just before going to sleep, and the unwinding period was rarely used for unwinding only. In the case of P2 we rarely saw any response related the notifications, and due to his strict interpretation of the text messages resulted in him never using the unwinding part of the intervention.

Although these findings correspond with what was found through assessing the indicators, it provides richer understanding of the actual performance of the intervention (and potential courses of action for redesign).

Reflective user perspective

During the study two main interviews were performed that both constitute the reflective user perspective. The ethnographic interview at the beginning of the study, combined with the sensitisation workbook, provided a reflective account of the participant on their baseline behaviour; whereas the experience interview provided a reflective account of the user on their experience of using the intervention.

Ethnographic interview

The use of the ethnographic interview (appendix IX and appendix X) contributed to understanding the broader context of the participant and their behaviour. Although this was a necessary step for getting a feel for the context of the participant, during the analysis of the data for evaluation purposes it proved less useful then for instance the experience interview. However, this interview did explicitly inform the choices made during the instrumentation, and thus is in that regard influential on the results of the thing perspective. Additionally, qualitative statements from the interview helped to attribute value to and understand certain activities. For example, being 'away' in case of P1 means that she is either socialising with friends or doing exercise which can generally be seen as a beneficial activity.

Experience interview

The experience interview (appendix XII and appendix XIII) gave a reflective account by the participant on their experience of the efficacy

and appropriateness of the intervention. In the first case a total of 20 elements were identified that gave insight into the efficacy, and 44 elements that gave insight into the appropriateness of the intervention; while in the second case 13 efficacy elements were identified and 23 elements of appropriateness. A breakdown of these elements into the respective types of appropriateness and whether they indicated a positive or negative influence on the efficacy and appropriateness can be found in Table 6 and visually in Fig. 44.

Even though there are inherent limitations to this visualisation of aggregated values, some things do become evident. First, we see that all types of appropriateness surface during the interviews, although not in equal amounts. In both interviews the total number of elements relating to aesthetic appropriateness is lower than for other types of appropriateness. Participants do not structure their thoughts according to the coding scheme, hence we often see statements that can be coded as multiple types of appropriateness at the same time. For instance, one participant elaborated on the intervention by stating that

> The prototype was quite impatient in the sense that it very often asked things. It was quite pushy, and at a certain point time it just thought 'forget it', and then it stopped after asking a few times (P2.exp.8-9).

showing both an aesthetic appreciation of the tone of voice of the intervention as a personal judgment on the influence exerted in relation to his personal values. Although we often see multiple statements coded together there are no pairs that occur significantly more often than other pairs.

When qualitatively zooming in on the operationalisation of the individual types in the coding scheme (Table 5 on page 63) we see that in general all the individual elements manifest themselves in varying degrees in the experience interview, with the notable exception of consequential effects of which none were found. When comparing the interviews to the coding scheme apart from the main types also the individual subtypes/ operationalisations were found, with the notable exception of consequential effects (elements that indicate that something in the user's life has changed).

Assessing appropriateness

For understanding the appropriateness of the intervention the experience interview (appendix XII and appendix XIII) proved to be most valuable source of knowledge. Apart from looking qualitatively at the results of the interview, it is also possible to quantitatively draw some conclusions based on the data as presented in Table 6 and Fig. 40.

In the interviews (and the data) it surfaced that P2 did not engage as much with the prototype as P1, which is reflected in the lower number of elements for both the efficacy and the appropriateness as well. The low number of systemic appropriateness elements for P2 when compared to P1 reflect this same observation, as when the participant does not engage with the intervention it is hard to relate how it would fit into their daily life. Additionally the responses of P2 are significantly more negatively skewed than those of P1.

For P1 it is clear from the graph that in terms of its aesthetics the intervention can be considered as appropriate to the situation. The simple interactions were considered to be very appropriate to the situation, as:

> What I really enjoyed was that you can turn it off through turning it [...] The way that it works is just really cool, that when you shake it, it gives a little bit of light en then when you turn it around it turns on. That you easily use it, without buttons (P1.exp.78-82)

> And because I really like such a lamp, warm light, I fancy that. I love that it is a bit dark and then you have some light, I do think that is quite 'gezellig' (P1.exp.132)

This example also shows that one aspect of the design can have several effects in terms of its appropriateness to the situation. For instance, given that the participant already owned a wake-up light, although the intervention introduced new interactions, the intervention resembled closely what she already owned. This means that the interventions is both aesthetically and systemically appropriate as there is fit with the user's daily life.

At the same time these intuitive controls can lead to annoyance when the device is not doing what is 'expected'

> The only thing that wasn't completely clear to me was that when I turned the light around it started to run, [...] but then when I thought I do not want it run half an hour I didn't know how to turn it off. (P1.exp.37)

> Yes I found that quite annoying as there were cases that I accidentally turned it around and then forgot that I cannot do anything for half an hour, that is the only thing that can think of that I did not like (P1.exp.96)

		Efficacy	Aesthetic	Moral	Systemic
P1	Total	**20**	**10**	**18**	**16**
	Positive	15	9	8	4
	Negative	5	1	10	12
P2	Total	**13**	**6**	**12**	**5**
	Positive	6	2	5	1
	Negative	7	4	8	4

Fig. 44 Breakdown of the elements that indicated efficacy or a type of appropriateness, showing the total number of elements and whether they indicated a positive or negative influence on the efficacy or appropriateness. Note that these values comprise of all occurrences not just unique instances

Table 6 Aggregated values of the breakdown visualised Fig. 44, per participant, and type of element including whether it indicated a positive or negative influence.

This example shows friction with the influence exerted by the intervention, as the intervention intentionally does not allow to skip the unwinding period. Even though the user knows that it might be intentional

> Like you know that that is the way that it is intended, you just want to be in control of that thing (P1.exp.163)

there is a certain level of annoyance that is the type of issues that could lead to reduced adherence to the intervention. This illustrates an example of an element that may result in obstruction of the formation of a durable bond that can be identified through the experience interview.

The experience helped to gain in-depth insight into the mechanisms of the intervention that can argue for the appropriateness of the intervention. For instance, an important element that was appreciated by the participant was that the bedtime notifications were noticeable yet ambient.

> And then you decide what you are going to do with it, whether I finish watching or immediately turn everything off. (P1.exp.74)

> Of course it depends on what I was doing, if there were still five minutes left of an episode I would finish it, but if it was still an hour I would stop, otherwise it would be to late (P1.exp.76)

We can see here that the intervention invokes an internal response in which the user decides what is the appropriate course of action, leaving them more in control. A similar pattern was observed with the chatbot

> For instance watching an episode or a movie on tv, and then you just want to finish watching it and it takes a bit longer. [Researcher] And then you received the next message? [Participant] Exactly. (P2.exp.79-80)

however here it triggered annoyance given the 'aggressive' character of the chatbot.

Conditions of effectiveness

Especially statements that illustrate the systemic appropriateness illustrate an important aspect of the design interventions: the conditions under which they can be effective. For instance the reminders that the bed light delivers only works when the user is in the same room as the bed light. When the user is often at home and this occurs, than that is something that can be addressed through improving the intervention. However, it can also occur when the user is not at home, for instance while being at a social event. This illustrates conditions under which the intervention is not effective, but that can and should probably not be addressed through this particular intervention. Yet they do affect the overall effectiveness of the intervention.

Manifestation of design

Although the manifestation of design and properties of fit were not explicitly addressed in the protocol of the experience interview, in follow-up questions several statements from the participant explicitly addressed the manifestation and properties of fit in relation to the appropriateness of the intervention.

For instance, P2 discussed the directionality of the intervention as limiting his use of the intervention. The chatbot was very specific in its directives—asking the user whether they were already in bed in order to go to the next state where the user would be instructed to do some unwinding activity. However:

> At least, I couldn't always respond affirmative that I was already in bed [...] SleepyBot assumed that I do my relaxation in bed, so I always responded negative on the question whether I was already in bed (P2.exp.11,18)

This way the unwinding part of the intervention was never even executed through the specific interpretation of the intervention's message; directly impacting the effectiveness of the intervention as the mechanism is not fully induced. Similarly, P1 discussed the presence of the intervention:

> Yes, it is quite a physical element that reminds you. Of course it reminds you when it's time to go to bed, but you always associate it with your intentions.. by seeing it en the fact that it is a physical object you know that you are taking care of it and that you need to do something about it (P1.exp.119-120)

Which in her experience was actually a comforting idea.

When discussing the manifestation of design there seems to be no clear contribution to a specific type of appropriateness, as insights contribute to understanding the efficacy, aesthetic, moral and systemic appropriateness of the intervention.

Anticipating effectiveness

Based on the assessment of the efficacy through the indicators and the appropriateness we can try to anticipate the effectiveness of the two interventions. In this work we adopted a two-tiered approach to the evaluation of the interventions, first looking at the performance in the design situation as established by the behaviour 'adopting regular sleep and wake times', then understanding their performance in the extended situation established by 'sleeping better' and 'balancing sleep and other practices'.

Based on the results we estimate that the interactive bed light is efficacious at achieving the intended behaviour with several aspects that need to be further improved (such as the bed light not being at the same location as the participant, and being able to in some way able skip part of the unwinding phase). At the same time we consider this intervention to be effective only in situations where people are at home performing activities that can be cut short such as watching television or Netflix. The intervention may be more suitable for people with a less active social life during the week who experience these problems of staying up too late. For social situations additional interventions need to be developed.

For the bed light we thus see that the moral component of the appropriateness needs to be addressed, whereas for the systemic appropriateness only the parts that could obstruct future use have to be addressed. Addressing the moral component will not be a simple task though as it likely to influence the efficacy of the intervention. As the individual elements are inherently linked it may not be as easy to address one element without compromising on the effect on other levels.

The chatbot is not efficacious at achieving the intended behaviour as the mechanism is not even induced. An explaining factor for this is the directionality of the intervention which may be addressed through reformulating the textual messages, however, it is also an inherent implication of this specific manifestation of design. It is arguable though whether this concept should be further developed, as it also scored low on appropriateness meaning that it is highly likely that many more things are required to change in order to achieve a durable effect. Here especially the moral inappropriateness may be the biggest driver in non-usage attrition.

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1 For P1 this was calculated during the period between 18:30 and 2:00 and for P2 the period between 19:00 and 2:00

2 All quotations of participants in the text were translated from Dutch to English. Quotes are referred to by participant number—data source—line/day number, where *ethn* is the thing ethnography interview, *exp* the experience interview, and *data* the data worksheets.

D
General discussion

Given the results of the study it is time to take a step back to reflect on the results of the study in relation to greater context of the thesis. First we will examine the findings from the study and discuss them in relation to the research questions.

Here we will discuss our operationalisation of effectiveness and appropriateness, examine how the sources of knowledge related to each other during the study, how we anticipated the effectiveness through the appropriateness and efficacy, discuss the effect of the manifestation of design on the appropriateness and finally discuss the repercussions on critically evaluating design interventions.

Then we will examine the limitations of the work present, discussing the type of interventions for which the results of this thesis are applicable and some other limitations concerning the elements that were not considered in this study, by providing concrete examples of changes to the design process as well as discussing wider implications for design practice.

Since this research was set up with design practice in mind we will continue the chapter with discussing the value of the activities and results of this study for design practice through reflecting on the design goal of this study.

We conclude the thesis with a conclusion outlining the contributions of the work and some final remarks. Afterwards there are some personal reflections on the process of this graduation project.

Discussion

In this section we will discuss both parts of the research—the theory development and the research through design study—by means of the research questions.

Operationalising effectiveness and appropriateness

Designing for behaviour change is inherently concerned with intentionally achieving a *change* in *behaviour*, which thus by definition is an effect that can be observed and measured. For behavioural design we see that such an effect can be assessed on the dimensions of effectiveness and appropriateness. For assessing those dimensions it is important to carefully define what is meant by those terms, hence the first research question:

RQ1 How can the dimensions of effectiveness and appropriateness be operationalised?

When discussing the effectiveness of an intervention we differentiated between the *efficacy* of an intervention, and its *effectiveness*. Thus the actual effectiveness depends on the adherence of users to the intervention—the formation of a durable and stable bond with an influential agent. This adherence is likely to explain why interventions seem to be effective on the short-term while that positive effect is not sustained (Abrahamse et al., 2005). Through examples we established that when an intervention is not appropriate in the situation it ultimately results in friction that obstructs the formation of a stable attachment to a thing—and could ultimately lead to non-usage attrition.

From reviewing existing literature on the influence of artefacts on behaviour three types of appropriateness were identified: *aesthetic*, *moral*, and *systemic* appropriateness. The categorisation of the types of appropriateness were not the product of a systematic literature review, hence they may seem unfounded and it is unknown whether this distinction covers the entire concept of appropriateness[1]. However, through operationalising the factors in a coding scheme we did empirically evaluate these categories during the study. Although they did not manifest themselves in equal amounts, we were able to find instances of each type including the individual elements in both interviews. This suggests that the model resonates with reality.

The causal relationships in the model were not empirically verified and merely developed from drawing on previous work and examples. We did however observe during the study elements of friction that are likely to influence the adherence to the intervention in the long-term, which combined with findings from literature gives reason to support our proposition. However, to assess whether there is a causal relationship between the appropriateness and the effectiveness additional studies need to be conducted.

Sources of knowledge

During the study we aggregated data from a variety of different sources, hence the following research question:

RQa How do different sources of knowledge relate to each other while integrating them during evaluation?

In the introduction of this thesis we discussed the conventional approaches

to evaluating design interventions in the behavioural sciences and design practice, presenting them as a dichotomy between quantitative and qualitative approaches. In the study we collected and integrated the data from a longitudinal *thing*-perspective, a *reflective user*-perspective (before and after the intervention), and an *intervention*-perspective.

When analysing the perspectives an important factor to be cautious of is the introduction confirmation bias, for instance by deliberately corroborating insights from one perspective with the data from another perspective. It was tempting during analysis to 'fact-check' statements from the interview with the sensor data, in order to pass judgment on the truth of the statements in relation to the rest of the interview. However, people may not be completely aware of their own behaviour—explicating a recollection of their behaviour instead of being intentionally deceitful. We addressed this issue by first analysing and interpreting the data individually before starting to look for connections and patterns between different data sources[2].

As a result the perspectives themselves were not compared and contrasted to each other as were they either quantitative or qualitative, but each individual source of knowledge was analysed both quantitatively and qualitatively. For instance, the data worksheets helped to qualitatively observe whether the mechanism was induced whereas the elements of the experience interview were aggregated and visualised to get an impression of the appropriateness.

During data analysis we often shifted between the interpreted visuals and the data worksheets. As can be seen Fig. 45 there was a continuous cycle between the interpreted timelines and the data worksheets[3]. As interpretation is a reductionist move, some of the contextual richness is reduced in order to be able to compare in this case

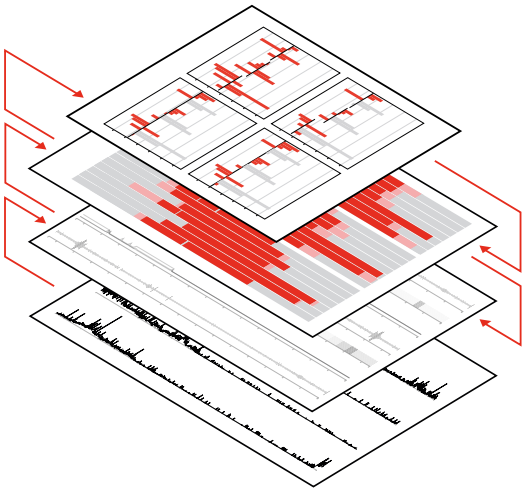

Fig. 45 The process of analysing the sensor data is not one directional. After turning the raw data into data worksheets, interpreted timelines and indicator graphs we often cycled between the data worksheets, interpreted timelines and indicator graphs to make sense of situation

several days concurrently. However, when for example understanding whether the mechanism was induced it is important to go back to data worksheets[4] to get more context. Connections can happen between various levels of abstraction suggesting that it is important to keep the data partly transparent during the process, thereby recognising that visualisations are not neutral carriers of information (Correll, 2019). Reflecting on the results in this study there probably could have been more to explore in terms of data visualisation and the connection between interpreted visualisations and 'raw' visualisations.

During analysis there were significant gaps in the data and often it was quite ambiguous to label an activity as one or the other. The results from the study did not provide enough data to perform statistical analysis to investigate the efficacy of the intervention, while at the same time the interviews provided room to question the validity of the statements of the participants.

However, the fact that all perspectives are open-ended and did not provide definite answers may actually be a key quality of the work performed. This stimulated to connect and triangulate insights, gaining inisghts and supporting arguments with elements from multiple sources of data. Thereby we actively engaged with the data resulting in decisions that were our own.

Although the use of several perspectives is beneficial to the results of the experiment, the results from this study do not imply that a sensor-based perspective is an absolute necessity. Based on this study we have to concede that the results that the sensor data provided with do not outweigh the effort undertaken to collect that data. In part that is because there is no off-the-shelve infrastructure that could be used and thus had to be developed first. Moreover, the relative short duration of the study and limited amount of things instrumented yields results that are quite limited. For a study of this duration experience sampling strategies, or sleep tracking through an app would have been more accessible approaches to data collection.

Anticipating effectiveness

When operationalising the effectiveness and appropriateness we found a relation between the intervention being efficacious and intervention being effective through understanding the appropriateness of said intervention. Thus we studied the following:

RQb How can the effectiveness of an intervention be anticipated through assessing the appropriateness and efficacy?

First, one way to anticipate the effectiveness that is not explicitly discussed in this thesis is using the model in a preventative manner. As the input to a design experiment is a tentative solution that proposes a mechanism and manifestation, there are likely to be many ideas that preceded the concept and didn't make it as a solution fit for evaluation. It is likely that through discussing interventions through the operationalised model of appropriateness can aid during the production of ideas.

Based on the experiments as carried out in this study it is hard to draw conclusions for the efficacy of the intervention on the basis of the quantitative data alone. Given the short duration of the experiments there was not enough data to approach the quantitative data through statistical analysis only. Hence we developed several charts that aim to give insight into the specific indicators. Although they provided with some results, those were not conclusive.

An underlying factor that could explain the limited usefulness of the indicators is that this work aimed to incorporate and evaluate behaviour on multiple levels of abstraction. In the experiments in this work we tried to concurrently approach a situation holistically, while at the same time reduce behaviours to measurable indicators. Higher order behaviours are harder to capture in specific and measurable dependent variables which affects the quantitative results, leaving more room for interpretation.

In this study the indicators of effectiveness hinged on both abstract and specific interpretations of the behaviour, rendering them less effective in measuring outcomes. This suggests that designers need additional support in operationalising their behaviour as an input to an experiment and determine the dependent variables to be measured. It would be an interesting direction for further investigation to see whether we can verify whether the quantitative indicators are descriptive of the behaviour using qualitative means, so that in a follow-up study only the quantitative measures can be used.

Although quantitatively the study may not have provided the insights we were hoping for, the application of a single case design did have two additional benefits of interest for designers. It provided the ability to actually do qualitative research within a quantitative study. In a between-groups study the ultimate goal is to keep consistency between every individual participant in the study. In single case designs that is not necessary, providing more flexibility for the designer to also inquire qualitatively.

We focused on evaluating the efficacy by examining whether the mechanism was induced, and there was a respective response in behaviour. Given that in this work the interventions were more theory-inspired than they are theory-based we did not make use of theory to describe the elements that we were looking for. It would be interesting to further explore what the explanatory and predictive qualities of theory can mean for the evaluation of the mechanism and behaviour.

The interviews helped to identify the elements that could be changed to improve its appropriateness. However, other than for instance usability errors these are more dilemma's than elements that can be easily addressed. For instance you can remove some of the coercive behaviour of the bed light, but that would also make it less influential and thus less effective in the end. In case of the bed light, removing all influential elements of the product would simply make it a bed light. Tackling these elements will require discussion within the design team about the direction taken. Is maximising the effectiveness prioritised above the intervention being fully moral appropriate, risking that it may result in a group of users not adhering to the intervention?

Moreover, other than when designing for usability the idea is not to design away all friction to create seamless experiences. Design for behaviour change is intentionally concerned with change, which is something that humans are inclined to resist. Hence a design interventions will always cause a certain level friction as people change their behaviour, preventing that will simply mean that no behaviour is changed. Central should be the identification of issues that are vital in preventing people from discarding the intervention.

An important aspect of the appropriateness of the intervention was the absence of elements that indicate consequential effects. This can be attributed to the short duration of the study, leaving no chance to appropriate the interventions or discover changes in daily life.

Moreover, these may also be significantly harder elements to elicit through an experience interview as it requires the participant to compare two situations focusing on small elements that the participant may not even notice. Similarly, for noticing these changes in the sensor data would require a very accurate picture of the baseline state and then perform detection of differences that may not even be attainable through human perception. Finally, this may simply be something that is not attainable, given that it relatively easy to reason backwards from the current situation, whereas reasoning forward to the future is significantly harder to do.

Manifestation of design

The theoretical exploration suggested that another factor that influences the appropriateness of the intervention is the manifestation of design. Hence we studied the following research question:

RQc What is the relation between the selection and formgiving of the manifestation of design and the appropriateness of an intervention?

In this study we varied the manifestation of design while keeping the mechanism constant in order to observe differences in the efficacy and appropriateness of the intervention. While we did observe differences, it is arguable whether those differences can be solely attributed to the manifestation of design. Although the design concepts share a similar mechanism as well as certain similar design elements—they diverged significantly from each other during the conceptualisation process. This divergence can be ascribed to the definition of mechanism in this work. Where Tromp and Hekkert (2017) conceptualise the mechanism as the strategy and style of the intervention, in this work the mechanism was seen as the strategy while the style was seen as the linking factor between strategy and manifestation. Hence the style was also open to variation which resulted extra variations. This variation was acceptable for this study as we were exploring the relations instead empirically validating them.

This research question implies that the manifestation of design contributes to the appropriateness of the intervention. While that was the case in the study the manifestation also impacted the efficacy of the intervention, as in the case of the chatbot the directionality of the intervention impacted whether all elements of mechanism was induced. This makes sense from the perspective that the manifestation is the interface between the inner and the outer environment (Simon, 1996). This is a further complication to the model as the manifestation of design can now concurrently influence the efficacy and the appropriateness of the intervention.

We proposed an initial list of properties that can help in describing the fit of the manifestation with the context. During the interviews we encountered that participants referred to some of these properties in their own laymen terminology. This suggest that these people are actually able to discuss these properties and that they potentially can be integrated in the protocol for the experience interview.

Evaluating design interventions

After examine the three research questions that were formulated in the theory development part of this thesis, we will now proceed with discussing the final research question:

RQ2 How can the integration of multiple perspectives on the situation improve the critical evaluation of design ideas in terms of their effectiveness and appropriateness?

As the introduction of this thesis set out social and behavioural design call for sound and deliberate design and evaluation. Designs that do not live up to their promises can nurture false beliefs that people are doing good, or could (potentially) do more harm than they do good, as was illustrated by one participant who remarked:

> I felt a bit disappointed in myself because I wasn't living up to my intention to change my sleep ritual (P2.exp.52)

which given the intervention that he received may have not been fully to blame as the intervention simply wasn't effective.

In our version of a data-informed design experiment we stayed close to the conception by Schön (1983) of a move-testing experiment, where the logic is "Do you like what you get from the action, taking its consequences as a whole?". When comparing the study as performed in this work to contemporary evaluations we see that an important benefit of our approach is that insight is gained concurrently into the performance of the

intervention as well as the opportunities for improvement.

The main assumption underlying the work was that the integration of multiple perspectives would lead to a more critical evaluation of the intervention. Based on the results we can say that in this study that was the case, given that the individual perspectives would not have led to the findings as presented here. For instance, upon listening to the experience interviews the portrayal of how the intervention performed was significantly more positive than when analysing the sensor data. If hypothetically speaking we would have arrived at similar recommendations, then still the integration of multiple perspectives allows to prioritise improvements and place them in perspective.

A conditional aspect for the integration of multiple perspectives to improve the evaluation is that the perspectives should be of a heterogeneous nature—they should shed light on the blindspots of other perspectives. Thus complementing an interview with a survey at the end of a study will probably yield less interesting results then doing small interviews or experience sampling during the study and comparing that to an experience interview at the end of the study. Hence there are a variety of characteristics that go beyond the traditional division between quantitative and qualitative, as other factors like longitudinal and momentary impressions of the situation, interpretations of the situation from people and things, and objective observations and subjective inquiries in values should be taken into consideration as well.

This requires creative ways of choosing and collecting appropriate data sources, that is highly dependent on the behaviour at consideration. For instance, the collection of grocery receipts or collecting fitness tracker data may provide with new longitudinal perspectives. Here the ability to perform thorough informed consent procedures can aid in the willingness of participants to hand over those specific types of potential private information.

In the study we performed a two-tiered evaluation where the first the performance is related to the design situation, and then to the extended situation. This serves a few benefits, as first it allows to discuss the intervention on its merits in inducing the mechanism and behaviour on its own. This brings focus to assessing the mechanism of the design—focusing on whether those elements are induced into the situation without immediately including the fit into the greater context.

Relating the intervention to the extended situation defines the limitations of the intervention, showing the cases where the design is rendered ineffective due to other behaviours and systemic influences. Based on that analysis decisions can be made whether to add elements to the design or alter elements of the design to make it more appropriate. Another conclusion could be to accept that this is a limitation of the intervention, and that another design intervention is required to address that aspect of behaviour. Finally, a conclusion could be that the systemic influence needs to be addressed by other actors such as organisations or governments, as those influences cannot be resolved by delegating responsibility for changing behaviour to the user.

The results of such an experiment allow us to explicate under what conditions the intervention does and does not work, and for whom. Based on this we can decide what the right level of persuasive influence of the intervention is and assess whether the intervention is proportionate. Thereby it provides both insight into the performance of the intervention as it is now, and potential avenues for improvement.

In order to do this effectively it is imperative to have specific descriptions of the components of the design intervention:

the addressed behaviour, the behavioural specification and the mechanism. In the case of this study these were vague and not operational, which hindered precisely identifying what had to be observed in the situation during the analysis.

As pointed out when discussing the sources of knowledge the perspectives gained through the study were relatively open-ended, and conclusions could not be easily discerned across various sources of information. Relying on the ability to integrate seemingly opposing perspectives (Dorst, 2006; Tromp & Hekkert, 2010) coming from the different sources of knowledge the responsibility of making conclusions is rightly delegated to the designer. It is significantly harder in this approach to hide behind individual statement of a user, as it is the designer who is making the connections. Based on those (objective) connections the designer concludes by making their interpretation of the information and the repercussions that those conclusions should have on the design of the intervention.

In this study we approached the involvement of users in a top-down way where the data after the study is collected is analysed by the design team, whereas other studies also feed back results from the data processing back to the user (Bogers et al., 2016) or even involve participants in the sensemaking process (Fischer et al., 2017; Kurze et al., 2020). Given the results of this study user involvement may have been used to verify and correspond findings. At the same time, the main conclusions of this approach are on quantifying the effect of the intervention as-is (where user involvement does not contribute) and the identification of improvements which can be performed through analysis of the experience interview. Potentially presenting the final results of an experiment to a participant and then integrating those reflections could be a valuable addition that has not been explored in this study.

1 One could argue though that through our use of systemic appropriateness any remaining elements end up under this type of appropriateness.

2 This is primarily the case for the sensor data and the data from the interviews. The data produced by the intervention was used in conjunction with the sensor data; mainly to also fill in blanks from the sensor data.

3 A similar process happens with the statement cards, where sometimes it necessary to see the statement in the perspective of the interview.

4 Although we sometimes went back to the raw data to verify some anomalies this rarely provided extra knowledge, suggesting that this process is effectively one directional.

Limitations

The work present comes with a few limitations in terms of its applicability to other domains and other types of interventions. This section will outline the main limitations of this thesis. First, this work only considers behaviour that is mediated through things. The theoretical model is largely developed by basing it on literature and examples from the domain of product experience. Although we place it in the context of general context the work was evaluated with two interventions that are clearly from the product domain. Further research is required to investigate whether the theoretical model is also applicable for interventions that do not have physical touchpoint, such as services and policies.

Through our choice of context and concepts we arrived at two design interventions that are both personal things 'owned' by the user, a case where we can clearly imagine the formation of a durable bond with an influential agent being induced. However, we did not investigate semi-personal/shared interventions or even public interventions, where such a bond may not be as self-evident[1].

The theoretical model proposed in this work concerns the transition of design interventions efficacy to their effectiveness. Central in this transition is the notion of adherence, which we conceptualised as being the formation of a durable and stable bond with an influential agent. This model thereby does not take another concept into account—the acceptance of a design intervention. A conditional element to adherence is that people start to use the intervention in the first place, and the authority that 'subjects' the user to use. This is an important aspect as for instance interventions aimed at eating behaviour generally tend to get used by people from high socioeconomic status who are already willing to change their behaviour, whereas the people who benefit from such an intervention the most are among lower status groups (Ludden & Hermsen, 2020).

Finally, an important part that was not considered during the execution of this study was the interaction effect between multiple participants in the same case. Given that there is a N=1 in both cases we were not able to investigate the emergence of shared themes amongst participants. Even though ideally each individual session should be considered by itself, especially qualitative perspectives lend themselve for analysing across instantiations of the study.

At the same time the designer should tread carefully when doing such a thing, given that each item that may surface in the study could manifest itself as becoming a driver of non-usage attrition. Glossing over them by focusing only on clusters and shared themes might result in overlooking the factor that is the end most critical in predicting the eventual adherence to the intervention.

1 This could however largely be a matter of reasoning from the present world as a reference where we do not see many (semi-)public things that could have the potential for forming a durable bond. For instance, examples such as the Goedzak (appendix II on page 111) and the Citygard container (Fig. 10 on page 32) do exhibit such a potential.

Implications for design practice

Although the work in this thesis mainly contributes to the academic discourse on evaluating design for behaviour change, the approach in this work was deliberately chosen with design practice in mind. Hence our research questions were rooted in a design goal:

DG How can behavioural designers be supported in critically evaluating design ideas on their effectiveness and appropriateness through the use of collecting and harnessing various sources of data.

In this section we will discuss the implications that this work can have on design practice. First we will discuss concrete applications of this work in design practice, and then we will examine the larger value and repercussions that the ideas put forward in this work could have on design practice. An important point to highlight is that this work was developed from the perspective of the designer, but that does not imply that the work as outlined should only be performed by designers. Ideally, it should involve a multidisciplinary team of designers, data scientists, psychologists and sociologists.

The results from this study can be relevant to design practice in earlier stages of the design process than the evaluation of a concept. Ideally a larger contextual research and field study should inform the development of the intervention, which is informed by the initial design brief or target behaviour. In such an interview behavioural laddering can be used to inform questions that aim to understand behaviour at varying levels abstraction. This can support in identifying people's values well before the conceptualisation of a design intervention. This way elements that may lead to reduced effectiveness can be anticipated and even prevented from emerging during use.

We believe that one vital element for this is the discussion of a concept in terms of its manifestation of design. Although true manifestation-independent design is likely to remain an academic exercise, being more explicit in why a certain manifestation of design is chosen can help to argue for the appropriateness and thus effectiveness of the intervention. Further work is required to turn the properties of fit into something that can be used in practice in order to critically examine the manifestation of design.

Second, the study shows a way to perform remote user studies that go beyond a normal momentary use-evaluations. Due to circumstances we were forced to perform the majority of the study remotely, which as a result made the study more realistic given that in practice it is also not possible to visit a participant several times. If tools for design experimentation would be developed further they could be sent to participants for true remote user testing without the need for visiting the participant—although we stress the value of seeing a participant at least once during a study.

Scale of time

For the remaining concrete applications of the elements in this study we differentiate between three time scales[1] of experiments, *momentary* experiments spanning a few hours or days, *medium length* experiments spanning

a few days to weeks like the study in the work present, and *longitudinal* experiments that take several weeks or months.

No matter the duration of the study, all experiments should try to anticipate the effectiveness through assessing the performance in effectiveness and appropriateness of the intervention. The longer the experiment takes the more rich and valid the results will be, and the more likely the results and conclusions are to reflect the actual performance of the intervention.

For *momentary* experiments the value of this work can lie in complementing the evaluation with the protocols in this study for assessing the appropriateness of the intervention.

Medium length studies (such as the one presented in this work) benefit from the introduction of multiple perspectives on the situation, for instance through experience sampling or performing several reflective interviews during the experiment. Here some form of control inspired by a single-case design can be introduced, as even when there are no measurements performed participants can relate to what happens when the intervention is removed. In such a study it also makes sense to study both qualitatively and quantitatively whether the mechanism is induced in the situation.

Although a *longitudinal* (sensor) data perspective has the potential to greatly improve the evaluation of design ideas, the present study also shows that there is limited value when using such a perspective in relatively short studies. It will give qualitative insight, but for statistical analysis it will simply be too short. Hence we only suggest doing that kind of experimentation in studies that are of a longitudinal nature, spanning several weeks or months.

Apart from the concrete applications as presented before, the work could nurture some changes in the mindset of design practice which could be beneficial to the development of the field. To conclude this section we will discuss several of these larger implications.

Data as a design material

Even though (sensor) data could provide benefits to the evaluation of social and behavioural design, we see a potential divide to be bridged. Fields like social and behavioural design are quite disparate from fields like data science and human computer interaction design, as they consequently attract different types of professionals[2]. Many interventions aimed at behaviour change even intentionally seem to avoid the use of technology given that it is a material that the behavioural and social designer is unfamiliar with, yet the work present also shows that both fields can benefit from each other.

First, although the two concepts in this work were of a technological nature, we also see value for the evaluation of non-technological interventions in a similar way. Here a toolkit similar to how we instrumented other things in the situation could also be applied to instrument the intervention itself.

Second we hope that by turning sensor data into design material through the use of data worksheets we bridge the divide with designers who have a non-technical background. Much like acting machine diagrams allow to design the interactive behaviour of a prototype without writing a line of code (van der Helm et al., 2015), the data worksheets allow to introspect the data in a way that does not require full understanding of the mechanics behind collecting such types of data. Previous work suggest that even when giving laymen the raw sensor data in graphs they are able to (collectively)

interpret it (Fischer et al., 2017; Kurze et al., 2020), thus through the extra interpretations performed that should even be eased more. Additionally, formats like data worksheets may also help to communicate between disciplines (e.g. between a data scientist collecting the data and a designer performing the research).

Empirical learning

By taking elements from science, the present work has the potential to nurture a 'research through design' mindset within the practice of design while at the same time increasing knowledge dissemination. Design practice is still largely centered around empathy where 'walking the walk' is an inevitable part of the design process, inherently leading to many 'reinvented wheels'. Although behaviours are complex and contextual and require mapping for each new intervention (Cash et al., 2017; Dolan et al., 2010; Fogg, 2009), that does not imply starting from the zero at the beginning of every project. Although benchmarking is part of many design practices process, learning from the 'success'-stories on other agencies website often gives a distorted view of best practices given that failures often do not end up there. Ideally we would foresee a shift from empathic to an empirical mindset, where designers build on the work of others instead of reinventing the wheel by all going through the same contextual research and development of interventions. Through documenting the experimental outcomes in a format that can be shared across the social and behavioural design community, others can learn from what works and what does not.

An additional benefit of this that it can fuel the exchange of knowledge with the behavioural and medical sciences, by demonstrating the value that design can have in the production of scientific knowledge and assuring a place at the table when it concerns the further development of the field of behaviour change (Hermsen, 2019).

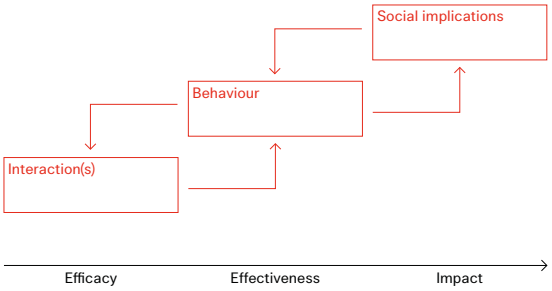

Fig. 46 Model based on Tromp (2013) showing the the ability to reason back to the likely impact that the intervention will have

Creating impact

In the end the goal of design for behaviour change is to effectuate change, not only on an individual level but also on a societal level. A designers motivation to design is not to develop effective design interventions per se but to create impact and change in the social world. And here it is important to note that we cannot equate effectiveness to impact. In Fig. 46 we appropriated the model by Tromp (2013) that explains how behaviour links the social world an the user's interaction by putting them on a temporal scale and relating them to the proposed terms efficacy, effectiveness and impact.

Although this is slightly oversimplifying things, we could see the efficacy of the intervention as whether the desired interactions are induced. When those are maintained over a longer period as a stable attachment to the intervention is formed the behaviour is changed and the intervention is effective. The impact of the intervention then is the relation between the changed behaviour and the collective concerns that are addressed. For instance, although an intervention may be very effective at shortening shower durations, the impact created is relatively low as it has a limited effect on the ecological footprint.

Ideally a design project starts at the social implications and reasons back to the interactions that has to be changed through an intervention. Consequently, through assessing the effectiveness of an intervention in a design experiment we can reason the other way around and then anticipate the impact that the intervention will create given the results of the experiment in terms of the interventions benefits and limitations.

Driving implementation

A conditional aspect for creating impact is that the design intervention is implemented in the first place. The problems that social and behavioural design tackles are of a complex, open, dynamic and networked nature (Dorst, 2015). This alters the traditional client-designer relationship significantly—as tackling those problems may involve multiple stakeholders, each with different backgrounds such as for instance (semi-)public organisations. Interventions may not even be the result of a design brief as delivered by a client, but can also be self-initiated by design studios or developed in an innovation lab.

As a result the road to implementation of these design interventions is substantially more uncertain, especially when it concerns funding next steps.

For instance, there may be enough resources to develop a proof-of-concept in an innovation lab but in order to scale up additional funds need to be recruited through subsidies and grant applications. Similarly, a municipality may be willing to do a pilot test, yet for a wider implementation it would need to convince the city council to reserve budget. Hence we often observe a series of consecutive pilot tests being performed that each hope to result in continuation of the project.

Thus the results of an evaluation often need to have enough convincing power to persuade stakeholders to take the next step. Here we can make use of the dual intention to learn something from the experiment. Experiments can contribute to epistemic learning and political learning (Ansell & Bartenberger, 2016).

Epistemic learning is the type of learning that we have been most concerned with in this study, as it is the knowledge that improves our understanding of the natural and the social world. Political learning is the learning that leads stakeholders in the process to alter their preferences, goals, frames and commitments. It is important to note that not all stakeholders will have to learn the same thing. Rather, the learning is relative to one's own set of perspectives, attitudes, interests and concerns (Ansell & Bartenberger, 2016).

By increasing the variety of different sources of data on which decisions are based it is more likely that there is something for everyone to learn, and can help to unite stakeholders behind making the next move and subsidise the following episode in the road to implementation. This is in line with findings from (Cash et al., 2017) who suggest that successful behavioural design projects—a combination of 'Was the project process successful for the team' and 'Has the project customer used your recommendations/ implement your interventions?'—combined qualitative and quantitative data in the field study.

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1 The absolute length in time is largely dependent on the behaviour at consideration. For instance, with sleep behaviour the actual occurrence of the behaviour is once per day resulting in significantly longer experiment durations than when developing an intervention for hand washing.

2 Although there are great examples where they do work together well, such as in the innovation lab Garage2020 where multidisciplinary teams are composed of designers, healthcare professionals and data scientists.

Future research and development

In the previous section we already indicated several times the need for further studies and development. Hence we will provide an account of what would be the most promising directions for future research. Additionally we will provide with some directions supporting and facilitating the development of tools for design experimentation.

Directions for future research

In line with a wider call for more theory development in design research (Cash, 2018; Cash, 2020), we also see opportunity supporting the theoretical foundations of design for behaviour change. In this work we explored, and developed an initial model that has potential to be developed into something that can further the theoretical foundations of design for behaviour change.

As a first step the relation between effectiveness and appropriateness needs further experimental testing. For understanding the appropriateness of an intervention one could think of a study that compares the result of the protocol as used in this study and the results of an expert-based assessment (i.e. Delphi method or narrative-based study (Tromp & Hekkert, 2016)).

For empirically testing the relationships between efficacy, effectiveness and appropriateness a possible direction could be to design a longitudinal study consisting of two phases where first a concept is evaluated in a similar manner as this study. After improving the design based on the elements that surfaced during the first evaluation, it is then evaluated again and compared to the initial design.

Another element for further inquiry is the contributions of the individual types to the overall appropriateness of an intervention. An important element here is how the concept (in)appropriateness can be represented: is it something that is greater than the sum-of-its-parts, a tolerance level that when exceeded by many individual elements results in attrition, or small faults in the intervention that all individually could 'break' in time?

In this work we identified that the interesting situation may arise where through the process of reframing the designed behaviour may be completely different from the behaviour that was the entry point into the design process. This could prove interesting ground for future research to investigate how designers can gain insight into the relations, and the respective intensity of the relationships between behaviours. In line with this understanding the role that different levels of specificity can play could be investigated further. A special point of attention here is the formulation of measurable dependent variables and indicators, while at the same time keeping enough feeling with the extended situation.

We identified a relation between the manifestation of design and the overall appropriateness of the intervention. However, we also conceded that in the case of this study by keeping the mechanism the same in terms of its strategy the two concepts diverged too much to draw conclusions based on these results. Thus further experimental testing would be required to fully understand the relation between the manifestation of design and the appropriateness of an intervention. An experimental design for understanding

the role that the manifestation of design plays in relation to the appropriateness of an intervention would require a higher degree 'mirroring' between the manifestations of design, by for instance keeping the style of the intervention constant as well. Taking the concepts from this study, we could see a design where the interactive bed lights is compared to a mobile phone application that also acts as a wakeup light (such as for instance the Google sunrise alarm in Fig. 20 on page 47); or the chatbot application is compared to for instance a smart home speaker that both act as a bedtime coach.

Additionally, the interplay during the conceptualisation of interventions between strategy, style, mechanism and manifestation of design, especially in relation to the use of theory, could be another interesting avenue for further study.

Cash et al. (2017) describe a multi-case study of a Danish design studio who use the data gathered data during field work to establish a baseline to which interventions could be compared to later on in the process. It would be interesting to explore how such an approach would relate to this work and other related work. For instance, could data from qualitative studies in the front-end of design, such as in Giaccardi and Nicenboim (2018), be used to evaluate the effects of things later in the process? Additionally, another interesting direction for research could be to understand how we can qualitatively verify that quantitative measures describe the behaviour completely, so that in follow-up studies only measuring quantitatively can be sufficient to evaluate the intervention.

Directions for tool development

It would be an understatement to say that the infrastructure and tools used in this work for gathering and processing data were less than optimal. Hence we will provide with some directions for the development of a tool for design experimentation.

Adding more perspectives on the situation has one giant implication: it requires equally more work to process that data. The majority of time spent during the analysis of the data was on turning the data into information. That was partly because we had to devise the data worksheets, but it was also due to for instance transcribing interviews. Therefore we see the potential for data infrastructure that can help in this refactoring process.

In line with that, the process of annotating the data worksheets felt very similar to coding an interview, yet even more 'machine'-like as heuristics emerged that helped in identifying patterns for activities. This suggest that a large part of this work has the potential to be automated, either through employing a rule-based system (where the designer explicates the heuristics for coding as rules for the machine to complete) or through using machine learning (where the designer codes a small part of the worksheets which serves an input for the patterns that the machine will use to complete the rest). The use of machine learning could also be interesting for uncovering patterns that were not attainable initially to human perception (Giaccardi & Nicenboim, 2018). This could potentially fuel new human-machine tools in design research and establish new modes of cooperations between human and machine while doing research.

The data worksheets could made even richer by including data from other sources, such as for instance the temperature and weather during that day (which can for instance explain strange peaks in sound when a window is likely to be open).

In terms of the probes we see potential for sensor that are more general-purpose than the ones that were used in this study. Although they were flexible and modular, often the same configuration was used. It would be

interesting to explore how general-purpose sensors can be combined with specific-purpose sensors (such as a sleep sensor placed under the mattress in the case of our study).

The probes need to be more reliable, as in this study there were too many questions on the actual validity of the data. Edge computing could help to process data on device using filtering algorithms or other means to already improve the quality of the data before it is sent to the database. At the same time an important limitation to an effective tool is battery-life, so the right balance needs to be found here.

Conclusion

In order to tackle the global crises that humanity faces, larger systemic changes will have to co-exist with concrete interventions that shape behaviour and alter our lifestyles significantly.

Social and behavioural design call for sound and deliberate design and evaluation. It requires designers to take responsibility for the effect and consequences of their designs. Designs that do not live up to their promises can nurture false beliefs that people are doing good, or could (potentially) do more harm than they do good. 'Move fast and break things' is something that is simply unacceptable when it concerns design that explicitly aims to alter human behaviour. Instead we require controlled spaces for experimentation where designers structurally and continuously assess the performance of their work.

This study investigated how integrating various sources of qualitative and quantitative data on a behavioural situation contributes to critically assessing and anticipating the effectiveness and appropriateness of an intervention aimed at changing behaviour. By collecting data from a variety of perspectives we were able to gain insight into the efficacy of the intervention in changing behaviour, and assess the appropriateness of the intervention in relation to the design and extended situation of the behaviour at consideration.

A data-informed design experiment is an experiment where various sources of knowledge are integrated in order to critically examine the merits and limits of a design intervention. *Data-informed* here does not imply the use of sensor or other time-series data only, but a variety of sources that span factors like longitudinal and momentary impressions of the situation, interpretations of the situation from people and things, and objective observations and subjective inquiries in values. Data is meant to inform the design process in order to assess how the mechanism in the intervention performs, to decide what the right level of persuasive influence of the intervention is and assess whether the intervention is proportionate. Thereby it both provides insight into the performance of the intervention as-is, and potential avenues for improvement.

Instead of introducing behavioural cocktails or Swiss Army knives we can structurally assess what elements need to added, removed, changed or repaired for the intervention to be more effective. Second by relating the intervention to the extended situation we can also determine where the limits of this intervention lies and where another intervention or even systemic change is required.

When we assess design interventions in such a way we can more clearly describe what works for whom, or what doesn't. This has the potential to nurture a culture where designers build on their previous work and the work of others. If we truly want to design a world that affords to doing the *right* thing then we will have to employ all our resources to do that effectively instead of constantly reinventing the wheel.

Personal reflections

So this is it (ja nu echt). More than a year after the first ideas started emerge I finished my graduation project. I knew it was going to be quite the rollercoaster, but some things that you will encounter along the way you will never be able to predict.

Apart from the challenge and complexity of the project, this project also was my first step in the transition from designer to researcher. Executing a research project forced me to 'shed' some of my designer 'feathers', which proved to be more challenging than I anticipated. Where designers iterate by moving quickly, researchers iterate by making many steps at the same place. The work is propelled forward by doing iterations on the very small step that you are making, making the step smaller and smaller in each iteration. Not making big rough leaps forward but rather small steps on the same place was a completely different mindset.

For a significant part of this project it felt like I did not make any progress, while in fact there was more progress than I could see. In the end I can say that I particularly enjoyed turning the overly activist opinions that stood at the cradle of this project into a research setup and results that are way more nuanced and considerate. Although the process and results of the project are by no means what I expected, I consider them to be way more relevant and interesting than what was my initial.

The past months definitely were quite lonely, especially when most of the time there is not really someone one around to discuss the process of research with as equals. Although I can enjoy solitude, even this was too extreme for my tastes. When alone, it is hard to see what exactly is a comparable baseline, especially when you are constantly drawing on work from scholars have years of experience in doing research while I'm just new to the game. It also made it hard to focus on what was essential, and when enough is enough instead going all in for every part of the research.

Setting up a research project as a mini-PhD with a topic that definitely has the potential to be a full PhD might have been a little too ambitious and definitely pressed me on the fact that prioritising, focusing, dealing with uncertainty and making choices are not my strongest developed skills. Then increasing the complexity by juggling multiple roles in a project at the same time did not make that better. However, this has taught me valuable lessons and if I were to start a PhD at least I have already some insights on how not to approach it. And despite the process, navigating such complexity might just be the work that I enjoy doing most.

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Image credits

Fig. 6: Afdeling Buitengewone Zaken, retrieved from https://afdelingbuitengewonezaken.nl/project/social-service-design-eenzaamheid-ouderen-sor?_locale=nl

Fig. 7: Dijksterhuis & van Baaren/Design Innovation Group, retrieved from https://vangbuitenshuis.nl/@221082/slag-gedrag-betere-pmd-afvalscheiding-bedrijf/

Fig. 9: Rijnmond, retrieved from https://www.rijnmond.nl/nieuws/177772/Meer-gepimpte-vuilcontainers-in-Rotterdam

Fig. 10: Room for concepts, retrieved from https://roomforconcepts.com/citygard/

Fig. 11: The wub (CC BY-SA 4.0), retrieved from https://commons.wikimedia.org/w/index.php?curid=44690318

Fig. 12: Superflux, retrieved from https://superflux.in/index.php/work/uninvited-guests/#

Fig. 13: Shinya Suzuki (CC BY-ND 2.0), retrieved from https://www.flickr.com/photos/shinyasuzuki/17443550596

Fig. 17: Sleep Cycle, retrieved from https://www.sleepcycle.com/how-sleep-cycle-works/

Fig. 18: Casper, retrieved from https://venturebeat.com/2016/09/22/why-mattress-startup-casper-built-a-chatbot-for-night-owls/

Fig. 19: Casper, retrieved from https://casper.com/uk/en/press/#

Fig. 20: Google/Emily Suvanej, retrieved from https://www.housebeautiful.com/shopping/home-gadgets/a24271934/google-pixel-3-stand-review/

Image credits for the examples in the typology of behavioural design interventions are listed in appendix II.

All other images by the author

Appendices

Approved project brief

3812

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: van Arkel
initials: T given name: Thomas
student number: 4275411
street & no.:
zipcode & city:
country:
phone:
email: me@thomasvanarkel.nl

Your master programme (only select the options that apply to you):

IDE master(s): ( ) IPD (★) DfI ( ) SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ( ) Medisign ( ) Tech. in Sustainable Design ( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Nynke Tromp dept. / section: ID/DA
** mentor: Elisa Giaccardi dept. / section: ID/HICD
2nd mentor:
organisation:
city: country:
comments (optional):

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF
To be filled in by the chair of the supervisory team.

chair Nynke Tromp date 18 - 11 - 2019 signature

CHECK STUDY PROGRESS
To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 42 EC
Of which, taking the conditional requirements into account, can be part of the exam programme 30 EC
List of electives obtained before the third semester without approval of the BoE

✓ YES all 1st year master courses passed
NO missing 1st year master courses are:

name D. Schipper date 20-12-'19 signature

FORMAL APPROVAL GRADUATION PROJECT
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ✓ APPROVED NOT APPROVED
Procedure: ✓ APPROVED NOT APPROVED

- project brief has been submitted late

comments

name Mv Morgen date 21-1-2020 signature

Initials & Name T van Arkel Student number 4275411
Title of Project Data-informed design for behaviour change

Data-informed design for behaviour change — project title

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

start date 18 - 11 - 2019 — 21 - 05 - 2020 end date

INTRODUCTION **

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

Coinciding with our increased understanding of the impact of products on people, society and our planet, numerous tools, methods, frameworks and techniques were developed that support designers in designing an intended social or environmental effect such as design for emotion, design for behavioural change and design for wellbeing—or so called methods for effect-driven design (Fokkinga, Hekkert, Desmet, & Özcan, 2014).

An integral part of effect-driven design is to assess the impact of a designed intervention. When designers are explicit and intentional in the effect that they want to achieve, it is essential that they evaluate such interventions on effectiveness and appropriateness. Some of the current strategies for performing such an assessment are through the use of a narrative-based study, a pilot study or an experiment (Tromp & Hekkert, 2019). Yet more commonly in practice design ideas are validated by employing user tests in which (prototypes of) a product or service are used to elicit user response.

Advances in the domain of computing increase the availability of data, the variety of different sources and present new opportunities for designers to gather data while doing user research—which could help to support design experimentation in practice. Examples of this integration and use of data in doing research for design are a set of tools that can be deployed as digital probes (Boucher et al., 2019), widgets that can be used while co-creating smart products (Verweij, Kirk, Rogage, & Durrant, 2019), data-collecting prototypes for doing design enquiry (Bogers, Frens, van Kollenburg, Deckers, & Hummels, 2016) or by outfitting everyday objects with cameras and sensors in order for them to act as co-ethnographers (Giaccardi, Cila, Speed, & Caldwell, 2016) (Giaccardi & Nicenboim, 2018). These show the value data can have in the design process, especially in the (re)framing of design problems and situations in the front-end of the design process. However, in the evaluation of design ideas the use of data has not yet really been applied to aid designers in learning about the effect of ideas and steer their course of action. A mindset required for such an approach while doing research is reflected in the last example. By including the knowledge and behaviour of nonhuman entities, it posits a view that aims to enhance, complicate and even challenge our initial human-centered beliefs (Giaccardi, 2020).

Integrating such a perspective should come naturally to the designer. In their work designers integrate various—often conflicting or contradictory— perspectives into a design solution so they can gain a holistic overview over the situation (Dorst, 2006; Tromp & Hekkert, 2010). However, similar to the inclusion of scientific knowledge, in order to fully grasp and assess the value of a perspective in order to integrate it requires a good understanding of and experience with handling such perspectives. Interpreting data will likely make an appeal to different and/or potentially underdeveloped skills of the designer which could hinder efficacious inclusion of such a perspective and could even hinder the creative capacity of a designer to come up with innovative solutions. Thus dealing with such a perspective needs further inquiry.

A data-informed experimental design approach has to potential to bridge the approaches of theoretical designers and practical designers, and nurture an academic way of working in design, but how can designers be supported in such practice?

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: Examples of research projects which explore the use of data in the design process.

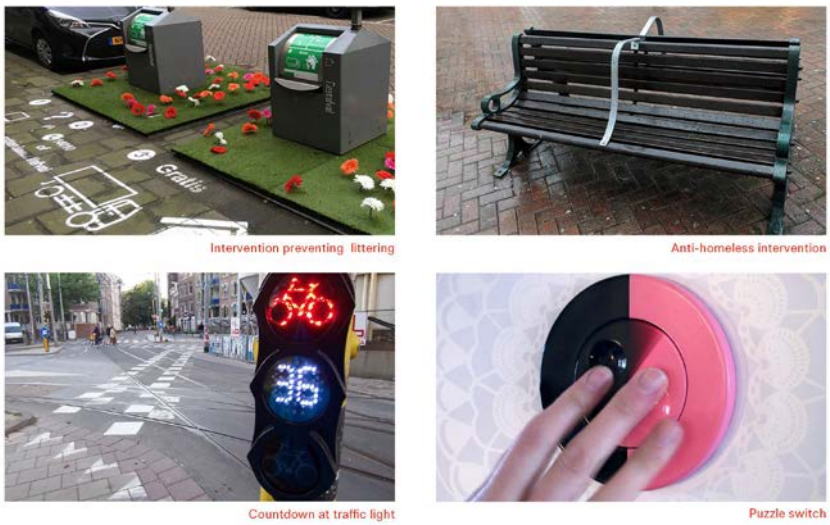


image / figure 2: Examples of designs for behaviour change

PROBLEM DEFINITION **

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

The project will focus on design for behaviour change, a specific type of design for effect. Here data could potentially serve well in order to enhance or challenge the perspectives gained through a traditional user-centered approach. The project will focus on using data to gain insight into the effectiveness and the appropriateness of a design idea. Here effectiveness is the measure to what extent a design idea achieves the intended effect, and appropriateness is the appraisal of the means to achieve that effect (which includes for example the consolidation of the effect and the ethical dimension of a design idea).

The contribution of the project will mainly be in three domains, the context of design for behaviour change, the interaction between designers and data and the technology for facilitating design experimentation.
The main aim of the research is to investigate the inclusion of data during the evaluation of design ideas on their respective effectiveness and appropriateness. Driving the research is the following design goal:
DG: How can behavioural designers be supported in collecting and harnessing data within the design process in order for them to critically evaluate design ideas on their respective effectiveness and appropriateness.

Derived from this design goal is the following research question:
RQ: How can a data-informed perspective improve the evaluation of design ideas?
This research question is supported by the following subquestions:
RQa: What are the critical conditions for setting up a successful data-informed study?
RQb: How does a data perspective relate to other sources of knowledge in design?
RQc: What are the critical barriers and opportunities for the inclusion of a data-informed perspective in the design process?

ASSIGNMENT **

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

The aim of the graduation project is to investigate the inclusion of a data during the evaluation of design ideas on their respective effectiveness and appropriateness. The obtained knowledge will be embodied in a (sketch/prototype of a) tool that supports designers in doing design experimentation.

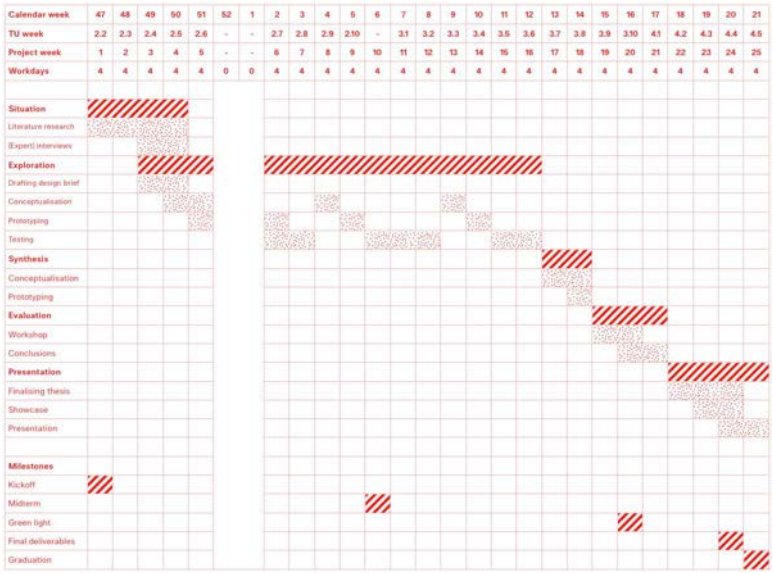
The project will adopt a research through design approach (Stappers & Giaccardi, 2017). For a design brief in a specific application context a series of design interventions will be developed. Through the process of attaching sensors to the design intervention (which is not necessarily has sensing capabilities itself) and other relevant things in the context—access is gained to the respective data worlds of those things. Through visualisation and analysis of the data we hope to be able to gain insight to some extent into the effectiveness and appropriateness of the design intervention—concurrently with knowledge concerning the research questions and directives for the future tool. Here the main goal is to find ways to minimise the effort needed for design professionals to maximise their learnings.

Those insights will be embodied into a design tool in order to convey the research results to design professionals. Another outcome of the project will be—building upon the gained understanding on the inclusion of data in the evaluation of design ideas—hypotheses and directions for future research. If the results are suitable for publication, the results could potentially be turned into a research paper.

PLANNING AND APPROACH **

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

start date 18 - 11 - 2019 21 - 5 - 2020 end date



Phase 1: Situation
The first phase is meant to situate the research and determine the direction for the RtD phase of the project. Literature will be reviewed for the definition of the key terms used within the project such as effectiveness and appropriateness. Next to that an overview of different of different strategies and approaches in design for behaviour change and design evaluation will be made through expert interviews and interviews with design professionals, in order to determine the approach for the RtD phase of the project. Finally this phase gives the directives for drafting the fictitious design brief used in the RtD phase of the project.
Phase 2: Explorations
The project will adopt a research through design (Stappers & Giaccardi, 2017) approach. Based on a fictitious design brief a design for behaviour change will be evaluated. Through a series of design explorations new knowledge is obtained, which will incrementally help to build on the design of the final tool. During this phase interviews with experts and design practitioners will be used to corroborate findings with design practice.
Phase 3: Synthesis and Phase 4: evaluation
The obtained knowledge will be synthesised into a (sketch/prototype of a future) tool for doing design experimentation. The fidelity and manifestation of this tool is dependent on the findings of the exploratory phase of the project.
Afterwards this tool will be used as a vehicle to convey the research results during an evaluation workshop with designers in order to reflect on findings.
Phase 5: Presentation
The project is concluded with the writing of a thesis, delivery of a presentation and potentially—depending on the results—a paper.

MOTIVATION AND PERSONAL AMBITIONS

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

My main motivation to set up the project as outlined above is to deepen my design research skills. During the MSc programme I have taken a research elective in which further developed a research proposal in collaboration with Nynke Tromp and Jaap Daalhuizen (DTU). Given the fact that I want to explore whether a future academic career (i.e. do a PhD after my graduation) would suit me, combined with the fact that this research project wasn't 'mine' from the beginning, I want to plan and execute a full design research project which at the same time reflects my skillset as a designer. Thus the primary focus of this project is doing research as opposed to doing design. My main personal goal is to improve the research skills required to undertake such a project, such as literature review and academic writing. At the same time I also feel that the graduation project should reflect my design skills, hence the choice for a research through design approach.

My second personal ambition is to combine and balance academic research activities with design and engineering activities. That is why the project will likely involve prototyping with hardware and electronics. Next to that I want to gain more experience with collecting and analysing data.

Finally another personal ambition for this graduation project is to manage it in such a way that a healthy balance between work/life is maintained. Throughout my studies this has always been an issue and I think that the graduation project is the right occasion to be mindful of this.

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FINAL COMMENTS

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

Examples of behavioural design interventions

This appendix provides descriptions for the examples featured in the typology of behavioural design interventions in Fig. 8 on page 26. First a description of the example is given, followed by an explanation for its placement within the typology.

Debt collection letter

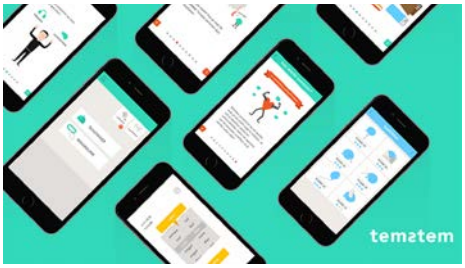
[Manifestation type/communication]

A redesigned letter for the municipality Enschede that aims to increase the amount of debts being repaid.
By applying knowledge from behavioural economics in a visual *communication* the concept aims to nudge people into paying their debts by communicating the information clearer.
Image credit: Duwtje, image retrieved from `https://duwtje.com/project-enschede-2/`

Casper Glow

[Manifestation type/product]

An interactive bed lamp that aims to let people wind down before going to sleep.
Image credit: Casper, image retrieved from `https://casper.com/uk/en/press/#`



Temstem

[Manifestation type/app]

A smartphone application for people who hear voices and are obstructed by them in their daily activities
Image credit: Reframing Studio, image retrieved from `https://www.reframingstudio.com/projects/temstem`

Greenwheels

[Manifestation type/service]

A service that aims to have people trade in their car for a car that can be used when they need it, thereby sharing it with other people.

Image credit: Greenwheels, image retrieved from https://www.greenwheels.com/nl/

Donor campaign

[Manifestation type/campaign]

A campaign that aims to increase the number of organ donors

Image credit: image retrieved from https://duurzaamheidskompas.nl/blogs/donor-janee/

Kennismakingsdiner Startpakket

[Manifestation type/infrastructure]

Kennismakingsdiner Startpakket is a toolkit developed by Afdeling Buitengewone Zaken that allows caretakers of residential buildings for elderly people to organise a 'welcome dinner'.

The kit as such provides the infrastructure to organise a dinner where elderly meet their neighbours and discover common ground, which eventually aims to increase feelings of connectedness and reduce feelings of solitude.

Image credit: Afdeling Buitengewone Zaken, image retrieved from https://afdelingbuitengewonezaken.nl/project/social-service-design-eenzaamheid-ouderen-sor?_locale=nl

Speedlimits

[Manifestation type/policy]

Setting a speed limit—and enforcing them respectively—changes people behaviour while driving.

This is an example of an intervention that manifests itself as a policy—as those in a way are also being given form to. Other policies for behaviour change are for example subsidies and excise duties.

Image credit: Frank van Beek, image retrieved from https://frankvanbeek.nl/News/26

Footsteps

[Manifestation level/part]

Painted or stickered footsteps around a garbage bin nudge people in putting their garbage in the bin instead of dropping it on the ground.

The intervention manifests itself on a part of a larger artefact by placing visual cues in the built environment surrounding the garbage bin.

Image credit: image retrieved from https://stadslab2050.be/het-lerend-lab/wat-doet-een-stadslab/nudging-de-kunst-van-het-slimme-duwtje

Miito

[Manifestation level/product]

Miito is a water cooker that can only boil water in a single cup, thereby limiting the amount of unnecessary water heated.

In this intervention the entire product contributes to the change in behaviour.

Image credit: Miito, image retrieved from https://www.kickstarter.com/projects/747044530/miito-the-sustainable-alternative-to-the-electric

WastedLab

[Manifestation level/system]

This is a system that introduces a virtual currency related to the amount of plastic you hand in. This currency can be spent at local shops, trading it for reductions.

Here multiple elements are introduced at a system level, including but not limited to the currency, the bags and the relation with local entrepreneurs.

Image credit: WastedLab, image retrieved from https://de.smart-magazine.com/wasted-recycling-rabatte/wasted-lab-amsterdam-2/

Bedtime

[Moment of intervention/antecedent]

A smartphone application that reminds you to go to bed at a certain predefined time.

By reminding you of your bed time, it acts before the actual behaviour occurs.

Image credit: Apple, image retrieved from https://support.apple.com/en-us/HT208655

10S Fork

[Moment of intervention/behaviour]

A fork that sends out haptic feedback whenever you are eating too fast.

This thing intervenes in the moment that the behaviour occurs

Image credit: Slow Control, image retrieved from https://www.touchofmodern.com/sales/10sfork-by-slow-control/10s-fork-black?open=1

Energy AWARE Clock

[Moment of intervention/consequence]

A clock that visualises the energy consumption of the household.

This intervention shows the effects of the behaviour, thereby aiming to change the behaviour by reporting on that.

Image credit: Loove Broms, image retrieved from https://www.loove.org/Energy-AWARE-Clock

Camden bench

[Intervention influence type/decisive]

A piece of street furniture that is designed to only allow sitting, limiting all other types of interactions such as skateboarding, sleeping, drug dealing and other criminal activities.

Image credit: The wub (CC BY-SA 4.0), image retrieved from https://commons.wikimedia.org/w/index.php?curid=44690318

Safe to bike

[Intervention influence type/seductive]

Interactive biking light that notifies the user t pay attention when they near a crossroad or other place that is dangerous.

Image credit: Frolic Studio, image retrieved from https://www.frolicstudio.com/portfolio/safetobike/

AWARE Handle

[Intervention influence type/coercive]

A handle for a heating installation that is painful to use when turning up the heat.
By exercising physical pain it coerces the user into doing the right thing (or enduring the pain).
Image credit: Loove Broms, image retrieved from https://www.loove.org/AWARE-Handle

KeyMoment

[Intervention influence type/persuasive]

A key holder that drops your bike key whenever you pick up the car key.
By dropping the other key and you having to pick it up you are persuaded to rethink your decision.
Image credit: Matthias Laschke, image retrieved from http://www.pleasurabletroublemakers.com/#/keymoment-1/

Traffic light

[Intervention strategy/resolve]

An interactive traffic light that shows the amount of time that you still need to wait before a green light.
By being informative about the waiting time it resolves feeling of uncertainty and respective agitation.
Image credit: zebrasprocket, image retrieved from https://www.flickr.com/photos/15235675@N07/1594161273

Wormenhotel

[Intervention strategy/bypass]

A Wormenhotel uses organic waste as a resource for the production of compost.
By reframing waste as a resource an incentive will be created to collect organic waste, thereby bypassing the previous conflicts
Image credit: Stichting Buurtcompost, image retrieved from https://platform.groenkapitaal.nl/initiatief/stichting-buurtcompost/

WWF Paper dispenser

[Intervention strategy/transform]

A paper towel dispenser that shows a visual message about disappearing rain forest.
By transforming long term concerns into short term concerns it addresses overuse of paper towels.
Image credit: World Wildlife Fund, image retrieved from https://www.oneclub.org/awards/theoneshow/-award/7189/wwf-paper-dispenser

Flowerfields

[Point of intervention/behaviour]

A flower bed surrounding a garbage container, limiting the amount of displacements.
The intervention is focused on changing an undesired behaviour, the displacement of waste.
Image credit: RTV Rijnmond, image retrieved from https://www.rijnmond.nl/nieuws/177772/Meer-gepimpte-vuilcontainers-in-Rotterdam

MANGO

[Point of intervention/practice]

A lamp that doubles as a heating element, invalidating the need for centrally heating an entire room (Kuijer, 2017)
Note: the picture used is Soft Light by Simon Frambach, a different concept that provided a better visualisation.
Image credit: Simon Frambach, image retrieved from http://simon-frambach.com

Goedzak

[Point of intervention/system]

A semi-transparent bag that allows people to give away things they do not need, but others might.
Through this intervention behaviours in the entire system are changed, relating to our feelings towards altruism and the concept of waste.
Image credit: Waarmakers, image retrieved from https://www.waarmakers.nl/projects/goedzak

appendix III:

Infrastructure prototyping

As outlined in the study setup an important part of the experiments was the collection and processing of sensor data derived from instrumented things in the situation. For this a custom infrastructure was developed that supported in collecting, processing and visualising the data. First we will examine how behaviour can be operationalised for measurement. Then we will discuss what the repercussions of instrumenting things were on the requirements for the infrastructure. Finally we will describe the process of the development of the infrastructure.

Operationalising behaviour

Behaviour is an action that is performed by a person and thus by definition can be measured (other than for instance emotion which is an internal appraisal of a stimulus (Desmet & Hekkert, 2007)). However, it is not always the case that with existing and accessible methods we are able to measure them objectively. Because our measurement tools lack in accuracy or precision, or because the practice that we are after is too dispersed. And when there is reframing, it is likely that we even have to measure two behaviours.

In order for the analog world to be represented in a digital format you need to leave out details, as it requires abstraction. One way to make behaviour measurable is to specify it further to more concrete behaviours (as we do through specifying behaviour). Another way is to employ a proxy variable. This means that another behaviour is used as a stand-in for the actual behaviour. Both ways demonstrate a top-down approach to handling the behaviour, by going from the abstract behaviour towards more specific behaviours.

We can also do a bottom-up approach, infer from time-series data—through for instance simple arithmetics or machine learning—slowly layering up to the actual abstract behaviour.

An important part of the design experiment process is the formulation of indicators. These are quantifiable measures that can be observed in the situation, and ideally should altogether represent the behaviour in its totality. In this study we will do that by instrumenting several things in the situation, and then use their data to level up to the indicators that are specified.

Instrumenting things

Instrumenting things means to outfit them with sensors in order to gain access to their data worlds. This part will go through several considerations and implications on the infrastructure when instrumenting things.

Sensitisation

The main aim of the instrumentation is to keep the study economical in terms of actual costs, but also in terms of time and effort (for instance, do not collect data that you are not going to use). However there is a fine line here, as sometimes data that does not seem interesting at first could be the key in the eventual evaluation.

A baseline ethnographic study helps in deciding on the specific instrumentation. In order to decide on the instrumentation we need to consider the following hierarchy of question:

1. What do want to learn/what are we looking for?
2. What kind of sensors do we need to get those insights?
3. Where do we need to place them (what things?)
4. Where exactly do we need to place them?

Sensor networks

In order to instrument things a first step was to consider the sensor network architecture for collecting the data. Laput et al. (2017) created a Sensor Utility Taxonomy (Fig. 47) in order to illustrate the landscape of approaches in environmental sensing. Given the use-case in this study it was important to sense many facets, and given the thing perspective it is likely that we will need many sensors. That is why the system chosen approach is to design a distributed sensing system, although we do see potential for general-purpose sensing in the future (where instead of instrumenting individual things a single sensor is placed in a room).

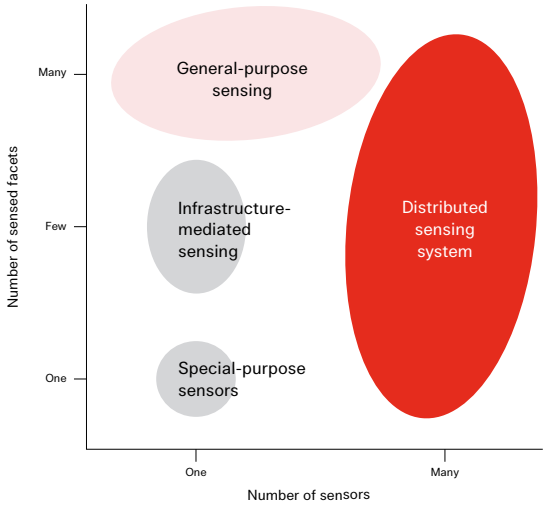


Fig. 47 Sensor Utility Taxonomy, after Laput et al. (2017), showing the major approaches in environmental sensing

Network architecture

An overview of the architecture of the sensor network can be found in Fig. 48. In this overview the probes are the devices that will be placed on the things in order to attain access to their data worlds. Data from the probes is sent to a collector over the local network. This collector stores the data in a local database, and sends the data over the internet to an online database instance. Here the researcher can introspect the data coming from individual sessions. Through key management the collector can only push data to its own database, and not read the data backwards. Only on the side of the researcher can data from both databases be read during the study.

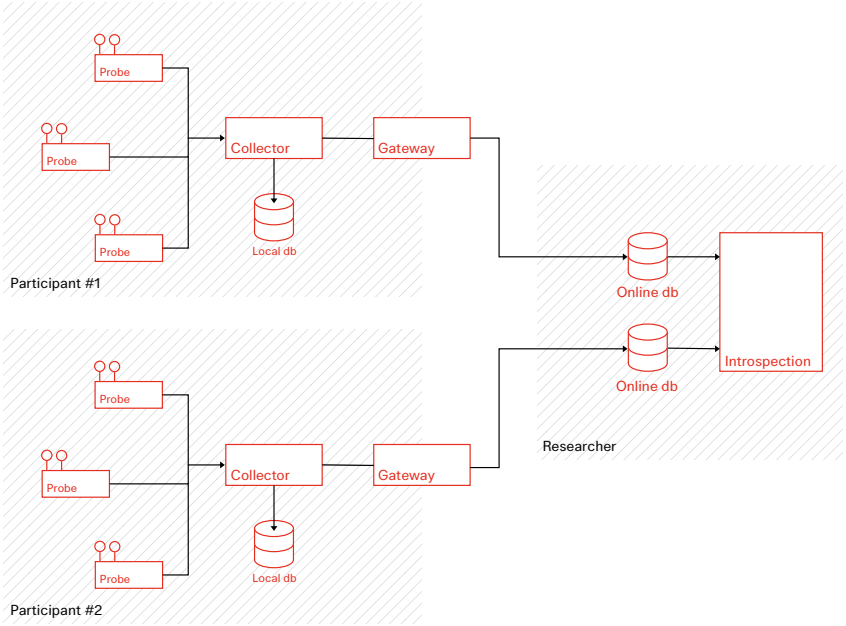
Reading sensors

When reading the sensors there are three ways (Fig. 49) to sample sensors when the goal is to use that sensor data for visual analysis. The predominant approach when measuring continuous variables is by using time-series, where at a set sampling interval the sensor is sampled and a measurement is recorded. This results in evenly-spaced data, where the time between the measurements is similar between each measurement. Another approach could be to record a measurement on a significant value change, which results in unevenly spaced data. This often is a good approach to limit the amount of data that has to be sent over to the server, and makes it easier to navigate the data set. However, if one measurement is accidentally missed then more data is lost than in case of evenly-spaced data. Finally the two approaches can be combined by taking a set amount of sample at a specific interval on a significant value change. This approach is often taken for measuring accelerometers in order to capture many data points only when something is actually happening.

Given that we do not have to be economical in sending data, as we are not powering the probes on battery power anyway, all probes sent their data evenly-spaced.

Processing sensor data

Although we do not have to be economical in terms of battery power, one downside of this approach is that we will end up with an enormous amount of data points. For instance a light sensor that records its value every ten seconds will produce over 180 000 data points in three weeks time. That is why windowing



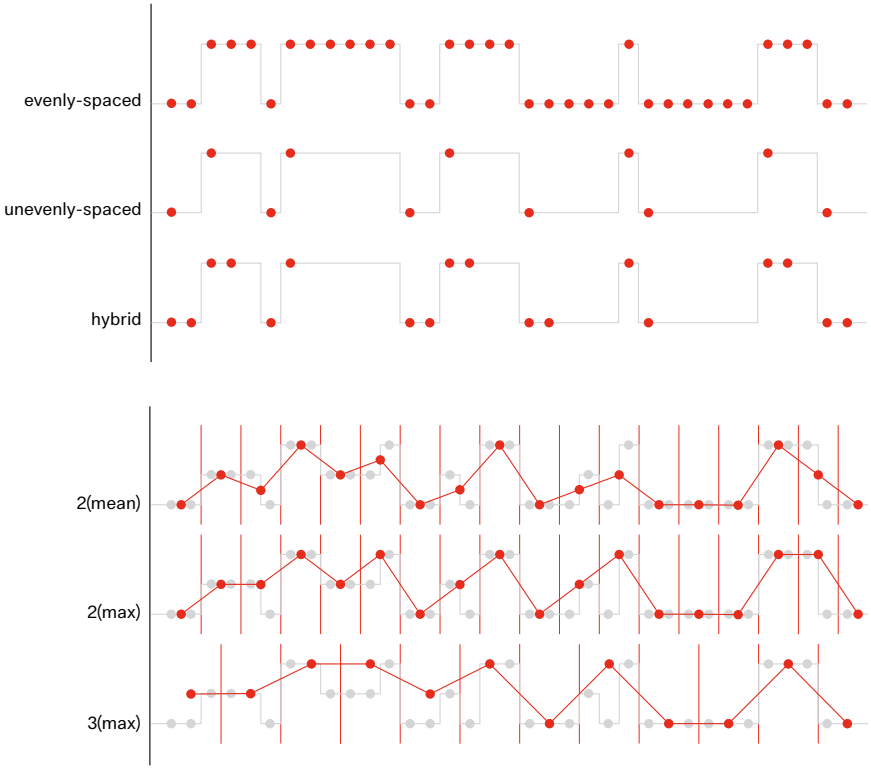


Fig. 48 Overview of the architecture of the infrastructure for collecting thing sensor data

Fig. 49 Graphs showing the different sample methods where grey line shows the phenomenon to be measured, and the red dots denote a measurement (where in the case of hybrid sampling two values are recorded after a significant value change)

Fig. 50 Graphs showing the different windowing and aggregate functions where grey dots show the actual measurement and red dots are the calculated points based on the window and aggregate function

and aggregate functions (Fig. 50) were heavily used in this project. Windowing is the process of calculating transformed values based on dividing the time period into windows of a specified time. Within those windows all data points will be transformed into a single value using an aggregate function, for instance the mean value, the maximum value or the standard deviation. Depending on the activity that we are measuring we can pick the most informative window and aggregate function, for instance sample a motion sensor every 500 milliseconds and take a window of one minute with a maximum value to know whether someone was present in that period.

Prototyping

Based on this architecture and guidelines for sensor sampling a prototype of the probe was developed to collect the thing data. There were two options, develop a custom infrastructure, or make use of existing platforms. Our requirements for the infrastructure were the following:

1 Extensible/modular (we can select sensors depending on the use case)
2 Flexible (sensors can be positioned in different ways; code can easily be changed to tailor to our use case).
3 Microphone for measuring sound levels
4 Economical (using components that were already in the lab)

A board such as the Arduino BLE Sense would have been an interesting candidate for this study, however given that they were not available in large quantities in our lab it was not an economical option. Other boards such as the TI SensorTag, Estimate boards or the Sen.se Mother either missed the microphone, weren't as flexible or all of them were not available in the lab.

That is why in the end we settled for a probe design based around the Arduino Nano 33 IoT, given that we had plenty in the lab. This is not an optimal solution as they need to be connected over WiFi to send data, which as a consequence means that they cannot run on battery power[1] and have to be connected to mains constantly. On the other hand we were able to use a custom PCB shield that allowed to connect Grove sensors to the Arduino board providing with the right level of extensibility and flexibility, as well as the ability to connect an I2S microphone.

For the collector a Raspberry Pi was used, with a USB stick connected for storing the data locally. An overview of the entire kit that was used during the study can be found in Fig. 51.

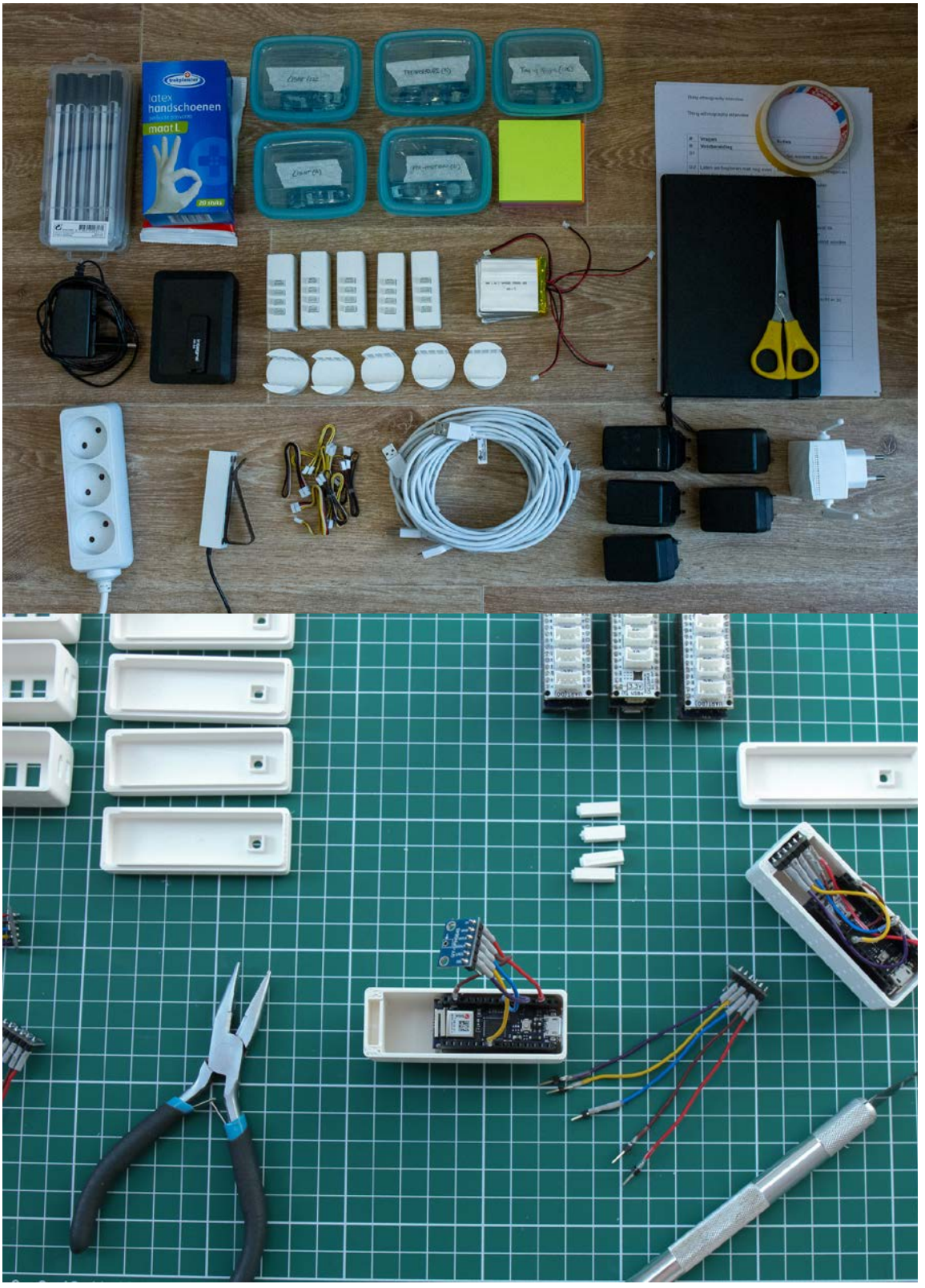


Fig. 51 An overview of all components that were used during the study
Fig. 52 The assembly process of the probes

Information sheet

17.04.2020

This information sheet aims to inform you on the implications of participating in this study in order to be able to give informed consent. If you have any questions on the matters discussed in this document please do not refrain from asking them.

Purpose and procedure of the research

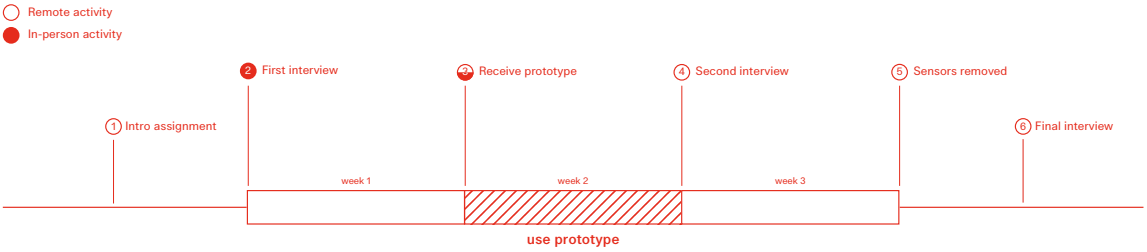
The purpose of this research is to evaluate a design for changing and managing sleep behaviour through the use of a distributed sensor system.
The research spans a period of 21 days in which the sensor system will be deployed. You will receive and use a prototype for the duration of seven days within the aforementioned 21 day period. An overview of the activities performed during the research is shown below. This figure also indicates whether activities will be performed in-person or remotely.

1 An *intro assignment* will be provided to be completed before the first interview.
2 The *first* audio-recorded *interview* will happen in-person. During this interview the sensor boxes will be installed at various locations in your home.
3 After seven days you will *receive* (either in-person or digitally) a *prototype* of the design to be evaluated.
4 After using the prototype for seven days a *second* audio-recorded *interview* will be conducted on your experience with the prototype.
5 After 21 days the *sensor* boxes can be *removed* and returned to the researcher.
6 Some time after completion of the study a *final* audio-recorded *interview* will be conducted to share your experience of the study.

Benefits and risks of participating

Apart from personal gratification and contributing to the project and design science in general, participating in the project offers the following benefits:

The prototypes might help in adopting an improved sleep behaviour which could have positive effects on your general well-being. Next to that using the prototypes and talking about your experience can be generally considered as entertaining activities.



Apart from benefits, participating in this study also comes with several risk which we will address below as well as how we try to mitigate these risks:

Given that we are evaluating an untested design, the prototype might also pose adverse effects on your sleeping behaviour (which has a respective negative effect on your well-being).

The deployment of the sensor boxes may lead to increased feelings of anxiety as they have a physical presence within private places in your home. We try to make the setup of the system as unobtrusive as possible, and your participation can be suspended or terminated at any given moment during the study without providing a reason for doing so.

In this study we make use of prototypes that might malfunction. Upon receiving the prototype the researcher will give you instructions in how to best prevent or deal with these potential issues.

This study will be carried out amid the outbreak of the Covid-19 pandemic. Due to the nature of some of the activities in this research there may be a risk of being exposed to the virus during the execution of those activities. In order to mitigate this risk most of the activities during the study will be performed remotely. In case that is not possible the researcher will adhere to all guidelines from the National Institute for Public Health and the Environment during the visit (i.e. keep a distance of 1.5m, do not shake hands, wash hands with water and soap during the visit, cancel the visit when exhibiting symptoms etc.).

The study will make use of internet-connected devices which have the risk of being compromised during deployment. If this would happen, the researcher can disable (part) of the system. Devices in your home will only have write access to the server and cannot read data from the server. No data that can be tied to you as a person will be stored on device or on the server.

Procedures for withdrawal from the study

At any given moment in time you can withdraw from the study without providing a reason. For the purpose of this study you can suspend your participation for a temporary time, or terminate your participation altogether.

If you wish to suspend your participation temporarily for a single location with an active sensor box:

1 Notify the researcher that you wish to suspend your participation temporarily, and indicate the location that you want suspended
2 The researcher will note the time that you have requested suspension (and thus will not consider data collected after that moment). You can unplug both the power cable as well as the battery cable.
3 If you wish to continue the research at that location, notify the researcher.

If you wish to suspend your participation temporarily for all locations with an active sensor box:

1 Notify the researcher that you wish to suspend your participation temporarily
2 The researcher will note the time that you have requested suspension (and thus will not consider data collected after that moment). The researcher will terminate the data collection remotely (or will give you instructions to do so yourself)
3 Stop using any given prototype
4 If you wish to continue the research, notify the researcher

If you wish to terminate your participation:

1 Notify the researcher that you wish to terminate your participation. You can unplug the data collection point from the power supply, as well as all the sensor boxes.
2 The researcher will note the time that you have requested termination (and thus will not consider data collected after that moment).
3 Stop using any given prototype

Data collection, storage and usage

During the project there are three main types of data collected. *Sensor data* on your activity is collected through various sensors in a sensor box. This data is used to evaluate the design. Each sensor box has a microphone embedded which is **not** used to record audio, but merely to measure the sound level. It is not possible to record audio through these sensor boxes. The sensor data is stored in an online database managed by InfluxData (hosted on an Amazon Web Service (AWS) in Europe). Data will be de-identified upon entry in the database and cannot be linked to you as a person. Only the primary researcher has access to this database, and the data itself will only be shared with members of the research team. During the execution of the study the researcher will be notified by the system on possible system failures, and the researcher might check the data occasionally to see whether everything is operating as expected. The researcher will not actively track or follow your behaviour.

Audio recordings are produced in order to recall parts of the interviews that are carried out during the research. Those recordings will be stored locally. The recordings of the interviews will be transcribed anonymously to text. Only the transcripts will be shared among the research team. Individual quotes from the transcripts may be used in the outputs of the project, but those cannot be linked to you as a person. Remote interviews will be conducted through the use of video conferencing software that uses end-to-end encryption (FaceTime or Skype). Only the audio of these interviews will be stored.

Visual material produced during the study will be anonymised if necessary. Visual material produced during the introduction exercise will be stored on the service provider's server for the duration of the study.

Future use and reuse of information

The main outputs of the project will be a thesis published in the TU Delft repository, a portfolio post on the graduate student's website and potentially a scientific publication.

Sensor data will be retained on the server for up to six months after the completion of the study. Only part of this dataset will be archived and used in the output as mentioned above. Visualisations of those parts of the data will be archived for future use and publication.

Audio recordings will be retained until the end of the study, the anonymised transcripts will be archived in the project's entry in the TU Delft repository.

Visual material will be retained for the output as mentioned above, and for future use and publication. Material produced during the introduction exercise will be removed from the server after the end of the study.

Research team and contact

The research team is composed of Thomas van Arkel (graduate student/researcher) and is supervised by dr. ir. N. Tromp and prof. dr. E. Giaccardi at the Faculty of Industrial Design Engineering, Delft University of Technology.

For any questions regarding the above mentioned, please contact:

Thomas van Arkel
t.vanarkel-1@student.tudelft.nl

appendix V:

Informed consent form

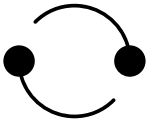
Please tick the appropriate boxes	yes	no
Taking part in the study		
I have read and understood the study information dated 16/04/2020, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
I understand that taking part in the study involves being observed through the use of sensors data, several audio-recorded interviews, using prototypes for a period of time, and that pictures can be taken during the execution of the study. The interviews will be audio recorded and transcribed to text.	☐	☐
Risk associated with participating		
I understand that taking part in the study could involve the following risks: increased anxiety due to placed sensors, discomfort due to prototype failure, and possible exposure to viral infection.	☐	☐
Use of information in the study		
I understand that information I provide will be used for a thesis published in the TU Delft repository, a portfolio post on the graduate student's website and potential scientific publication.	☐	☐
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	☐	☐
I agree that my information can be quoted in research outputs	☐	☐
Future use and reuse of the information by others		
I give permission for visualisations of the data and anonymised transcripts that I provide to be archived in TU Delft repository so it can be used for future research and learning.	☐	☐

Signatures

Participant name	Signature	Date

I have adequately given the participant the opportunity to read the information sheet, and to the best of my ability, ensured that the participant understands to what they are freely consenting.

Researcher name	Signature	Date



Mijn avondritme

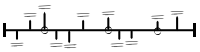
Vul dit boekje in voor het eerste interview. Tip: Sommige opdrachten gaan makkelijker als je ze gedurende een avond doet.

① Maak een tijdlijn met de activiteiten die je gewoonlijk doet tussen het avondeten en het moment dat je in slaap valt.
Tip: Je kan dit gedurende een avond in- en aanvullen

__ : __
Klaar met avondeten

__ : __
In slaap gevallen

voorbeeld



② Omcirkel in de tijdlijn maximaal drie activiteiten die voor jou het meest belangrijk/waardevol zijn.

③ Waarom heb je deze omcirkeld?

1. _____

2. _____

3. _____

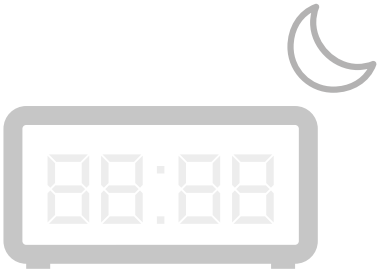
③ Tijdens de activiteiten die je noemt maak je gebruik van veel voorwerpen (groot of klein) in je huis. Plak een blauwe sticker op ieder voorwerp dat je gebruikt tijdens je avond. →

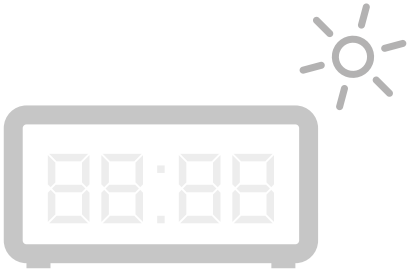
④ Van de voorwerpen die je hebt bestickerd: welke gebruik je het meest consequent? (i.e. welke gebruik je iedere avond)

1. _____
2. _____
3. _____
4. _____
5. _____

⑤ En van de voorwerpen die je hebt bestickerd: welke gebruik je het langst? (i.e. nemen het grootste deel van je avond in beslag)

1. _____
2. _____
3. _____
4. _____
5. _____





⑥ Geef aan hoe laat je gewoonlijk naar bed gaat

⑦ Hoe vaak in de week ga veel later/eerder dan dit tijdstip naar bed?

_____ keer

⑧ Waardoor komt dat?

_____
_____
_____
_____
_____

⑨ Geef aan hoe laat je gewoonlijk opstaat

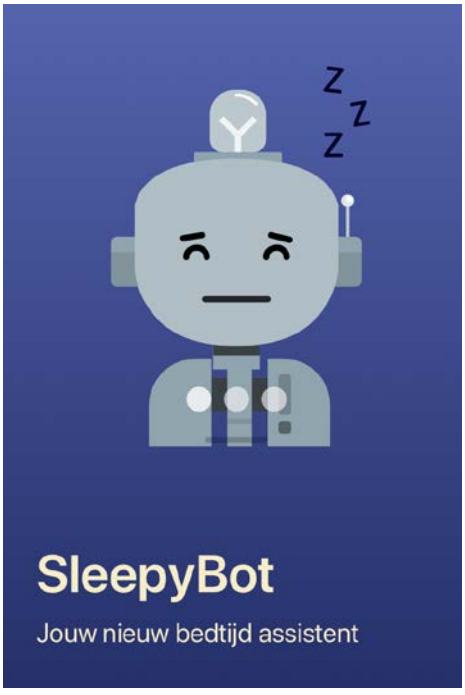
⑩ Hoe vaak in de week sta je veel later/eerder op dan dit tijdstip?

_____ keer

⑪ Waardoor komt dat?

_____
_____
_____
_____
_____

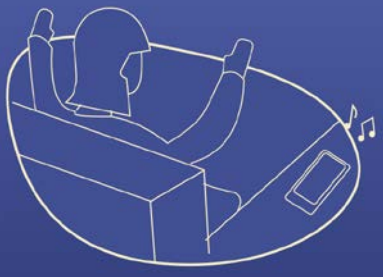
Prototype manuals



Onstpannen de nacht in
De tijd nemen om tot rust te komen helpt bij het hebben van een goede nachtrust. SleepyLight dimt langzaam, zodat je nog even de tijd hebt om alles op een rijtje te zetten of nog even te lezen voordat je in slaap valt.

Uitgeslapen de dag in
Langzaam zal SleepyLight je in de ochtend weer uit je slaap halen onder begeleiding van ontspannende geluiden. Alles voor een goed begin van je dag!

Onstpannen de nacht in
De tijd nemen om tot rust te komen helpt bij het hebben van een goede nachtrust. SleepyBot helpt om je aan je bedtijd te herinneren, zodat je zorgeloos nog even de tijd kan nemen om alles op een rijtje te zetten of nog even te lezen voordat je in slaap valt.



Uitgeslapen de dag in
Iedere ochtend een paar berichtjes om je te motiveren om een goede start van de dag te maken.
Alles voor een goed begin van je dag!

Thing ethnography protocol

#	Questions	Actions
0	**Preparation**	
0.1		Wash your hands, organise all materials
0.2	Let's start by reviewing the informed consent form. Did you have any questions about the information sheet and/or the informed consent form?	Clarify any questions and sign the informed consent form
0.3	Then this is the moment that I will start the audio recording	
1	**General**	
1.1	Who are you, and what do you do in daily life?	Make sure that at least **age**, **occupation** and **living situation** are mentioned.
1.2	So we are researching sleeping. Wat does sleeping mean to you?	
1.3	How important is sleep in relation to other activities?	
1.4	Can you tell something about the difference between your sleep behaviour before the start of the lockdown, and how it is now?	
2	**Sleep rhythm**	
2.1	Let's take a look at the assignment that you have made. The last question was about sleep rhythm. How would you describe your sleep rhythm?	Take the sensitisation workbook and go to the last page
2.2	How much sleep do you think you need per night?	
2.3	How often do you succeed in getting that much sleep?	
2.4	How do you feel about your own sleep behaviour?	
3	**Evening rhythm**	
3.1	The first part of the workbook primarily concerned your evening rhythm. What are the activities that you do during the evening?	Take the timeline, check if there are any gaps in the timeline
3.2	What do you think is important to do in the evening?	
3.3	What do you like to have done before going to sleep?	

3.4	Do you experience a conflict between certain activities and going to bed on time?	
3.5	What makes you go to bed later than you initially planned? Do you want to change that?	
4	**Activities**	
4.1	Then we asked you to think about the things that you use during those activities on the timeline.	
4.2	Which things did you put a sticker on?	
4.3	How do you use those things during the activity	
4.4	How did you rank the things, which one do you use most consistently, which one do you use the most?	
5	**Instrumentation**	
5.1	Then we will make the translation to the things that we will outfit with a sensor box.	
5.2		Make the choice for the objects to instrument
5.3	Then I will set the up. For that I will need the login for your WiFi network.	Give a post-it to write down the information.
5.4	This box will make sure that all the data will be streamed to the internet. Make sure that it is never unplugged from power.	Setup the *collector*
5.5	(Go through every object and explain which sensors you outfit them with etc.	Setup the probes with the appropriate sensors. Check whether they function before placing them at the right location.
5.6	Thank you for your time. This concludes the first interview. I will now place the sensor boxes on the places that we agreed upon. Starting tomorrow morning we will consider the data that they produce in the study, marking the official start of the study. In about a week you will receive further details about the prototype to evaluate.	

Transcript thing ethnography P1

P1: Ik ben [P1] en wat doe ik in het dagelijks leven?
Ja eh werken.

R: Wat voor werk doe je?

P1: Ik ben projectmanagement consultant bij [bedrijf 1] en op dit moment ben ik interim project planner bij een jachtbouwbedrijf.

R: Wat is je huidige woonsituatie?

P1: Ik woon alleen.. in een appartement.

R: We zijn dus bezig met een onderzoek naar slapen daarvoor hebben we je gevraagd om ook nog een opdracht te maken, daar gaan we zometeen door heen.
Maar eerst een aantal algemene vragen, want wat betekent slapen voor jou?

P1: Nou ik vind het vooral een levensbehoefte, want als je niet goed slaapt dan is de dag erna sowieso niet echt fijn.
Dus ja het is een moment om op te laden.
Dat betekent het eigenlijk voor mij.

R: Je zegt dat het een moment is om op te laden, heb je ook het gevoel dat je dat altijd kunt doen?

P1: Nee. Nee natuurlijk niet, als je natuurlijk slecht slaapt, of als je te laat gaat slapen.
Of vroeg op moet.
Vooral met vroeg opstaan, dan kan ik nog zo goed geslapen hebben maar dan voel ik me alsnog helemaal ruk.

R: Door het vroege opstaan?

P1: Ja, maar dan denk ik dat je automatisch ook niet helemaal genoeg geslapen hebt.

R: En hoe belangrijk is slapen voor jou ten opzichte van andere activiteiten?

P1: Nou ik denk altijd dat ik het heel belangrijk vind maar als er iets leukers voorbij komt dan zal ik altijd de andere activiteit doen.
Dus eigenlijk niet zo belangrijk dan.

R: En wat zijn dat voor andere activiteiten dan?

P1: Afspreken met vrienden, feestjes, dat vooral.
Sociale activiteiten.

R: Een social activiteit is dan belangrijker dan..

P1: Dan slapen ja.

R: En is dat dan alleen in het moment, of als je erop terugkijkt denk je dan nog steeds hetzelfde?

P1: Nee, vooral in het moment.
Wat ik net ook probeerde te zeggen, ik vind het wel belangrijk en dan de volgende dag denk ik dan van..
Maar het hangt er ook van af wat je de volgende dag moet doen, dus als ik echt gewoon vrij ben en niets hoef te doen ja dan vind ik het niet zo erg en dan wordt ik gewoon wakker ooit.
Maar ik heb wel eens vaker gehad dat ik de volgende dag moet werken en dat je dan denkt, dat was niet slim.

R: En dan nog even voor deze tijd, zou je misschien iets kunnen vertellen over hoe je nu slaapt ten

opzichte van enkele weken geleden.

P1: Ja slechter, wel dat ik iets later kan opstaan maar daardoor ga ik ook op de een of andere manier later naar bed want ik voel toch minder de drang, omdat je toch de hele dag thuis zit.
En je voelt je sowieso al de hele dag een beetje lamlendig heb ik in ieder geval door thuis te zetten.
Dus dan hecht ik er minder waarde aan dat ik op tijd naar bed ga, ondanks dat ik het probeer.
En de keren dat ik op tijd ging slapen dan ben ik heel onrustig eigenlijk, veel onrustiger.

R: En daar kom je achteraf achter, of wordt je gewoon wakker?

P1: Ja dat heb ik nu wel vaker dan normaal, ik heb ook wel eens een goeie nacht hoor, alleen ik merk wel dat ik sinds corona is uitgebroken ik onrustiger slaap en soms wel vaak wakker wordt.
Dus dan merk je het op het moment zelf.

R: Wat vind je daar van?

P1: Ja ik vind dat heel frustrerend, ja want je moet toch de volgende dag weer werken.
En wat ik al zeg, je bent al wat meer vermoeid omdat je de hele tijd op dezelfde plek zit.
En vooral omdat ik slecht slaap, omdat ik ook aan het piekeren ben over de situatie, dus dat vind ik wel vervelend.

R: Probeer je daar iets aan te doen? Heb je iets geprobeerd te veranderen?

P1: De enige dingen die ik kan doen heb ik denk ik al gedaan, dat ik dan de dag daarna eerder naar bed te gaan.
In ieder geval geen koffie meer drinken 's avonds wat ik nog wel eens deed.
Mijn alcohol proberen te minderen, dat soort dingen.
Of bijvoorbeeld nog wandelen ofzo 's avonds, dat je toch nog een beetje uitgeput raakt.

R: Als je de opdracht erbij zou willen pakken, en dan de allerlaatste opdracht.
Hoe zou je je slaapritme beschrijven?

P1: Ik denk dat dat wel redelijk consequent hou, ik zet bijvoorbeeld iedere dag mijn wekker om 7 uur.
Maar het verschilt echt van dag tot dag hoe laat ik er dan uit kom, want ik slaap daarna dan wel niet meer, maar de ene dag denk ik ik ben eigenlijk wel uitgerust en dan sta ik half acht netjes naast mijn bed.
Maar het gebeurd ook wel eens dat ik half 10 pas achter mijn laptop zit, omdat ik gewoon anderhalf uur moest blijven liggen ofzo.
Dus in die zin probeer ik het ritme wel gelijk te houden, maar de fluctuaties wanneer ik me dus uitgerust genoeg voel om uit bed te komen dat wisselt heel erg.
Dus het is een soort 'fake' structuur.
Het is dus wel een structuur doordat ik die wekker doordeweeks op dezelfde tijd te houden. Dat lijkt me een goede.

R: Doe je dit alleen doordeweeks?

P1: Ja, in het weekend gaat er geen wekker.

R: En is je ritme dan ook anders?

P1: Ik wordt wel relatief op tijd wakker, maar soms besluit ik om dan gewoon weer te gaan slapen, of ik blijf nog langer liggen.
Dus het is wel anders omdat ik mezelf dan niet die restricties opleg.

R: Heb je dat nodig?

P1: Ja wel, ik kan dan wel denken, en nog steeds, dat het dan vrijdag is geweest en dat je dan denkt yes nu is het weer twee dagen weekend.
In plaats van dat elke dag een beetje hetzelfde is nu.
Dus dat heb ik wel nodig, en vooral ook dat psychologische, dat ik even geen wekker hoef te zetten.
Of als ik wel iets wil doen, dan zet ik een wekker maar wel een stuk later.

R: Hoe zit dat dan met de andere kant van het verhaal, dus het naar bed gaan?

P1: Ik probeer wel om 11 uur, maar dat lukt vaak niet dus daarom heb ik half 12 opgeschreven, want ik denk dat dat het meest in de buurt komt omdat ik meestal om 12 uur in slaap val.
Dat vind ik overigens veel te laat, maar dat is zoals ik zei me nog niet helemaal gelukt nog..
En dat is denk ik ook elke dag zo behalve als ik heel moe ben dan ga ik wel eerder, dus ook wel eens om 22 uur.
En de vrijdagmiddagborrel gaat af en toe nog wel goed dus dan kan het wel eens een stukje later worden.

R: En dan in het weekend is het hetzelfde?

P1: Ja ik probeer wel in het weekend, omdat je toch niet zoveel doet nu, dus ik ga op zaterdagavond niet meer echt iets leuks doen ofzo.
Dus het is wel een beetje hetzelfde, dat je eindigt op de bank en dat je dan denkt ik ga wel naar bed.

R: Je zei ik probeer om 11 uur, maar dat lukt niet, hoe komt dat?

P1: Ja geen idee, ja nou ik weet het wel een beetje dat ik dan op de bank lig en dat het dan heel veel moeite om mezelf naar bed te krijgen.
Omdat ik dan denk morgen toch weer de hele dag thuis, dus nu is de motivatie eigenlijk nog lager, het is niet meer dat ik nu denk ik moet morgen om 6 uur op want ik moet om 7 uur in de auto.
Dus nu als ik me morgen moe voel en ik slaap een uur langer dan maakt het niemand uit.

R: Is dat echt iets van deze tijd?

P1: Nou nee, ik denk het tijdstip wel, niet mijn moeite om naar bed te gaan dat heb ik altijd.

R: Dat zou je ongeacht de situatie ook wel hebben?

P1: Alleen heb ik dan net iets meer motivatie omdat ik weet wat de consequenties zijn als ik het niet doe.
Maar ik ben wel een moeilijk persoon om mezelf naar bed te krijgen ondanks dat ik de hele dag denk ik moet echt vroeg slapen.

R: Hoeveel slaap heb je per nacht nodig?

P1: Ja ik ben denk ik wel zo iemand ben die die acht uur echt nodig heeft.
Maar ja ik zou het ook niet echt weten want ik heb dat ook al heel lang niet meer gehaald eigenlijk.
Dus ja dat denk ik wel. Ik slaap wel vaak te weinig, dat denk ik wel te weten.

R: Waar merk je dat aan?

P1: Ja gewoon moe, en vooral het opstaan 's ochtends, dat ik nou nooit eens op sta en denk 'yes'.
Ja in het weekend wel eens, dat je denkt nu heb ik echt energie..

R: Wat is dan het verschil met het weekend en doordeweeks?

P1: Nou in het weekend omdat je dan gewoon kan beslissen wanneer je besluit om iets te gaan, die vrijheid.
En in het weekend doe ik, ook nu, leukere dingen dan doordeweeks ondanks dat het niet de dingen zijn die ik normaal zou doen.
Dan je heb je wel zoiets van ik kan nu dit oppakken, of ik kan dat.
Ik ben sowieso gemotiveerder om aan de dag te beginnen.

R: En doordeweeks is dat anders?

P1: Ja, je moet zeg maar sowieso iets moet is het al meteen minder leuk.
Je moet jezelf motiveren om.. vroeger omdat ik zo vroeg in de auto moest zitten omdat je ergens moest zijn, en nu is het vooral moeilijk omdat je jezelf weer achter die laptop moet krijgen.
Terwijl je ook weet dat het niemand boeit als je niet verschijnt. Dus die motivatie is doordeweeks wel lastiger.

R: Je gaf aan dat je één keer in de week veel later of eerder naar bed gaat?

P1: Ja [na de vrijdagmiddagborrel] is veel later, maar ik heb ook wel eens dat ik een keer denk van nu

moet ik eens iets eerder, actief.
Maar dat pakt niet altijd goed uit zoals ik al zei.

R: Je probeert iets maar het heeft niet echt effect?

P1: Maar ik denk dat dat ook psychologisch is, dat ik denk nu ga ik eens om 22 uur slapen, en dan weten we allemaal dat soms werkt dat heel goed als ik echt moe ben.
En nu denk ik heel vaak, ik heb vannacht slecht geslapen dus ik ga vanavond om 22 uur naar bed en dan voelt dat heel geforceerd.

R: Wat vind je van je eigen slaapgedrag?

P1: Ik vind het soms wel irritant, dat ik me wel beter zou voelen als ik gewoon beter zou slapen.
Ik heb wel een tijdje gehad, toen ik dan net aan het werk was, dat ik op een gegeven moment in de flow kwam dat je gewoon om 23 uur ging slapen en dan elke keer om 6 uur op, dat was tijdens mijn thesis ook waardoor het ook werkte.
Dan ging ik in het weekend ook op tijd op.
Ik vind het nu irritant dat dat dus nu niet zo is, en dat je dan ook niet weet hoe je dat dan moet veranderen.

R: Oké dan pakken we nu het eerste deel van de opdracht erbij, met de tijdlijn. Het eerste deel ging vooral over je avondritme. Wat zijn de activiteiten die je 's avonds doet?

P1: Nou het is ook niet dat ik het altijd precies zo doe.
Maar ik ben denk ik altijd wel rond half acht wel klaar met eten.
Dan ga ik afruimen en opruimen.
Dan probeer ik te sporten, maar dat kan ook wel eens voor het eten zijn, maar ik probeer het nu na het eten ook met het oog op beter slapen.
Dus wandelen kan dat zijn, kan ook gewoon workout zijn.
Maar dat doe ik niet elke avond.
Dus echt een workout met een matje en oefeningen.

R: En dat doe je in huis?

P1: Ja dat doe ik in huis, of ik ga dus, zoals gisteren, anderhalf uur wandelen na het eten.
Ik doe niet elke dag die workout, want je hebt ook rustdagen nodig.
Maar dat wisselt dus een beetje of ik het voor of na het eten doe.
Ik vind het zelf fijner om het na het eten te doen, maar het hangt er een beetje van af.
Ik had ook Netflix opgeschreven, maar dat houd meer in dat je dan gewoon op de bank hangt en dat hoeft niet persé Netflix te zijn.
Dus het kan ook dat dat sporten dat dat er niet is, en dat het dan de hele avond bank hangen is, maar dit is wel wat ik probeer te doen.

R: Dus het is het één of het ander, of allebei?

P1: Ja, precies.
Kleine todo's afronden dat zijn gewoon kleine dingetjes die ik gewoon moet doen zoals ik vind mijn werkplek een beetje een rotzooi dus dat ruim ik dan op.
Ik heb altijd zo'n moment dat ik nog wel iets doe, maar vooral die kleine dingen die je hebt laten liggen gedurende de dag.
Daarna doe ik whatsapp/sociaal contact/video bellen opgeschreven, in deze tijd is dat wel het moment dat ik even geen Netflix heb, en vooral bezig ben met dat.
Dan ben ik met mijn telefoon bezig.
Dan ga ik douchen of in bad, en dan is het eigenlijk wel klaar, dat ik in ieder geval richting mijn bed ga.
Dan is het moment dat ik mijn wekker zet, en het plan voor de dag daarna even doorneem.
Dat ik bedenk, hoe laat moet ik er eigenlijk uit en vaak zit ik dan ook nog te lang op mijn telefoon.

R: In je bed?

P1: Ja in mijn bed.
Dus daar ga ik al met mijn eigen slaapgedrag.
Maar dat heb ik ook niet specifiek opgeschreven, want na het tandenpoetsen ga ik in ieder geval naar mijn bed maar het is niet dat ik dan meteen ga slapen.
Want dat gebeurd eigenlijk nooit.

R: Dus je gaat wel na het tandenpoetsen meteen naar bed.

P1: Ja want ik ga wel meteen in mijn bed liggen. Dus als ik dat eenmaal ga doen..

R: Dus dat is wel het moment dat je naar boven gaat, en dan niet meer naar beneden terug gaat, een soort 'point of no return'.

P1: Ja ja dan blijf ik boven.

R: Wat vind je belangrijk om 's avonds te doen.

P1: Ja ik had dus in ieder geval dat sporten, bewegen.
Dat merk ik nu wel echt dat dat goed werkt.
Voor mij ook heel erg dat sociale contact gedeelte.
Dus ik ga sowieso 's avonds al mijn whatsappjes langs, en eigenlijk reageer ik 's avonds wel op iedereen.
Gedurende de dag ben ik daar heel slecht in, ik weet dat ik er ook wel slecht in ben.
Dus dan neem ik echt een moment, dat heb ik blijkbaar nodig.
Of dus dan natuurlijk videobellen als ik dat met iemand heb afgesproken.
En het douchen of in bad is belangrijk, is toch even een chill momentje, even rust.
Even lekker natuurlijk.
Zeker als ik een heftige dag gewoon fysiek/mentaal, dan denk ik nu ga ik echt even een halfuur in bad.
Die is wel echt belangrijk voor mij.

R: Zijn er dingen die je graag gedaan wilt hebben voordat je gaat slapen?

P1: Vroeger legde ik altijd mijn kleren klaar haha, dus dat was wel een soort tic.
Dat ik wist wat ik aan zou doen de volgende dag.
Nu heb ik dat dan niet meer, ik hoef natuurlijk niet meer op een bepaald tijdstip weg.
Maar voor corona vond ik dat ik alles gedaan moest hebben om de tijd die het in de ochtend kost te verkorten.
Want ik ben beter in de avond dan in de ochtend.

R: En dat doe je nu minder?

P1: Ja dat doe ik nu wel minder.
Ik probeer wel natuurlijk als dat wanneer ik gekookt hebt dat ik dan de avond zelf nog wel even afwas.
Dan dat ik het in de ochtend moet doen, want dan wil je natuurlijk je ontbijt maken enzo.
Dus dat blijft wel gelden, alleen in mindere mate.

R: Ervaar je wel eens een conflict tussen op tijd naar bed gaan en bepaalde activiteiten?

P1: Ja, zeker in het normale leven natuurlijk.
Ik ben niet de beste in überhaupt weg gaan, dus als ik ergens op een feestje of bij iemand ben dan vind ik het heel lastig.
Ook al wil ik heel graag degene zijn die zegt 'ik ga nu', wacht ik toch heel vaak tot een ander zegt ik ga nu, zodat dat mijn cue is om weg te gaan.
Dus dat is wel een intern conflict, want ik wil eigenlijk wel omdat ik weet dat het beter voor me is, maar ik heb dan ook een soort angst om misschien iets te missen. Dus dat is dan wel een soort conflict, dat ik me dat wel besef, maar dan niet kan om te zeggen: 'ik vind het nu belangrijk om te slapen dus ik ga'.
Dat komt niet zo vaak uit mijn mond.

R: Dus daar zit wel een soort van conflict, maar is dat dan ook iets wat je nu nog hebt?

P1: Nou nu is het wel in mindere mate. In het begin toen iedereen aan het videobellen was en er van alles werd georganiseerd, toen had ik het alsnog een beetje.
Toen had ik ook van ik ga nu er niet uit totdat iedereen dat zegt dat ze weggaan.
Dus het blijft wel een ding, die wrijving tussen mijn sociale leven en mijn eigen gezondheid.
Maar natuurlijk wel in mindere mate, nu is het meer mijn eigen luiheid.
Dat ik denk ik ben daar een beetje aan het chillen op de bank, het is wel goed zo.

R: In de volgende opdracht vroegen we naar het vertalen van de activiteiten naar voorwerpen die je daar bij gebruikt.

182 P1: Ik vond dit wel lastig trouwens, omdat je dacht wat is nou een specifiek voorwerp.
183 Ik ging dan meer denken over hoe link ik het aan de activiteiten.

184 R: Anders kunnen we het ook wel over plekken hebben, want de keuken afruimen heeft natuurlijk wel een specifieke plek

185 P1: Maar ja dan dacht ik van moet ik dan opschrijven dat ik een pan aanraak, dat was een beetje...
186 Ik ben wel in mijn hoofd nagegaan van wat doe ik eigenlijk...

187 [Final part of the interview recording was lost]

Transcript thing ethnography P2

P2: Ik ben [P2] en ik ben architect, dus ik ontwerp gebouwen en doe studies naar gebouwen en stedenbouwkundige plannen.
Ik ben nu 27 jaar oud, en woon in een stadsappartement samen met twee andere huisgenoten van vergelijkbare leeftijd, één student en één werkende.

R: We zijn dus bezig met een onderzoek naar slapen, dus laten we beginnen met een simpele vraag: wat betekent slapen voor jou?

P2: Slapen betekent voor mij rechargen, herstellen, en eigenlijk dat wel.
Tot rust, ook al kan dat ook wel zonder te slapen, maar dat.

R: En is dat ook hetgeen wat slapen jou altijd brengt?

P2: Niet altijd natuurlijk.
Als ik gestresst ben dan slaap ik wel wat minder, en als ik bijvoorbeeld druk ben dan wordt ik ook wel wat minder lekker wakker.
En als ik gedronken heb natuurlijk dan wordt het de dag daarna ook wat moeilijker, of als ik ziek ben.
Of als ik heel erg fysiek inspanning heb gehad, dan is de rust ook wel wat minder.
Zeker voor de herstelperiode, die is dan ook wat langer.
En hoe minder ik slaap hoe minder ik tot rust kom, ik ben wel iemand die acht à negen uur nodig heeft om tot rust te komen.

R: En hoe belangrijk is slapen voor jou ten opzichte van andere activiteiten?

P2: Oeh, ik waardeer mijn slaap altijd wel heel erg.
Dus ik merk ook wel dat ik altijd wel het volle probeer eruit probeer te halen.
En als ik dat niet doe dan heeft het ook effect op mijn andere activiteiten.

R: Is het daarmee ook het belangrijkste wat je doet?

P2: Ik merk dat ik zeker doordeweeks probeer ik toch wel 12 uur aan te houden om naar bed te gaan.
Daar ben ik ook wel redelijk specifiek in, dus ook als er mensen over de vloer zijn dan probeer ik toch wel af te haken op dat moment.
Op het laatst zal ik misschien tot 1 uur, maar als het daarna wordt dan weet ik gewoon dat de volgende dag echt wat moeilijker wordt dus dat probeer ik te voorkomen.

R: De situatie is natuurlijk wel anders dan een aantal weken geleden, is er verschil in jouw leven?

P2: Ja, nou begin van de week is het meestal wel rustig maar dan zeker richting het eind van de week..
Normaal gesproken ben ik natuurlijk op kantoor bezig, wat betekent dat als ik langer doorwerk dat ik ook aanzienlijk later eet.
Op dit moment eten we sowieso een beetje tussen 7 en 8, dat was op kantoor ook wel maar dan wilde het soms nog wel uitlopen.
Waardoor ik om 9 uur pas thuiskwam, of soms wel pas later.
Dan werd er gewoon minder gegeten of besteld.
Waarbij dan dat effect heeft op wat ik wil doen, want normaal gesproken als ik dan vroeg klaar was dan zou ik nog even naar de film gaan.
Of misschien even een drankje doen bij vrienden of even gaan eten.
Zeker vanaf woensdag/donderdag dan begint dat toch wat meer te kriebelen om wat vrienden op te zoeken.
Om dan even een drankje in de stad te doen, wat natuurlijk betekent dat het dan vaak wat later wordt, dus meer richting 12 tot 1, dan 11 tot 12.
Dus dat is wel een groot effect, en zeker de vrijdagen en de zaterdagen dan werd er nog wel eens matig gegeten en dan kan het toch wel uitlopen van 2 tot later.
Dat is nu natuurlijk allemaal vrijwel niet het geval, toevallig afgelopen vrijdag dat ik dan tot 3 uur een beetje serie zat te kijken.
Soms zijn we over de vloer bij mensen, dan is het tot 12 of later, of er zijn mensen hier over de vloer waarbij het 12 of later wordt.
Maar het ritme om wel avond te eten rond een uur of acht dat blijft wel, dus dat is zeker iets wat wel versterkt is.

R: Laten we dan kijken naar de opdrachten, te beginnen met de laatste. We hadden het er net al een beetje over, maar hoe zou je je slaapritme beschrijven?

P2: Nu wel echt heel stabiel, omdat je gewoon minder te doen hebt.
Dus je gaat ook regelmatiger op tijd naar bed, zeker rond twaalf uur wel.
Waarbij ik nu wel een redelijk steady ritueel heb dat ik nog wel even tien minuten probeer te yoga'en, waarbij ik gewoon tot innerlijke rust kom.
Terwijl na het eten wordt er misschien een biertje gedaan en een beetje gechilld, en misschien een filmpje of serie kijken.
Waarbij je ook gewoon even uit je werk komt, dus die stappen zijn wel iets stabieler geworden.
Opstaan is ook ergens tussen 8 en half 9, waar dat vroeger natuurlijk een halfuurtje eerder zou zijn omdat ik nu natuurlijk niet naar mijn werk ga, dus dan ben ik hier aan het werk dus dan kan ik ook wat later mijn bed uitkomen.
Maar dat is ook wel hetzelfde gebleven, ik ga mijn bed uit, probeer ik 10 minuten een beetje lichaamsbeweging te doen, wat oefeningen met zo'n app.
Dan ga ik even douchen, en dan loop ik naar beneden om mijn laptop aan te zetten, rook ik een sigaret, en dan begin ik met mijn dagvergadering.
De marges zijn wat nauwer geworden aan die kant, maar redelijk vergelijkbaar.
Behalve dat ik nu wel probeer om elke ochtend die beweging te doen, omdat keukentafelstoelen iets minder ergonomisch verantwoord zijn dan een bureaustoel.
Dus ja eigenlijk al met al is het redelijk stabiel geworden, dus dat is wel gewoon fijn.
Maar ik merk wel aan de andere kant dat het moeilijker is om in slaap te komen als er grote veranderingen gebeuren zoals deze crisis, wat ook te maken heeft met werkgelegenheid natuurlijk, maar ook met naar buiten kunnen, met familie.

R: Enerzijds is het wel regelmatiger maar anderzijds ook niet helemaal?

P2: Het is wel degelijk regelmatiger geworden, het is wel anders geworden.
Ik vind het zelf wat gebalanceerder geworden, dus daar ben ik eigenlijk wel blij mee dus ik hoop dat ik dat ook een beetje kan doorzetten in de komende tijd als er ook versoepelingen plaatsvinden.

R: Ja, want nu ben je eigenlijk geforceerd om te veranderen, heb je het gevoel dat je weer snel in je oude patroon zou vervallen?

P2: Ja patronen zijn natuurlijk gewoontes, en gezien één van de belangrijkste gewoontes van hiervoor was kroeg, dat gaat gewoon het komende jaar niet naar dat oude patroon komen.
Waardoor ik wel vermoed dat de kans wel aanwezig is dat ik blijvend mijn patroon verander, of in ieder geval voor het komende halfjaar tot een jaar zal dat zo zijn.

R: Heb je het gevoel dat je daar ondersteuning bij nodig hebt als je dat blijvend zou willen veranderen?

P2: Ja ik denk dat het wel handig is, maar ik ben bijvoorbeeld een paar jaar geleden gestopt met roken voor een halfjaar, dat ging best wel goed.
Het was voor een sportevenement, maar toen was het sportevenement over en werd het zomer.
Waardoor er toch wel weer gewoontes naar voren kwamen die ik het halfjaar daarvoor niet had omdat het geen zomer was.
Waardoor ik weer terugviel in mijn oude patronen, dus ik weet wel dat in die zin dat die gewoontes veranderen kost lang.
Kost echt een jaar, waarbij je op cruciale punten is het belangrijk om die steun te hebben of in ieder geval die aanleiding te hebben om dat patroon te veranderen.

R: Hoe sta je dan tegenover die verandering?
Had je voor dit hele gebeuren ook al het gevoel dat er iets moest veranderen?

P2: Ja zeker, ik sportte bijvoorbeeld niet.

R: Hoeveel slaap denk je per nacht ongeveer nodig te hebben?

P2: Acht à negen uur.

R: Hoe vaak per week lukt dat?

P2: Ik denk zeker iets meer dan de helft, dus laten we zeggen vier van de zeven dagen.
Met als het een rustige week is gewoon de hele week.
En eigenlijk in het weekend dan slaap je natuurlijk gewoon uit, dus als je later je bed in gaat dan kom je effectief ook wel op hetzelfde uit.
Daar heb ik wel redelijk vertrouwen in dat dat is hoe het moet zijn.

R: Welke dagen zijn dat dan vooral, dat het lukt?

P2: Zondag-, maandag-, dinsdag- en woensdagavond sowieso, en dan richting het weekend wordt het onregelmatiger.

R: Wat vind je daarvan?

P2: Ja dat is prima, dat is ook iets wat ik nodig heb.
Ik merk ook dat zelfs als het donderdagavond laat is geworden dan merk ik ook dat ik op vrijdag in eerste instantie denk ik ga vroeg naar bed, maar uiteindelijk merk ik dat ik dan toch de energie krijg kom toch de energie krijg om toch iets te gaan doen, ten minste in het verleden.
Dus ik merk wel dat het is iets ook waar ik zelf onbewust of intuïtief leef ik daar ook wel een beetje naar toe, naar die onregelmatigheid richting het weekend.

R: We hadden het eerder over hoe belangrijk slapen is ten opzichte van andere activiteiten, dus richting het weekend worden die andere dingen belangrijker, en dan is die ruimte daarvoor belangrijker?

P2: Ja dat zou je zo wel kunnen zeggen.

R: Dan gaan we nu even kijken naar de tijdlijn, het eerste deel ging dus vooral over je avondritme.
Wat zijn zoal de activiteiten die je doet voordat je in slaap valt?

P2: Dus tussen het avondeten en dat ik in slaap val?
De afwas moet meestal gedaan worden, soms schiet dat er bij in, soms is dat niet echt nodig omdat we besteld hebben.
Zeker nu is de tv, met een filmpje of een serie en een biertje er bij wel zeker de standaard activiteit.
Een enkele keer wordt er een spelletje gedaan zoals Jenga, en dan is het eigenlijk rond een uur half elf/twaalf uur naar bed.
Tien minuten yoga en dan nog even plassen en dan mijn bed in.
Nog even op mijn mobiel tot dat ik denk ik kan nu wel naar bed.
En er wordt natuurlijk gerookt nog, maar dat hangt een beetje samen met het bier drinken.

R: Wat van die dingen vind je heel belangrijk, of waardevol, om gedaan te hebben?

P2: Ik heb nu even een tijdje niet gedaan, omdat ik een beetje een verstopte neus had, maar ik waardeer toch altijd wel die tien minuten yoga, omdat het heel even mijn lichaam strekt maar waardoor ik net even dat laatste fysieke unwind heb wat ook mentaal best wel werkt.
Dat is gewoon best wel chill, dus die vind ik eigenlijk wel heel erg belangrijk, ook al ben ik daar nog best wel laks mee.
Maar dat is ook de nieuwste soort activiteit van twee maanden oud.
Daarnaast vind ik onderuit op de bank zitten best wel belangrijk voor ongeveer de helft van de week, dat vind ik wel één van de belangrijkste dingen nu, of eigenlijk altijd al wel.
Even nergens aan denken, beetje lachen.

R: Want is bij jou het werk klaar vanaf het moment dat de computer dicht gaat?

P2: Ja in principe wel, dat is nu natuurlijk wat vager omdat je natuurlijk thuis zit te werken.
Waardoor ik toch wel mijn laptop wel vaak nog even aan laat staan voor het geval dat er toch nog vragen zijn.
Het is nu wat makkelijker om namelijk gewoon te stoppen met werken want je zegt 'we gaan nu eten', dus laptop opzij.
Maar ja zoals ik al zei, ik werkte eerst nog wel eens over op kantoor.
Dus op het moment dat er wel nog over wordt gewerkt dan laat ik mijn laptop nog even aanstaan.
Dus soms is het ook wel eerst nog even eten en dan nog een uurtje of twee aan het werk, dat is op zich wel relaxed omdat ik nu wel echt de tijd neem om te gaan eten in plaats van even het snel naar binnen te schrokken.
Waardoor ik het niet meer vervelend vind om over te werken, het is niet meer zo vervelend om tot laat aan het werk te zijn.
Omdat ik tussendoor veel meer de vrijheid heb om mijn eigen tijd te pakken om te eten bijvoorbeeld.

R: Hoe vaak gebeurd dat overwerken?

P2: Ja, we hebben net een project afgerond waarbij je tot laat, je moet gewoon materialen, het is gewoon een bepaalde tijd waarin het werk moet worden afgerond.
Want je hebt natuurlijk gewoon een deadline, en dat moet goed zijn dus daar ben je dan ook veel mee bezig dus dan werk je nog wel eens door.
En zeker nu is het dan wat makkelijker om dan nog even, dan moet je gewoon nog even doorwerken.

R: Hoe veranderd dat dan [de tijdlijn]?

P2: Dan is het waarschijnlijk eten, misschien afwassen, misschien zelfs niet, nog heel even uitbuiken, heel even aan het werk, en dan weer tv.
De timeframe veranderd niet heel erg, wordt misschien een halfuurtje opgeschoven.
Maar het komt tussen het tv kijken komt er werk in.
Het zal het niet compleet vervangen.
De tv wordt dan een kleiner aandeel.
Ik ga niet, of wacht eens is dat zo?, ik ga tot nu toe vrijwel niet compleet vervangen.
Dus ik ga altijd nog wel heel even iets anders doen voordat ik naar bed ga als ik tot laat moet werken.

R: Ervaar je wel eens conflict tussen bepaalde activiteiten en op tijd naar bed gaan?

P2: Soms als ik dus niet yoga, dan kan het zo zijn dat ik wat langer op mijn mobiel kijk omdat ik gewoon nog wat meer energie heb waardoor ik later naar bed ga.
Dat kan ook komen doordat ik teveel heb gedronken, waardoor ik geen zin heb om te yoga'en.
Dus dat is zeker conflicterend.

R: Wat zorgt er voor dat je wel eens later naar bed zou gaan dan dat je zou willen?

P2: Ja gewoon als er mensen over de vloer zijn, dat is denk ik toch wel de belangrijkste factoren.
En soms ook wel eens als ik tot later heb gewerkt dat ik toch denk ik wil nu even nog zitten, even nog tv kijken.
Dat werken dat conflicteert ook wel zeker.

R: Verlies je je dan ook nog wel eens in zo'n activiteit?

P2: Ja als het echt gezellig is, dan vergeet je nog wel eens hoe laat het is.
Zeker nu, het is echt wel gek omdat het nu toch wel weer echt langer licht blijft.
Dus dat is wel even wennen.
En het mobiel kijken, het appen, dat duurt soms ook wel iets langer dan ik zou willen.
Maar ik merk ook wel, het is niet zo dat ik überhaupt wakker lig van iets dat ik langer op mijn mobiel zit.

R: Dus die mobiel zit dan wel in je handen, maar dat is niet de primaire reden?

P2: Ik denk dat het soort van twee, een wisselwerking is tussen de twee.
Dus aan de ene kant niet zo goed kunnen slapen om een reden, en dan pak je die mobiel waar je dan ook langer op zit.

R: Dan de volgende stap, de vertaling naar voorwerpen, naar dingen.
Welke dingen had je in gedachte?

P2: Ik denk dat die mobiel dan toch het meest gebruikt wordt omdat die gebruik je tijdens als je tv kijkt, dan kijk je even wat na, of je bent even wat aan het babbelen en je wil even wat op zoeken.
Of je bent met iemand aan het appen, dus dat houdt ook wel verband met elkaar.
Dan natuurlijk de koelkast om even wat drinken te pakken, of misschien even wat eten op te ruimen.
De afstandsbediening omdat die je die gebruikt, ook als je opstaat en stopt met kijken, pauzeert enzo.
En dan de aansteker voor als je gaat roken, en dat gebeurt ook wel één keer per uur.

R: En dat yoga'en gebruik je daar iets voor?

P2: Ja daar gebruik ik mijn mobiel voor, ook met een app.
Ik heb gewoon een kleedje, dus niet een speciale yoga mat heb ofzo.
Dus wat betreft gebruik ik daar verder niets anders voor.

R: En bij dat tv kijken heb je daar een vaste plek voor?

P2: Ja meestal zit ik daar in de hoek van de bank, dus niet bij de muur maar in die andere hoek.

R: Is dat dan ook echt jouw plekje?

P2: Er wordt nog wel eens gewisseld maar dat is meer als er bezoek is, maar eigenlijk zit ik daar wel voornamelijk.
Af en toe wisselt dat een beetje, maar dat is wel meestal de vaste plek.
Huisgenoot 1 zit meestal tegen de muur aan, en ik wissel nog wel eens om met huisgenoot 2.

R: Je woont met andere mensen, hoe verhouden jullie ritmes zich tot elkaar?

P2: Ja dat is op zich wel grappig, want we hebben twee badkamers, dus huisgenoot 2 heeft een badkamer hier beneden, ik en huisgenoot 1 hebben een badkamer boven.
Wij werken ook allebei, de bovenste verdieping, en we beginnen allebei om negen uur met werk.
En dat is op zich wel grappig want in het begin was dat nog wel eens wisselend maar eigenlijk huisgenoot 1 gaat echt op tijd naar werk of misschien zelfs vroeger dus we hebben gewoon.
En hij doucht voordat ik douche en dan zien we elkaar beneden weer.
Dat is ook heel fijn, want ik slaap naast de douche dus als ik hem hoor dan weet ik ook nu begint mijn tien minuten voor mijn oefeningen en dan ga ik douchen.
Dat werkt heel goed dat ritme.

R: En in de avond?

P2: Over het algemeen gaat huisgenoot 1 als eerste naar bed, als hij thuis is.
Dan wisselt het een beetje tussen huisgenoot 2 en ik, een beetje afhankelijk van hoe druk hij is met zijn activiteiten of hij of ik als eerste naar bed ga.
En in die zin maakt het niet zoveel uit omdat het toch wel 10 minuten uit elkaar ligt, of langer.
Zodat je niet persé hoeft te wachten op iemand ofzo.
Dus de ritmes zijn best wel goed in sync.
Over het algemeen merk ik wel dat vaak als één van de laatste naar bed ga, en het gebeurd eigenlijk maar zelden dat ik in mijn bed lig en dat er hier nog mensen zitten.
En we zitten dan ook in huis ook wel op de beste plek.

R: Dan gaan we nu de vertaalslag maken naar waar we die sensorkastjes gaan plaatsen.
Dus dan is het wel handig om te kijken naar wat zijn nou de activiteiten en dingen die daar tussen zitten.
Dus je hebt je bed, ik denk dat dit ook nog wel interessant is [yoga]?

P2: Ja dat is voor mijn bed, dus dan ben ik wel tien minuten op die plek.

R: [Met je mobiel] doe je in je bed, en [tv kijken] is dan in dat hoekje. Misschien moeten we dan even een rondje lopen.

P2: Dus dit is de bank, dit is de tv.
Dus ja dat is die hoek.
Op het moment dat ik dan hier niet zit dan loop ik naar de keuken, toilet en balkon, dus dat is meestal aan elkaar verbonden.

R: Dus dat balkon is dan ook iets waar je vlak voordat je gaat slapen nog wel doet?

P2: Ja dat is de afwisseling met hier zitten, dus als ik dan niet hier zit dan ben ik daar.
Het is op zich wel met elkaar verbonden. [...]
Dan is dit de slaapkamer en dan wordt er hier geyoga't, en hier wordt er geslapen.

R: Gebruik je nog iets voor dat yoga'en? Of ga je gewoon op de grond zitten?

P2: Ja ik ga hier gewoon op de grond zitten, het is net zacht genoeg.
Zou het eigenlijk iets vaker moeten stofzuigen, maar over het algemeen is het redelijk schoon. [...]

R: Hoe word je dan wakker?

P2: Ja door een wekker, een stuk of zeven elke tien minuten één.
Van mijn telefoon op dat tafeltje.
Die ligt eigenlijk altijd daar omdat daar ook altijd mijn oplader ligt. [...]

Experience interview protocol

#	Questions	Notes	Aim
1	**General questions**		
1.1	How would you describe your sleeping behaviour?	Re-establish the baseline	
1.2	How would you describe your willingness to do something about that behaviour?	Re-establish the baseline	A/mor
1.3	What was your experience with using the prototype in the past week?		E+A
2	**Use**		
2.1	Describe how you used the prototype (maybe ask for photos in advance)	Were all the functions used? Did we already see deviations from the intended use	E A/sys
2.2	(Re-read the instructions) Do you see any differences in how you used the prototype? Why did you use it the way you did?	Explore how the use has deviated from the 'intended' use	
2.3	Were there days that you did not make use of the prototype? Why?		A/sys
2.4	Did you feel that made use of the full potential of the product, why (not)?		A/sys
3	**Experience**		
3.1	Did the prototype make you do things that you initially would not have done? How did that make you feel?		A/mor
3.2	What did you like about the prototype? What did you dislike?		A/aes A/mor
3.3	Were there things that annoyed you about the prototype?		A/mor
3.4	Are there elements of the prototype that you would not use		A/aes
4	**Behaviour change**		
4.1	Do you feel that the prototype supported you in changing your behaviour?		E
4.2	How did the prototype support you in changing behaviour?		E+A
4.3	Would you recommend this to a friend? Why (not)?	Take an 'outsider' perspective	A
4.4	Would you buy this for yourself? Why (not)?		A

Transcript experience interview P1

4 (1.1) Eerst nog over het onderwerp zelf, we hebben het hier natuurlijk al eens eerder over gehad, maar hoe zo je je slaapgedrag beschrijven? Nu, of de afgelopen weken?

Efficacy
5 P1: Nou, nog niet heel veel beter geloof ik.
6 Maar wel, denk ik me er wel een stukje bewuster van ben geworden.
7 Het is me ook wel een aantal keer gelukt om een keer eerder naar bed te gaan. Maar het zit nog niet zo in mijn systeem dat het een goed ritme is geworden.

8 R: Dus je erkent wel dat er iets is maar het is nog steeds wel moeilijk om er iets aan te doen.

9 P1: Ja, maar ik heb er dus wel vaker iets aan gedaan dan voorheen.

10 R: (1.2) Hoe zou je dan nog steeds je bereidheid om het te willen veranderen typeren?

11 P1: Ja nog steeds wel even groot...

12 R: (1.3) Dan even terugkomend op het gebruik van het prototype dat je hebt getest, want hoe was jouw ervaring met de lamp?

..Aesthetic
..Systemic
Efficacy
Efficacy
13 P1: Ja op zich sowieso vond ik het fijn want ik heb al een wake-up light, dus in die zin vind ik het sowieso fijn om op die manier wakker te worden, dus dat was gewoon überhaupt fijn.
14 Ik vond nog wel lastig ofzo, want een aantal keer was ik niet thuis toen ik hem wel had aangezet en dat die a moest dat ik naar bed moest.
15 Maar een aantal had ik hem wel mee naar beneden en dan.. het is niet altijd gelukt maar het was wel gewoon een goede reminder van oké, dit heb ik nu ingesteld en ik moet eigenlijk naar bed.
16 Dus in die zin helpt het dus wel alleen is het nog wel lastig om het ook echt te doen.
17 Maar je merkt wel dat het een soort extra.. het helpt wel dat je gewoon herinnerd wordt en dat je dan wel gewoon actief moet denken het is tijd om naar bed te gaan.

18 R: En je zei dus dat aan de ene kant er een paar was dat je niet thuis was als je bedtijd was, of zei je dat het lag aan dat je niet in dezelfde ruimte was als waar jij was.

..Systemic
Efficacy
19 P1: Ik denk dat het één keer was dat ik gewoon nog niet thuis was.
20 En inderdaad één keer dat die nog boven stond en dat ik toen dacht, oh ja.
21 Dus dat ik nog wel een soort drempel voelde om hem mee naar beneden te nemen, of daar gewoon niet ove had nagedacht.

22 R: Want dat was een van de eerste keren?

..Systemic
23 P1: Ja, ja.. dat het dan toch nog niet zo in je systeem zit, en ik denk ook niet dat dat in één week kan.
24 Dat je hem dan ook echt actief mee naar beneden neemt. Als je snapt wat ik bedoel.

25 R: En die keer dat je thuis was weet wat ook al weer de reden was dat je er nog niet was?

..Systemic
26 P1: Ja ik had hem toen expres heel erg vroeg gezet, en toen was ik nog bij een vriendin in Bergen op Zoom aan het eten, dus die combinatie was dat ik hem echt om half 10 al af had laten gaan of zo, en zelf pas rond een uur of 10, half 11 thuis kwam.
27 Dus ja dan loop je het mis.

28 R: Dus dan heb je gewoon dat hele moment gemist.
29 (2.1) Zou je misschien kunnen beschrijven hoe je ongeveer het ontwerp gebruikt hebt in een dag.

..Aesthetic
..Systemic
..Moral
Efficacy
30 P1: 'S ochtends gewoon als wekker dan, dus wat ik eigenlijk gewend was van mijn wake-up light, en nog steeds ook mijn wekkers op mijn telefoon voor de zekerheid.
31 Ik heb hem wel dan 's avonds, ik vond het dan wel fijn om die tijd als het dan bedtijd was om die tijd die dan ingesteld was om nog heel even in dit geval te lezen.
32 Om hem daar dan voor te gebruiken, en dan eigenlijk gewoon te gaan slapen.
33 En dan 's nachts om heel even dat dimlicht, als ik heel even naar de wc moest.

34 R: (2.2) Dan stuur ik je nu de handleiding nog een keer op, zoals je de ooit wel eens hebt gezien. Zou je die even gewoon kunnen herlezen.

35 P1: [Leest de handleiding]

36 R: Zijn er verschillen tussen deze handleiding en hoe jij het hebt gebruikt?

..Moral

37 P1: Nee, het enige wat mij alleen niet altijd duidelijk was is als ie dan, stel ik had hem omgedraaid dan ging die lopen dus ik denk dat dat het stukje het van het aanzetten, maar als ik dan bedacht dat ik hem helemaal niet nog een halfuur aan wou hebben dan wist ik niet hoe ik hem kon uitdoen.

38 Dus dat was het enige wat ik dan zelf niet wist en ook niet kon terugvinden, wel nog geprobeerd om op te zoeken. Maar verder heb ik hem op deze manier gebruikt.

39 R: (2.3) Waren er dagen waarop je geen gebruik hebt gemaakt van het prototype?

40 P1: Nee behalve die bedtijd herinnering die ik heb gemist, of dat maar verder gewoon als wekker sowieso wel.

41 En 's avonds eigenlijk ook wel steeds.

42 R: Was er nog een verschil tussen verschillende dagen, bijvoorbeeld doordeweeks en in het weekend?

..Systemic
Efficacy

43 P1: Nee eigenlijk niet, ja natuurlijk andere bedtijdtijden en opstaantijden in het weekend en doordeweeks, maar niet anders gebruikt.

44 R: Want hoe stelde die tijden in, hoe vaak wijzigde je dat?

..Systemic

45 P1: Nou ja eigenlijk deed ik dat geloof ik gewoon elke dag zeg maar.

46 Omdat ik ook weer een week had waarbij ik de ene week naar Vlissingen moest, de andere keer thuis werkte en de andere keer naar Kamerik dus dan heb je sowieso al andere tijden.

47 En dat doe ik eigenlijk sowieso, dus de avond daarvoor bedenk ik hoe laat ik vind dat ik op moet staan, dus dat heb ik nu eigenlijk ook zo gedaan.

48 R: Dan maak je in de avond je plan, en dan pas je het aan?

..Systemic
Efficacy

49 P1: Ja precies, dus dan eigenlijk, dus dan 's ochtends.. Een dag was ik heel erg moe dus toen heb die bedtijd expres vroeg gezet, maar die is wel iets meer consequent gebleven.

50 R: (2.4) Heb je het gevoel dat je het volledige potentieel van het ontwerp gebruikt hebt?

..Moral
..Systemic

51 P1: Ja dat denk in dus eigenlijk niet, want zoals ik al zei pas tegen het einde pas de draad te pakken kreeg met hem ook naar beneden mee nemen, toen dacht ik zo helpt het natuurlijk wel en als ik hem boven laat staan dan natuurlijk niet.

52 Dus in die zin pas tegen het einde.

53 R: Je hebt het gevoel dat je er een beetje naar toe ging maar dat het te kort was om dat echt te ervaren.

54 (3.1) Heeft ontwerp je dingen laten doen die je anders niet had gedaan?

Efficacy

55 P1: Nou het feit dat ik er nu bewust mee bezig was, dat heb ik natuurlijk wel vaker geprobeerd, maar nu toen ik hem gebruikte mijn telefoon eigenlijk weglegde en ook gewoon ging lezen en mijn telefoon al op vliegtuigstand had gezet.

56 Dus dat was wel lang geleden dat ik dat zo had gedaan.

57 R: Want je hebt je telefoon en al je apparaten naast je bed liggen.

58 Dus de lamp heeft die wake-uplight vervangen in dit geval, maar de rest ligt op dat tafeltje.

59 Maar je zet dan wel altijd je telefoon in vliegtuigstand?

Efficacy

60 P1: Ja dat doe ik sowieso als ik ga slapen, alleen was meestal mijn telefoon het laatste wat ik aanraakte voor ik ging slapen, maar nu deed ik dat dus al een half uur van tevoren weg om echt nog te lezen.

61 R: En hoe voelde je daarbij dat het ontwerp je dat liet doen.

..Moral
Efficacy
..Moral

62 P1: Ja dat vond ik wel fijn, dat is iets wat dan meteen ook weer als [het ontwerp weggehaald werd] moeilijk is om vast te houden.

63 Maar ik vond het toen wel fijn omdat nog steeds wel is wat ik zou willen dat ik uit mezelf zou doen.

64 R: Door het ontwerp gebeurde het nu ook?

Efficacy

65 P1: Ja omdat je er nu natuurlijk actief op gaat letten, en ook weet nog een half uur en dan gaat ie weer uit, en dan heb ik precies weer een halfuur gelezen, dus dan ben je er iets bewuster mee bezig.

66 R: Was dat het enige wat er echt veranderd is of waren er ook nog andere elementen die je gedrag veranderde?

67 P1: Het is natuurlijk lastig omdat ik natuurlijk zelf al een wakeup light heb dat ik dat gewoon nog steeds heel

		fijn vind om met licht wakker te worden, maar voor iemand dat nog helemaal niet gewend is zou dat natuurlijk een verandering zijn.
	68	R: En met die bedtijdherinnering, wat was daar het effect van?
	69	P1: Wat ik zeg, vooral dat je.. stel ik wil vanavond om half elf naar bed.
	70	Dan hou ik dat toch soort van in de gaten maar je mist dan toch een beetje een trigger, of je vergeet de tijd oprecht gewoon, waardoor je op een gegeven moment denk van nou ja nu ben ik toch al laat dus nu maakt het niet meer uit.
	71	Je hebt ook niet echt zin om heel gestresst de hele tijd te kijken hoe laat het eigenlijk is om naar bed te gaan.
	72	Want dat probeerde ik dan en dan dacht ik van ja, dan kan ik beter nu naar bed gaan of niet want ga ik nu de hele tijd nu ik serie zitten te kijken opletten wanneer ik moet slapen ofzo.
Efficacy	73	En met dit was het dan meer van dat je niet hoeft na te denken, want ik merk het vanzelf wel.
..Moral	74	En dan beslis ik zelf wel wat ik er mee ga doen, of ik nog even iets afkijk of echt meteen alles uitzet. [inaudible] actief, om het überhaupt te proberen om op tijd naar bed te gaan.
	75	R: Je zei, dan ging die af en dan maakte je dan de keuze wat je er dan mee deed.
..Systemic Efficacy	76	P1: Ja afhankelijk natuurlijk van wat ik op dat moment aan het doen was, kijk als mijn serie nog vijf minuten duurt dan kijk ik het nog wel even af, maar als het dan nog een uur was dan dacht ik wel laat ik dan wel stoppen, want anders wordt het gewoon te laat.
	77	R: (3.2) Wat vond je leuk/aangenaam aan het ontwerp?
..Aesthetic	78	P1: Wat ik sowieso wel fijn vond dat als je hem uit wil zetten als wekker dat je hem dan gewoon kon omdraaien.
	79	Dat vond ik wel leuk ofzo dat je hem dan actief uit zet.
	80	R: Waren er ook nog andere elementen?
..Aesthetic	81	P1: Hoe het dus werkt dat vond ik gewoon vet, dat als je hem schudt dat je dan een klein licht hebt, dat als je hem omdraait dat hij dan aanging.
	82	Dat je hem soort van makkelijk bedient, zonder knoppen.
	83	Dat vond ik wel fijn.
	84	R: Waren er ook dingen die je onaangenaam vond aan het ontwerp?
..Moral	85	P1: Ja dus in ieder geval dat ik dus af en toe niet wist hoe die uit moest als hij wel aanstond, want één nacht is die dus drie keer toe aangegaan waarna ik dacht ja nu trek ik de stekker eruit.
	86	En dan is het vooral irritant dat ik dan niet weet, waarom gaat ie aan en hoe krijg ik hem uit.
	87	Maar dat is maar één keer gebeurd.
..Moral	88	En dat is dan wel lastig, want als je dan duidelijke knoppen zou hebben dan weet je ten minste waar je op moet klikken, maar nu was het ik draai hem om maar er gebeurd niets wat moet ik doen?
	89	R: (3.3) Een beetje hierop voortbordurend, waren er ook dingen die je irriteerde aan het ontwerp?
	90	P1: Nee dat eigenlijk niet.
	91	Nou ja wat je zelf ook al zei het liefste zou die natuurlijk draadloos zijn, maar dat lijkt mij ook logisch dat je dan natuurlijk nog makkelijker even met je meeneemt.
..Aesthetic	92	Maar dat is in mijn ogen ook wel soort van het idee erachter.
	93	Dus dan zie ik dit meer als een prototype waarbij dat nog niet zo is maar wel met de gedachte dat dat zo zou zijn als dat eenmaal echt is als het op de markt zou komen.
	94	Dus dat lijkt me dan zeker nog een goede toevoeging inderdaad.
	95	R: En je noemde toe straks al iets van dat als je hem dan omdraaide dat de lamp dan het nog een half uur zou duren en dat je daar dan niet echts aan kon veranderen, wat vond je daarvan?
..Moral	96	P1: Ja dat vond ik dus af en toe wel irritant want ik heb ook wel eens per ongeluk nog omgedraaid, en dan vergat ik dat ik dan een halfuur lang niets kon doen, dat was dan wel het enige wat ik kan bedenken wat ik niet fijn vond.
	97	Omdat ik als ik hem uit wil zetten dan wil ik hem gewoon uitzetten.
	98	R: Dus daar wil je dan eigenlijk een soort 'override' voor hebben, dat als je hem uit wil zetten.
	99	P1: Ja want dacht eerst als ik hem dan nog een keer omdraai, dan gaat hij vast wel weer uit.
	100	Maar dat gebeurde wel niet, dus dan zou het wel fijn zijn als je dat zou kunnen doen.
	101	R: (3.4) Zijn er elementen van het ontwerp die je niet zou willen gebruiken?
..Systemic	102	P1: Nee ja, nou ik heb het snoozen dus niet echt gebruikt maar dat komt dus omdat ik dus nog die andere wekkers zet, dus dat is eigenlijk zeg maar mijn snooze.

103 R: Je gebruikt je backupwekker als de snooze functie

104 P1: Ja, maar anders zou ik het dus wel gebruikt hebben, want het is wel gewoon chill.
105 Maar het is dus niet een functie die ik niet zou willen gebruiken maar het is gewoon zo erin [gesleten] dat ik op mijn telefoon ook nog twee wekkers zet, dat dat voor mij voldoende is.

106 R: Stel dit prototype zou briljant hebben gewerkt, had dit dan je telefoon kunnen vervangen?

107 P1: Ja dat denk ik wel, ja want ik denk dat je dan nog iets actiever bezig bent met het idee dat je aan het snoozen bent, omdat je er dan zelf ook iets voor moet doen om dat zo ver te krijgen.
108 Nu hoef ik dat niet te doen.
109 Want ik weet toch dat ik nog drie wekkers heb, dus het is soort van snoozen maar dan met voorbedachte rade.
110 Dus ik blijf tot de derde gewoon liggen en dat weet ik van te voren, dat is meer een soort placebo effect dan dat het echt snoozen is en helpt ofzo.

111 R: Zou je dan dit ontwerp als een vervanging van je telefoon?

112 P1: Ja eigenlijk wel.

113 R: Zou je dan ook niet meer je telefoon in de slaapkamer meenemen, of dat dan weer niet?

114 P1: Ik denk dat ik die dan wel nog steeds mee zou nemen.
115 Omdat ik het fijn vind om mijn telefoon in de buurt te hebben.
116 En wat toch wel in de ochtend het eerste is wat ik doe is altijd checken of er iets belangrijks is, of ik iets gemist heb.
117 Ik lees ook het nieuws altijd nog voor het slapen gaan en bij het opstaan, dus dat zijn toch wel dingen waarbij ik denk dan neem ik hem gewoon mee.

118 R: (4.1) Heb je het gevoel dat het ontwerp je ondersteunde in het veranderen van je gedrag?

119 P1: Ja, want het is wel soort van redelijk een fysiek element dat je er aan herinnert.
120 Überhaupt natuurlijk dat ie gewoon af gaat bij je bed tijd, maar ook gewoon het feit dat je hem ziet associeer je er dan meteen mee dit is... door het te zien en dat het een fysiek voorwerp is weet dat je er mee bezig bent en er ook mee aan de slag moet

121 R: De fysieke verschijning van het ontwerp is een soort van constante reminder?

122 P1: Ja want normaal dan zeg je het wel tegen jezelf maar ja, er is niet echt een externe factor die je daarbij helpt.

123 R: Is dat dan ook niet irritant dat die er de hele tijd is, en er constant aan herinnerd wordt?

124 P1: Nee niet echt, ik hou er wel van van zo'n lamp weet je wel.
125 Ik vind dat niet per se heel erg storend.
126 En als die af ging dan was dat nou niet mega irritant ofzo want je kon hem natuurlijk ook gewoon uitzetten.
127 Dus het was gewoon meer zo van dit is het moment, ik voelde me niet zo van ik moet hier nu per se iets mee doen ofzo.
128 Ik dacht dit versterkt alleen maar mijn poging om dit te verbeteren bij mezelf.

129 R: (4.2) En hoe ondersteunde het ontwerp je precies om je gedrag te veranderen?

130 P1: Door die aanwezigheid, fysiek, en door het signaal af te geven.
131 En doordat ik het dus wel fijn vind zo'n lamp, warm licht, ik vind dat altijd wel prettig.
132 Ik hou ook wel van als het een beetje donker is van een beetje licht, dus ik vond het eigenlijk wel gezellig.

133 R: Dus ook dat hele gedrag van hoe dat licht uitging?

134 P1: Ja precies, dus ik vond eigenlijk ook gewoon leuk als hij weer aanging en zo.
135 Het was echt een goede ondersteuning, was niet echt dat ik er door geïrriteerd kon raken, want het was iets waar toch iets aan wou veranderen en waar die lamp me bij hielp.

136 R: Kreeg je al bijna een soort band met die lamp?

137 P1: Nou ja misschien wel als je het zo zegt, naar mate ik hem natuurlijk aan het einde vaker meenam dan voelt het wel soort van als een buddy, als je thuis bent dan, met je meeneemt.
138 Ik vind het wel grappig dat je hem dan ook weer met je mee naar boven neemt.

139 R: En je zei wel, als ik thuis ben natuurlijk.
140 Want dat was natuurlijk nu één keer niet.

141 Daar zit wel een dingetje natuurlijk, want als je er niet bent dan mis je het gewoon?

..Moral
Efficacy
..Systemic

142 P1: Ja precies, nou vraag ik me ook af in hoe verre het voor mij in het weekend dan ook wel of niet zou helpen, omdat ik daar echt een ander ritme aanhoudt, dat kan je niet echt een ritme noemen.
143 Daar kijk ik gewoon naar wat mijn behoefte is na de hele week.
144 Dus daar gaat zeker als ik hem langer zou gebruiken zou daar zeker vaker zoiets gebeuren dat ik er niet mee bezig ben, of gewoon niet ben.

..Systemic

145 Dus ik denk dat het wel iets heel goeds kan zijn voor doordeweeks, omdat ik dan actiever probeer dat ritme te houden.

..Moral

146 Maar het kan natuurlijk altijd een keer voorkomen dat ik er gewoon niet ben of vergeet, maar dat vind ik op zich niet per se storend, als ik maar overal gewoon in dat ritme ga komen.
147 Dan wordt het ook alleen maar makkelijker om daar gebruik van te maken.

148 R: (4.3) Zou je dit ontwerp aanraden aan je vrienden?

149 P1: Ja dat denk ik eigenlijk wel.

..Systemic
Efficacy

150 Omdat ik zeg maar ook weet dat ik niet per se de enige ben die dit lastig vind, misschien ook omdat we in de fase zitten van studentenleven, daar is een ritme allemaal minder makkelijk, minder toepasbaar en minder nodig.
151 En nu heb ik natuurlijk heel veel vrienden heb die ook begonnen zijn met werken, toch wel wat zwaarder valt, en er naar mijn idee toch wel veel valt te winnen als je gewoon een goed ritme hebt.
152 Dus dat het zeker de moeite waard is om te proberen.
153 Plus daarnaast dat we allemaal eindeloos op onze telefoon blijven zitten, ook voor het slapen gaan.
154 En dat is eigenlijk helemaal niet goed met blauw licht, en daar geloof ik ook echt in dat dat helemaal niet relaxed werkt, en dan werkt het toch goed dat je het je helpt om te zeggen oh dan ga ik nog even een halfuur lezen of whatever, maar niet op mijn telefoon zitten.

155 R: (4.4) Zou je dit zelf kopen?

..Moral

156 P1: Als die draadloos zou zijn en als ik weet dat ik hem uit kan zetten als ik een foutje heb gemaakt dan wel.

157 R: Dat waren mijn vragen dan wel, dankjewel!

158 [uitleg over afloop van de studie]

159 R: Die reden dat je hem natuurlijk niet uit kon zetten dat was wel deels bedoeld om je gedrag te veranderen.
160 Als je namelijk de intentie hebt om een halfuur te gaan lezen en je draait hem dan om, dan moet je ook gewoon maar gaan wachten.
161 Daarom kon je het niet aanpassen.

..Moral

162 P1: Ja ik snap het ook wel inderdaad, maar dat is grappig dat dat dan irritant.
163 Eigenlijk weet je dan ook dat het wel hoort maar stiekem best grappig want je wil gewoon in controle zijn van zo'n ding.

164 R: Ja maar daar zit dus wel een stukje wrijving dan tussen wat je eigenlijk zou doen, of wil en wat dan eigenlijk goed voor je is.

..Moral

165 P1: Ja maar dan is het ook nog wel eens lastig want welke tijd je hebt ingesteld, want ik kan me ook voorstellen dat je als je hem dan voor een uur hebt ingesteld dat je dan op een gegeven moment denkt ik wil eigenlijk toch niet helemaal een uur meer lezen ik ben toch eigenlijk wel moe genoeg en ik wil nu slapen.
166 Dan zou dat eigenlijk een goed teken moeten zijn dat je gewoon gaat slapen maar dan blijft je lamp aan.

Transcript experience interview P2

Experience interview

R: Je hebt nu een week een prototype gebruikt en daar zou ik het graag over willen hebben hoe je ervaring daarmee was. Maar eerst nog even kort om het terug te halen, want we hebben het er tijdens het eerste interview over gehad maar (1.1) hoe zou je je slaapgedrag willen beschrijven?

Efficacy

P2: Ja toch niet heel regelmatig, ik ga meestal wel rond 12 uur naar bed.
Maar het deel van voor het slapen gaan nog even wat anders doen dat komt er niet altijd van.
Het fluctueert nog wel eens of ik heel snel mijn bed in ga, of dat ik nog wel wat oefeningen doet ofzo.

R: (1.3) Hoe was je ervaring met het gebruik van het prototype in de afgelopen week?

..Moral
..Aesthetic
Efficacy

P2: Het prototype was best wel ongeduldig in die zin dat hij behoorlijk vaak opnieuw bleef vragen.
Redelijk opdringerig in die zin, waardoor ie op een gegeven moment ook dacht 'laat maar zitten' dus dan hield hij op na een aantal keer vragen.
Dus in die zin als ik niet op die tijd naar bed ging, dan was hij niet altijd even effectief.
Ten minste, ik kon niet altijd bevestigend beantwoorden dat ik al in bed lag.

..Systemic

R: (2.1) Kan je misschien beschrijven hoe je het prototype hebt gebruikt?

Efficacy
Efficacy

P2: Gewoon.. het was een reminder waar ik toch wel behoorlijk vaak de 'snooze' knop van gebruikte.
En voor de rest kan ik er niet heel veel over zeggen, ja ik reageerde zijn vragen.
En soms dan deed ik er niet echt iets mee en dan hield ie er mee op.

R: Dan stuur ik je nu de instructies, zou je dit nog een keer kunnen lezen.
(2.2) Zijn er verschillen tussen deze instructie en hoe jij het gebruikt hebt?

..Systemic

P2: In die zin, ja, want de SleepyBot ging er van uit dat ik mijn ontspanning in bed deed.
Dus antwoordde ik altijd ontkennend op de vraag of ik al in bed lag.

R: Waarom heb je het gebruikt zoals je het hebt gebruikt?

..Moral
Efficacy
Efficacy

P2: Ik wilde gewoon eerlijk antwoorden aan de bot, dus in die zin was het wel een geheugensteuntje om eens wat anders te doen.
Dus het was wel een goeie reminder als ik wel eens mijn oefeningen wilde gaan doen.
Maar in die zin, dat is een beetje hoe ik het gebruikt heb.
Als hij zei dat het bijna tijd was dan maakte ik aanstalten om mijn bed in te gaan.

R: Heeft dat dan dat momentje gecreëerd wat de bedoeling was om dat te bereiken?

..Moral

P2: Zoals bij het intake gesprek was dat natuurlijk al een activiteit die ik probeerde te ontwikkelen, dus ja in die zin hielp die daar wel aan mee.
Fijn om die reminder wel te hebben.

R: (2.3) Waren er dagen waarop je geen gebruik hebt gemaakt van het prototype?

..Moral
..Systemic

P2: Ja in principe in het weekend, dus op vrijdag en zaterdag maakte ik er dan geen gebruik van, en dat ging ook best wel goed om dan niet herinnerd te worden en geen schuldgevoel aan een AI te hebben.

R: (2.4) Heb je het gevoel dat je van het volledige potentieel van het ontwerp gebruik hebt gemaakt?

Efficacy

P2: Ja ik denk dat als iets actiever mijn best had gedaan, dan had ik er meer gebruik van gemaakt.
Dus ik zou zeggen dat ik niet 100% de bot heb gevolgd.

R: Je zegt, 'als ik me actiever eraan zou houden', waarom heb je dat dan nu niet gedaan?

Efficacy

P2: Ja uiteindelijk is het natuurlijk een kwestie van gewoontes aanpassen, en zo'n bot is daar natuurlijk een goed hulpje voor.
Maar dat duurt gewoon eventjes, ik denk dat met een week tijd veranderen mijn gewoontes niet zo snel.
Ik heb daar wel echt langer voor nodig.

R: Je was nog in het proces om hem te integreren in je eigen leven?

..Moral

P2: Ja, zeker.
En ik denk ook dat zo'n bot heeft ook de potentie om daarop in te spelen.
Stel dat ik bijvoorbeeld op donderdagen ook wel wat later naar bed ga dat ie dat dan ook merkt en dan kan zeggen van 'doe vandaag eens wat beter je best, de vorige drie keer ben je ook al later naar bed geweest'.

R: Dus dat soort gedrag zou ook beter werken voor jou?

P2: Ja ik denk dat het zeker omdat natuurlijk regelmatig vraagt hoe het gaat, en ik denk dat het dan de potentie erin zit om dat verder te ontwikkelen en nog zeker mijn gewoontes nog effectiever aan te passen.

R: (3.1) Heeft het ontwerp je dingen laten doen die je anders niet gedaan had?

Efficacy

P2: Ik ben wel wat actiever na gaan denken over dat soort dingen, over de intentie van zo'n product.
Als je zo'n ding download dan heb je natuurlijk de intentie om daar iets mee te gaan doen, dus überhaupt het hebben daarvan heeft al invloed, in die zin.

R: Heeft dit ding jou specifiek iets anders laten doen wat je anders niet had gedaan?

P2: Nee ik denk dat daar een week wel echt te kort voor was.

R: Maar dan heeft het je ook niet geforceerd om iets anders te doen?

Efficacy	49	P2: Nee, kijk hij heeft me er zeker wel aan herinnerd en ik heb er op dat moment dan ook op gereageerd maar ook lang niet altijd.
	50	R: Ervaarde je een mate van beïnvloeding van dat ding?
Efficacy	51	P2: Ja er was wel een mate van beïnvloeding, op het moment dat je zo'n ding download dan maak je een soort van commitment, omdat je er iets mee wilt gaan doen.
..Moral	52	Dus op het moment dat je er niet iets mee doet dan denk je wel, dat had ik eigenlijk wel moeten doen.
	53	Dus het is een zekere gewetensvraag.
	54	R: En hoe voelde je daarbij?
..Moral	55	P2: Ja een lichte mate van teleurgesteld in mijzelf omdat ik mijn intentie om effectiever slaapritueel te ontwikkelen niet lukte.
	56	R: Het zat hem meer in dat jijzelf iets niet deed, dan dat het kwam door de beïnvloeding vanuit het ontwerp?
..Aesthetic	57	P2: Ja kijk, het blijft natuurlijk een heel eenzijdig, een redelijk basic manier van me pushen om naar bed te gaan, dat hielp daar natuurlijk niet aan mee in het ontwikkelen daarvan.
	58	R: (3.2) Wat vond je aangenaam aan het ontwerp?
..Aesthetic	59	P2: Het was geen volledige robottaal, ik had wel het idee dat er overnagedacht was hoe die dan met mij communiceerde.
	60	Dat was zeker aangenaam.
..Moral	61	En ik heb het idee dat ie dat niet iedere ochtend deed, maar dat hij 's ochtends aanmoedigde van 'lekker bezig' dat was ook wel positief.
	62	Leuk om zo'n berichtje te krijgen van een lekker begin van je dag.
	63	R: Dus een soort motiverend element.
	64	P2: Ja het motiverende element was zeker een goede.
	65	R: Wat vond je onaangenaam aan het ontwerp?
..Aesthetic	66	P2: Dat er wel een soort van verschil in zat, of zo'n GIF'je wat ie dan stuurde, wat het wel leuk en gevarieerd houdt, maar uiteindelijk merk je wel dat het niet een eindeloze vernieuwing was.
	67	Er werden wel zinnen herhaald.
	68	Dat vond ik dan.. het lijkt bijna alsof iemand je een berichtje stuurt, maar je merkt wel toch dat er geen ontwikkeling was in het ding zelf.
	69	R: (3.3) Waren er ook dingen die je irriteerde?
..Moral	70	P2: Soms was ie al na 3 minuten weer dat ie meteen vroeg of ik al op bed lag, dan vroeg hij het eerst en dan zei ik 'nog niet' en dan drie minuten vraagt hij het al weer, en dat is dan toch wel een beetje aan de snelle kant.
	71	R: En hoe reageerde je daar dan op?
..Moral	72	P2: Als dat dan een paar keer achter elkaar gebeurde dan was ik daar wel geïrriteerd over.
	73	Maar ik kan niet echt tegen een bot zeggen van 'hou je bek'.
	74	R: Dat kan op zich wel maar dat deed hij natuurlijk niets mee.
	75	P2: Ik weet eigenlijk niet of, nee ik denk niet dat die daar iets mee deed.
	76	R: Wat was je gevoel daarbij dan als je voor de zoveelste keer zo'n berichtje kreeg?
..Moral	77	P2: Ja dat is natuurlijk irritatie in die zin. In het grotere plaatje denk 'ah ik ben niet op tijd naar bed gegaan' maar op dat moment denk je 'stom ding natuurlijk lig ik nog niet op bed want ik ben nog bezig'.
	78	R: Kan je misschien een voorbeeld geven van iets wat je aan het doen was terwijl je dan zo'n berichtje kreeg?
..Systemic	79	P2: Bijvoorbeeld een aflevering of een film aan het kijken op tv, dat soort dingen.
	80	Dan wil je dat gewoon even afkijken en dan ben je nog wat langer tv aan het kijken.
	81	R: Terwijl je dat al bijna aan het afronden was kreeg je al weer het volgende berichtje.
	82	P2: Precies!
	83	R: (3.4) Zijn er elementen van het ontwerp die je niet zou willen gebruiken?
Efficacy	84	P2: Nee hij deed precies wat ik van hem veranderde in die zin.
	85	Uiteindelijk is het natuurlijk gewoon een reminder dat ik naar mijn bed moet gaan.
	86	En een 'lekker gedaan' als ik opsta, daar kan ik niet echt bezwaar tegen hebben.
	87	R: Je noemde dat hij erg 'agressief', dat was de eerste reactie die je gaf toen ik zei dat je mocht stoppen met hem gebruiken. Wat bedoelde je daar precies mee?
..Aesthetic	88	P2: Ja dat is dus dat ie dan na drie minuten nog een keer vraagt, lig je al op bed, lig je al op bed, en dat hij dan uiteindelijk uit frustratie dan maar zegt 'slaap lekker hè'.
..Moral	89	Dus dat was redelijk kort door de bocht op dat moment.
	90	R: (4.1) Heb je het gevoel dat het ontwerp je ondersteunde in het veranderen van je gedrag?
	91	P2: Ja het had zeker de potentie om dat te doen, maar zoals ik zei.. ondersteuning ja.

92 R: (4.2) Hoe ondersteunde het jou daarin?

93 P2: De reminder natuurlijk, de essentie van de reminder is daar natuurlijk key in.
94 Dat zetje dat je toch nodig hebt.
95 Dus in die zin zie ik dan ook veel potentie daarin om dat uit te breiden, bijvoorbeeld tegenwoordig een wekker op je iPhone kan jou ook al reminden om naar bed te gaan, en die doet dat dan met een eenvoudig bericht.
96 En daarom heb je met zo'n bot meer een coaching willen.

97 R: Hoe zie je dan dat dit op je telefoon is, en bijvoorbeeld niet op een andere plek?

98 P2: Een telefoon is best wel fijn, want die heb ik eigenlijk altijd wel bij mij in de buurt.
99 Dus dat lijkt me veel efficiënter dan een object of een apparaat.

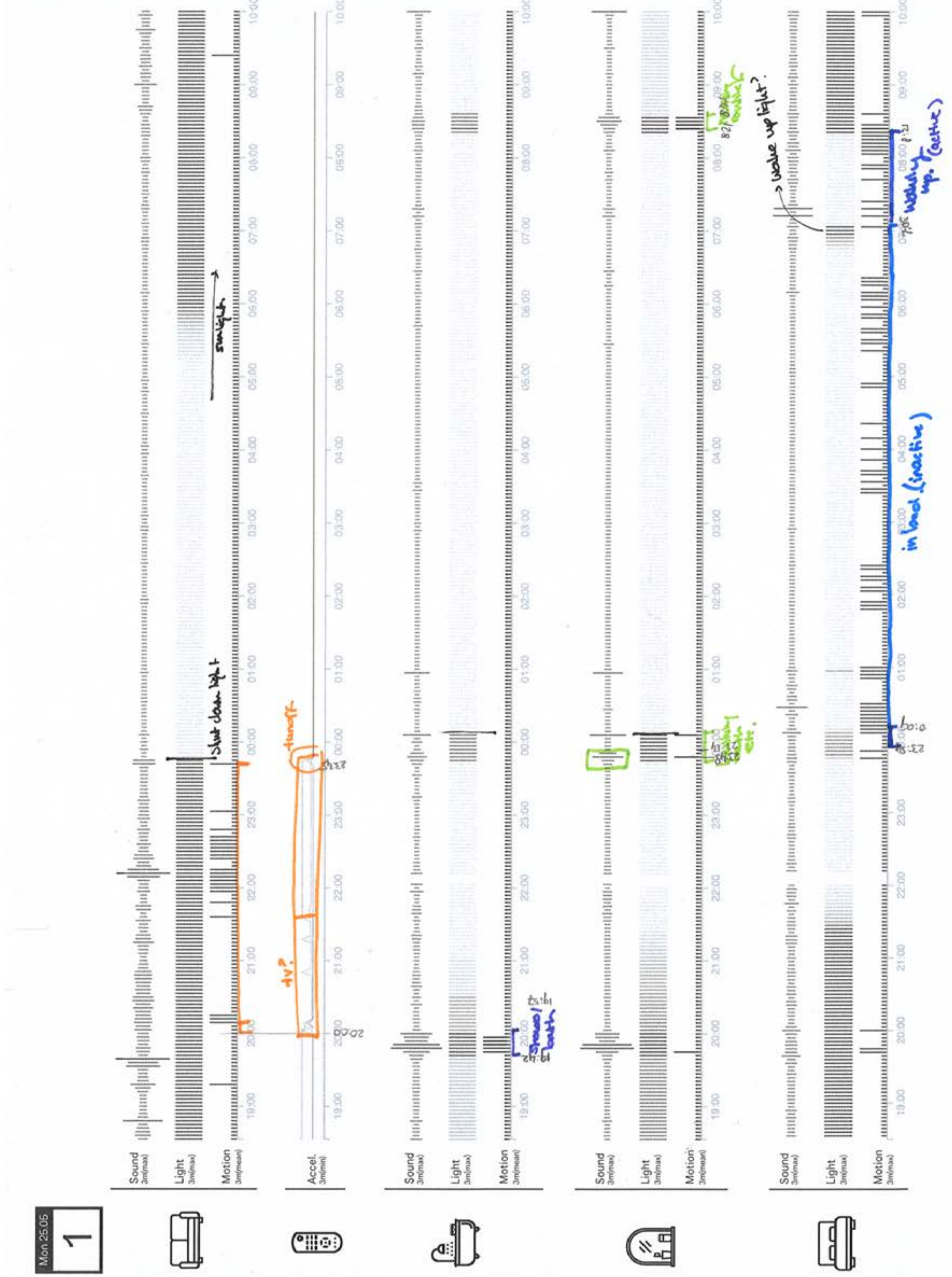
100 R: (4.3) Zou je dit ontwerp aanraden aan je vrienden?

101 P2: Ja als zij problemen hebben met naar bed gaan dan zou ik dat zeker aanraden.
102 Puur om de reminder en de potentie dat het een coachingsobject is om jouw gedrag te veranderen.
103 Als het product verder ontwikkeld wordt, waar ik vanuit ga, zeker met software en apps dan wordt er altijd doorontwikkeld.
104 Als coachingsdevice zou het ideaal zijn, en de mogelijkheden zijn eindeloos hoe ver je gaat met die coaching en hoe goed je het doet, en voor wie en hoe en waar.
105 Ik zie gewoon best wel veel potentie.

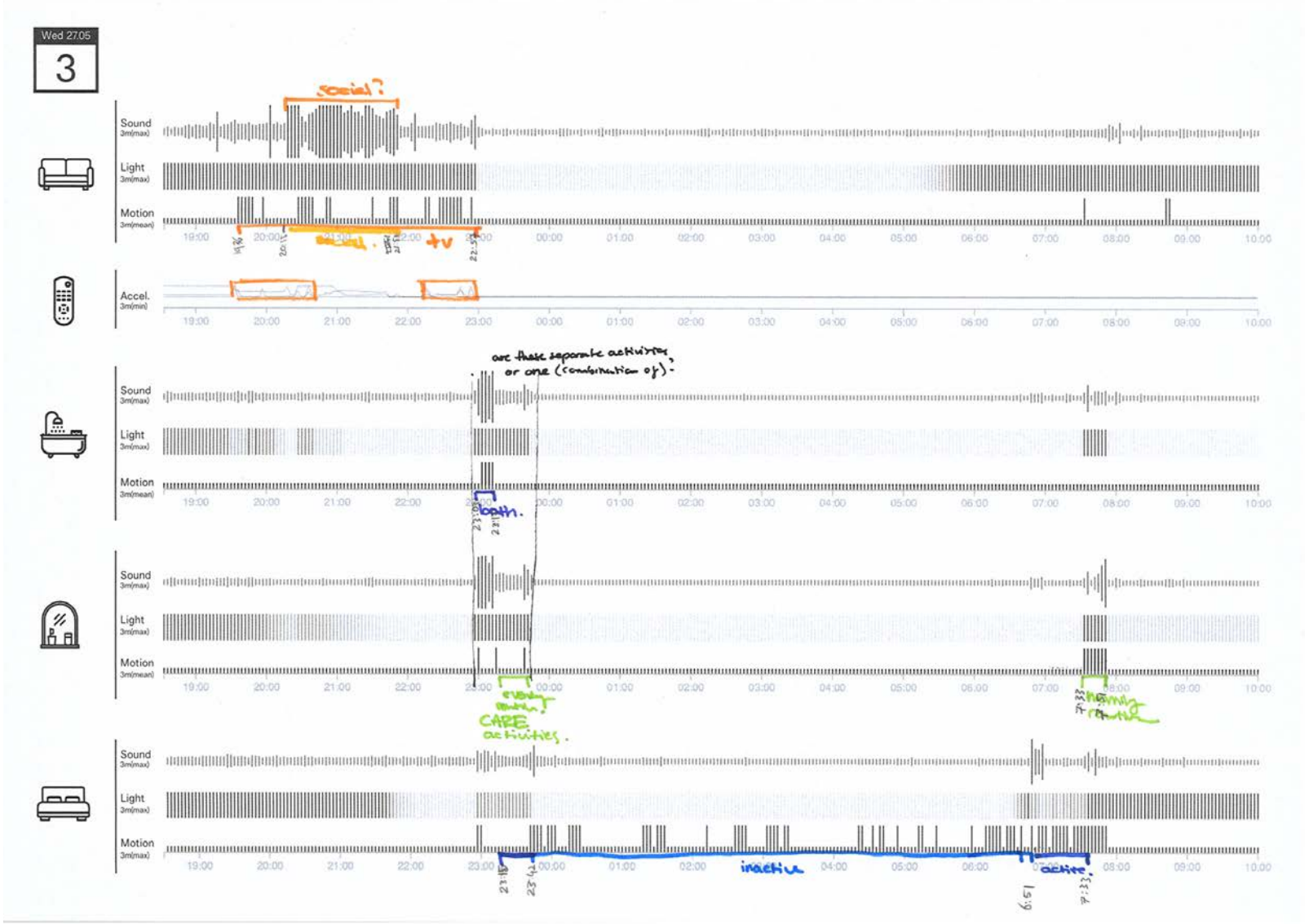
106 R: (4.4.) Zou je dit ontwerp zelf kopen/downloaden?

107 P2: Als er de intentie is om zoiets verder te ontwikkelen dan zou ik dat zeker de app prijs van een paar euro voor betalen

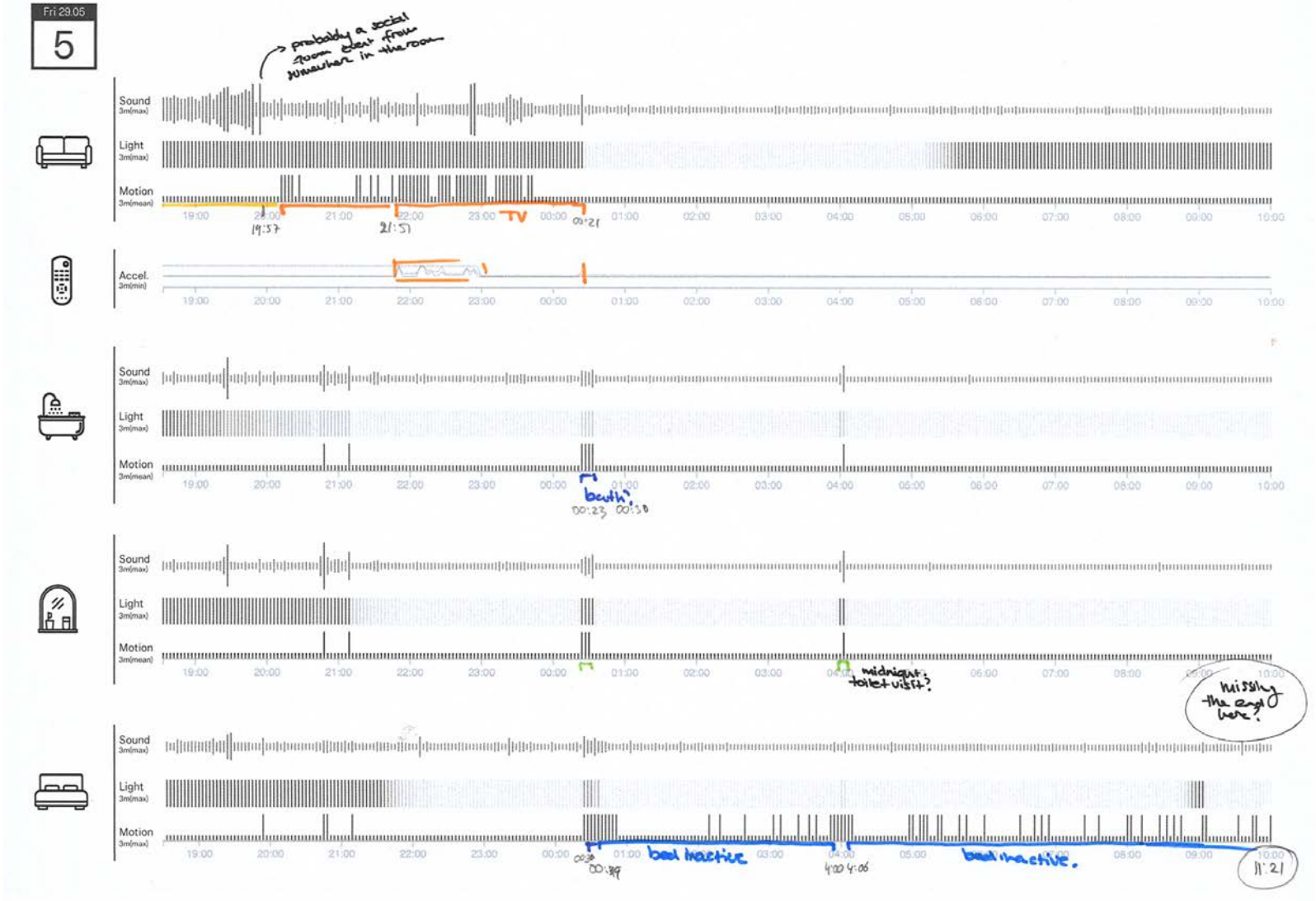
Data worksheets P1



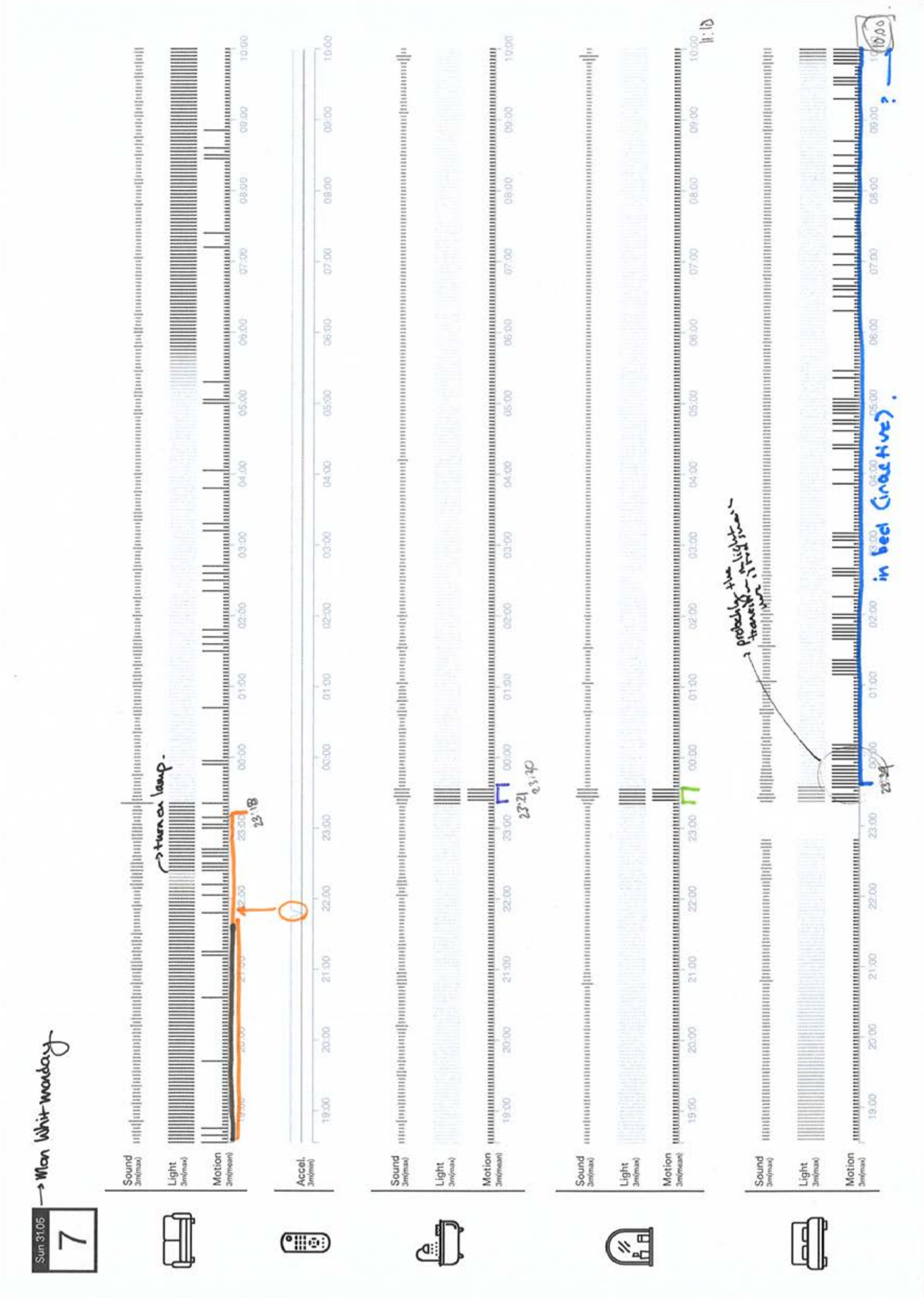
Tue 26.05
2
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Accel.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)
in bed

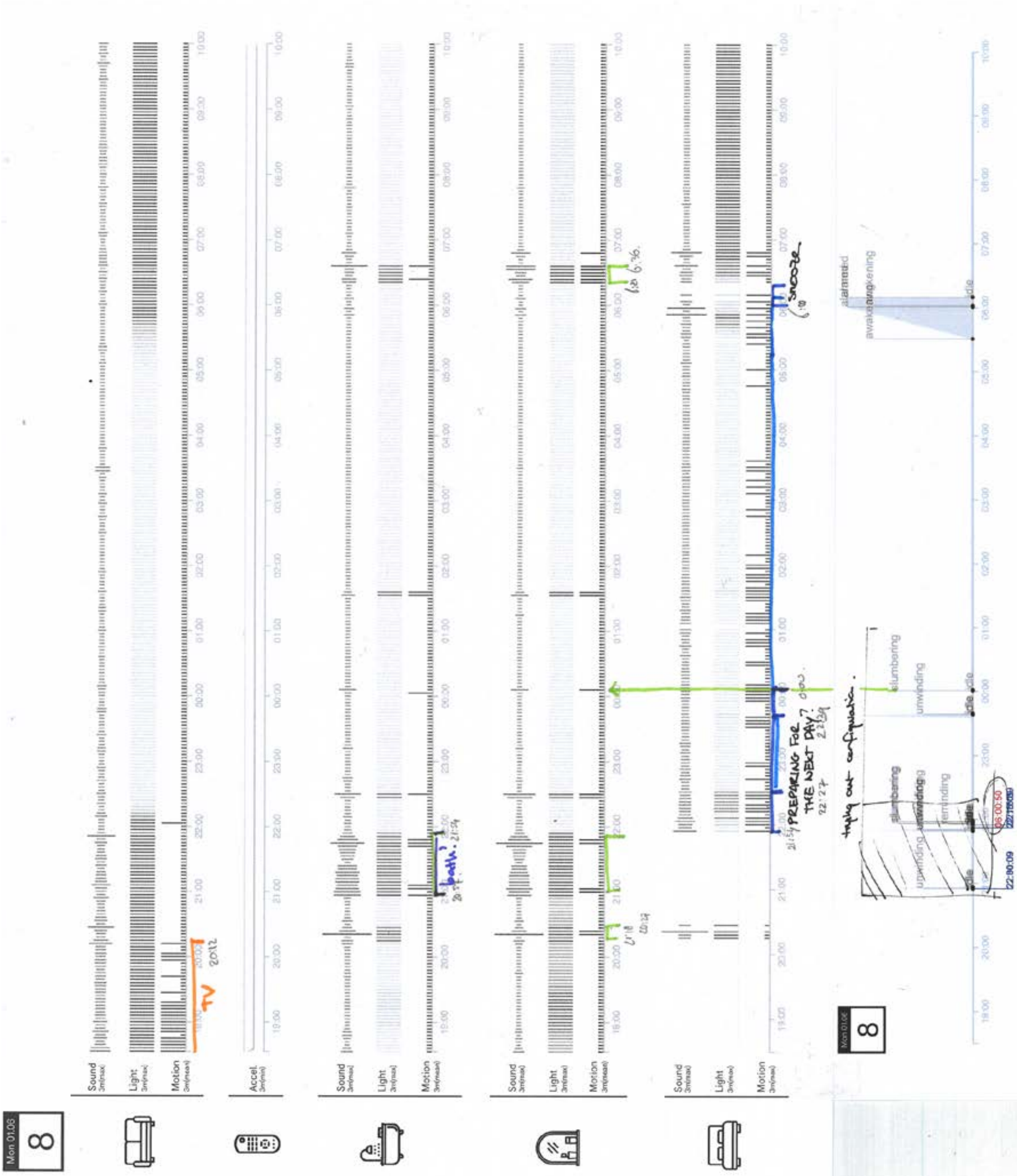

Wed 27.05
3
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Accel.
3m(min)
social?
+v
are these separate activities, or one (combination of)-
bath.
CARE activities.
inactive
active
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00

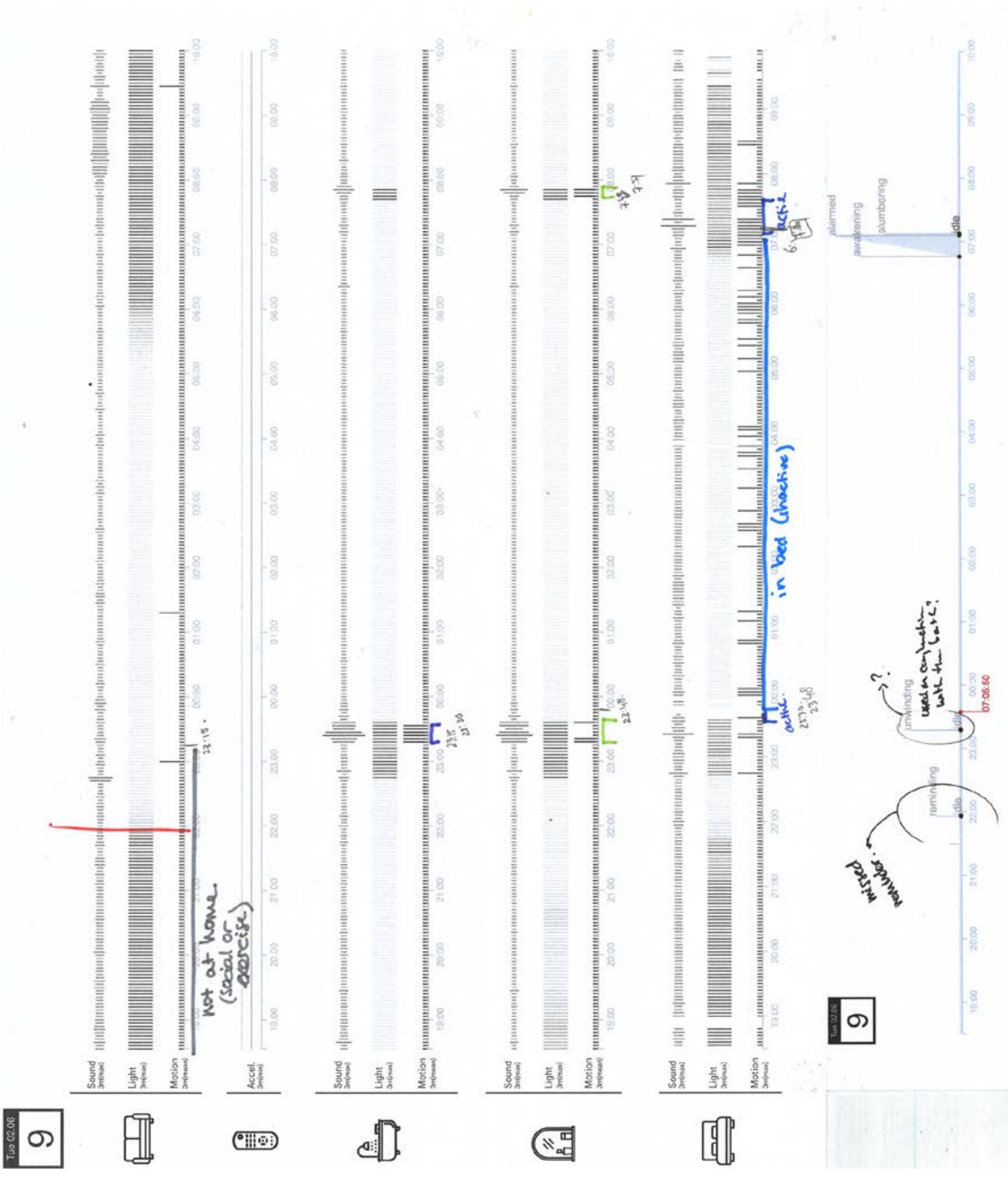
Thu 28.05
4
Sound
Light
Motion
Accel.
bed (inactive)

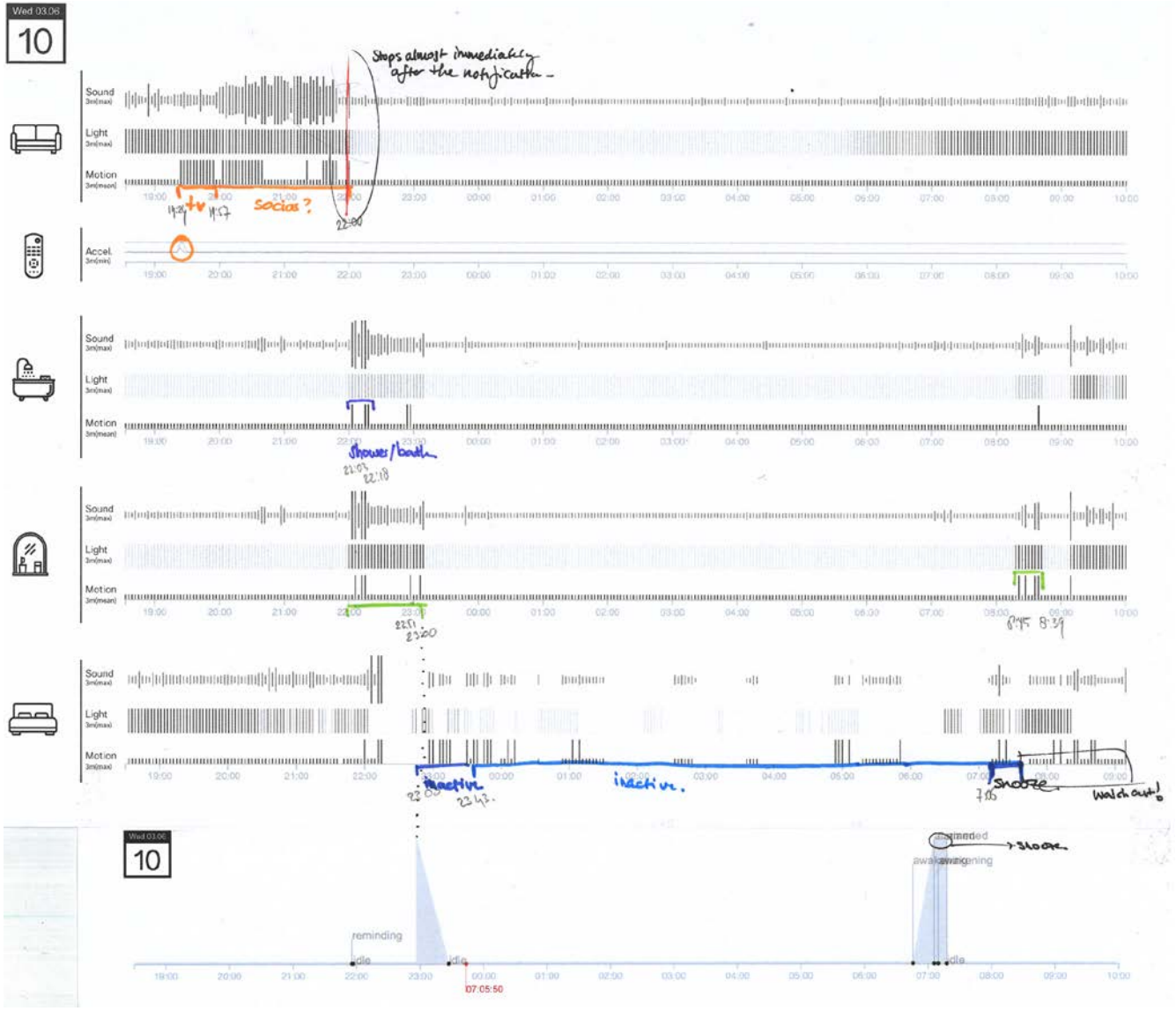

Fri 29.05
5
probably a social room client from elsewhere in the room
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
19:37
21:51
TV
00:21
Accel.
3m(min)
bath?
00:23
00:38
midnight: toilet visit?
missing the night here!
bed inactive
bed inactive.
00:39
4:00
4:06
11:21

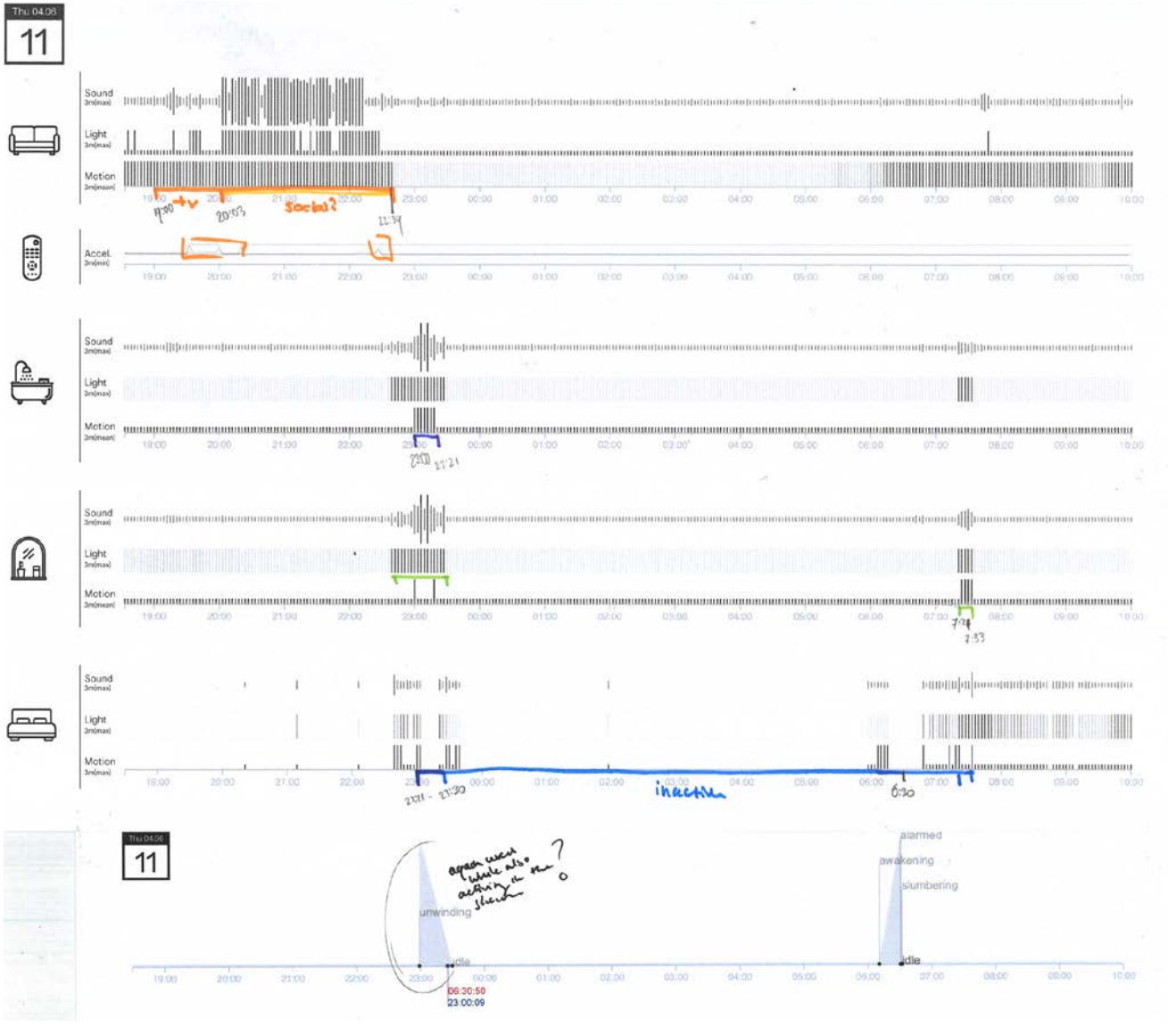
Sat 30.05
6
Sound 3m(max)
Light 3m(max)
Motion 3m(mean)
Accel. 3m(min)
→ enter?
bath
what happened here?

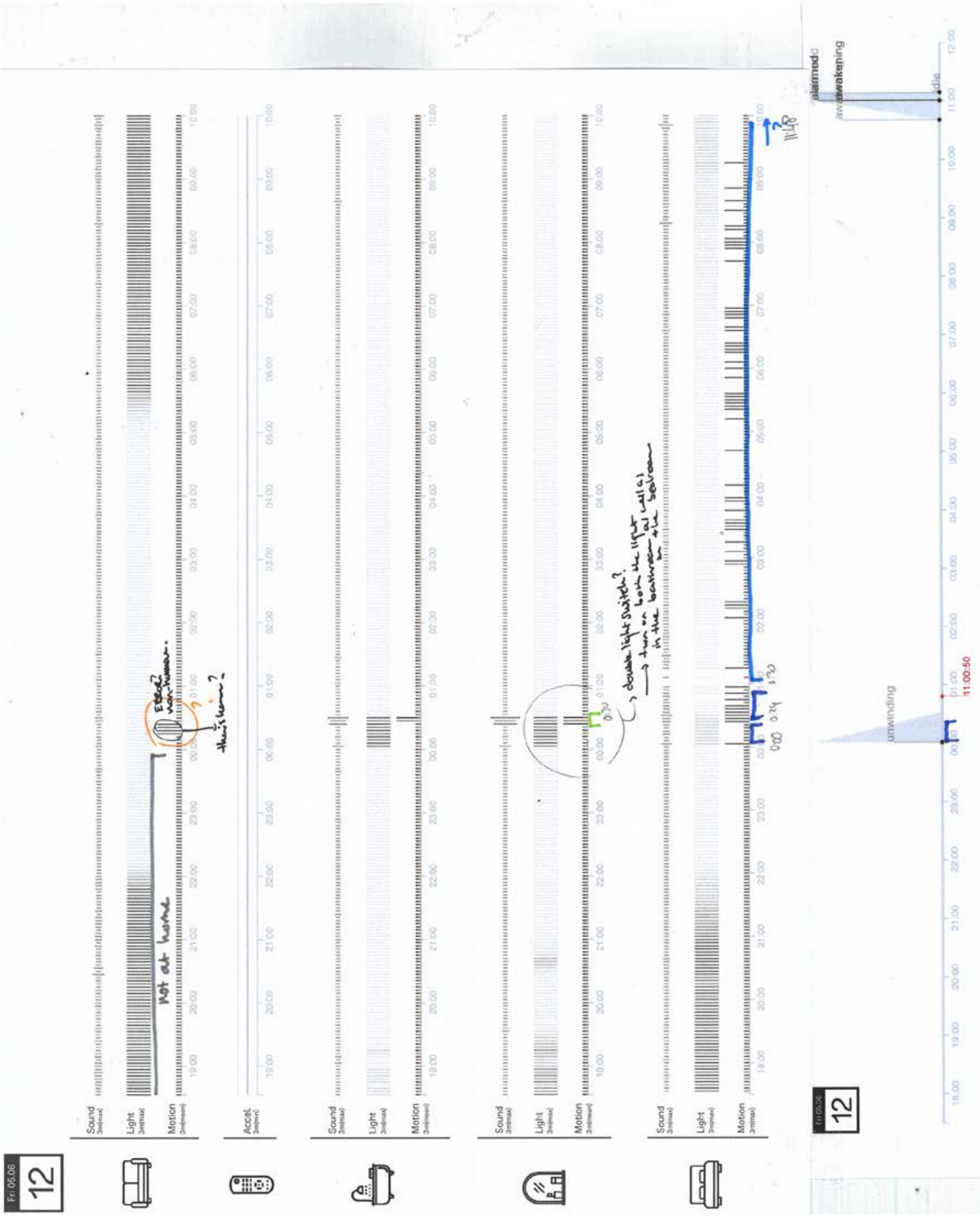

Sun 31.05
7
→ Mon Whit monday
Sound 3m(max)
Light 3m(max)
Motion 3m(mean)
Accel. 3m(min)
→ turn on lamp.
23:18
23:21
23:30
23:24
11:13
10:00
probably the transit in the light sensor
in bed (inactive).

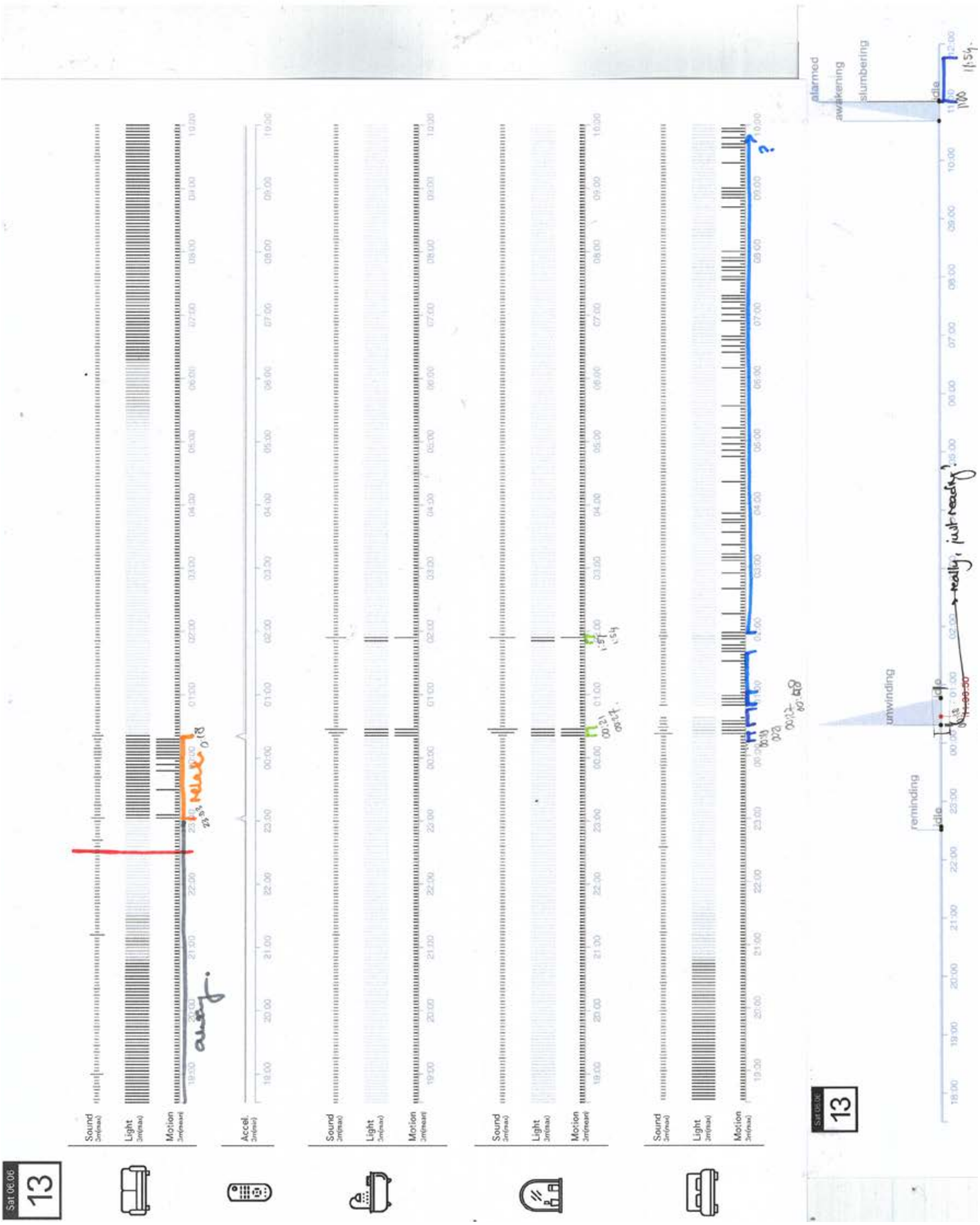

Mon 01.06
8
Sound
Light
Motion
Accel.
TV
bath?
PREPARING FOR THE NEXT DAY?
snooze
trying out configuration.

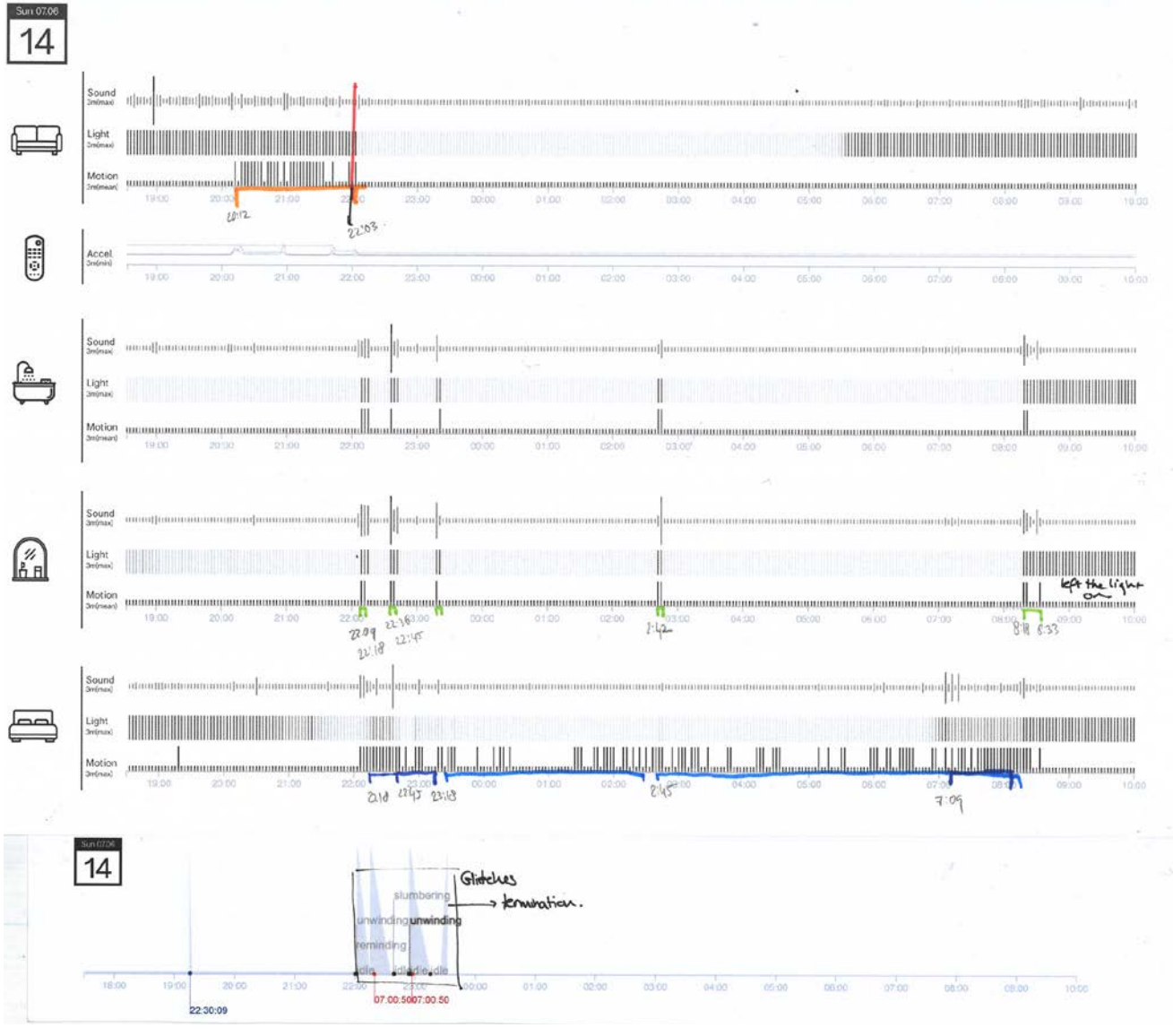

Tue 02.06
9
Sound
Light
Motion
Accel.
not at home (social or exercise)
in bed (inactive)
active
missed reminder?
reminding
unwinding
alarmed
awakening
slumbering
idle
07:05:50

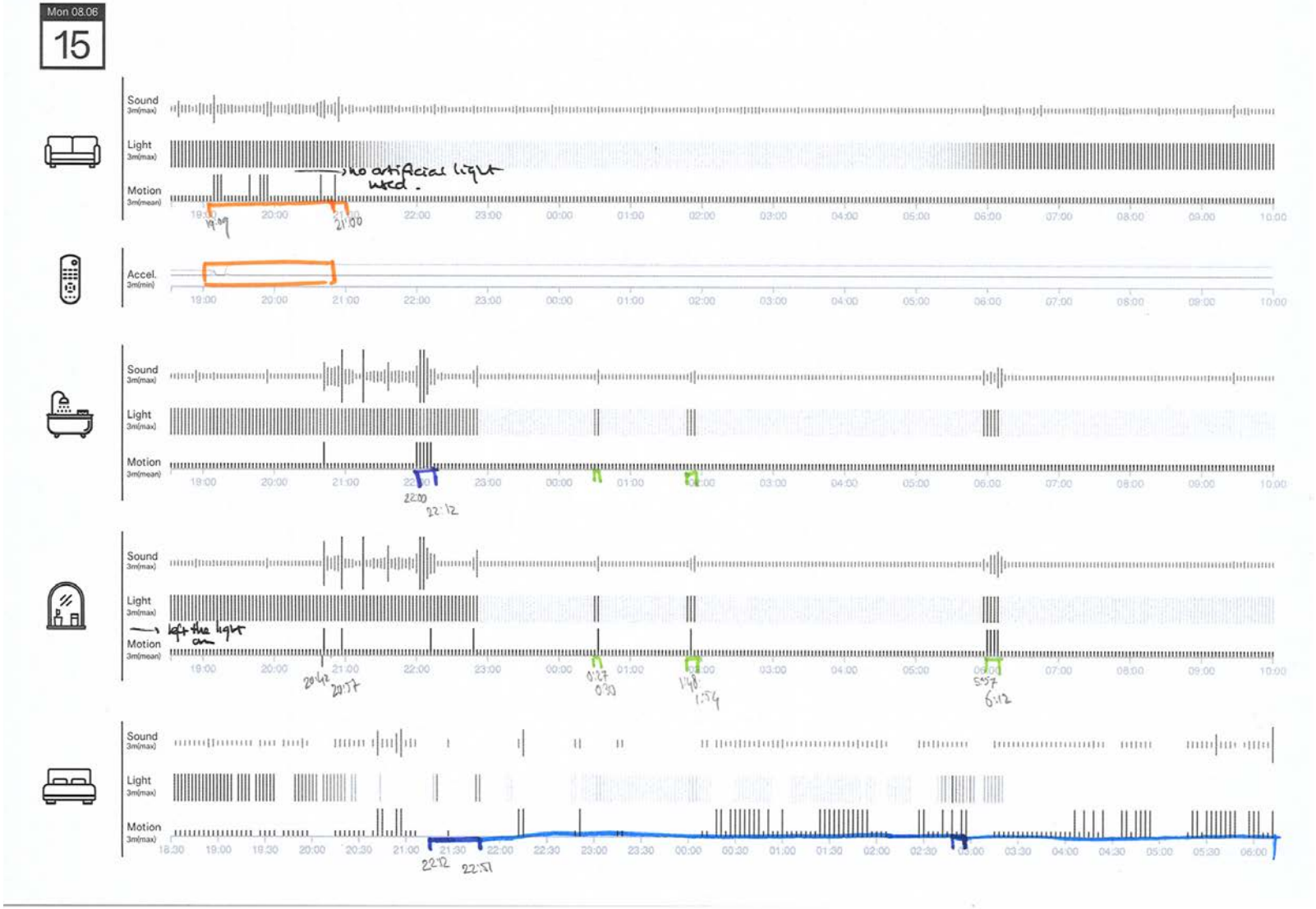

Wed 03.06
10
Sound
Light
Motion
Accel.
Stops almost immediately after the notification
tv
socias ?
Shower/bath
inactive.
inactive
snooze
Watch out!
reminding
idle
awakening
snooze
07:05:50


Thu 04.06
11
Sound
Light
Motion
Accel
tv
social?
inactive
Thu 04.06
11
unwinding
idle
alarmed
awakening
slumbering
idle
06:30:50
23:00:09

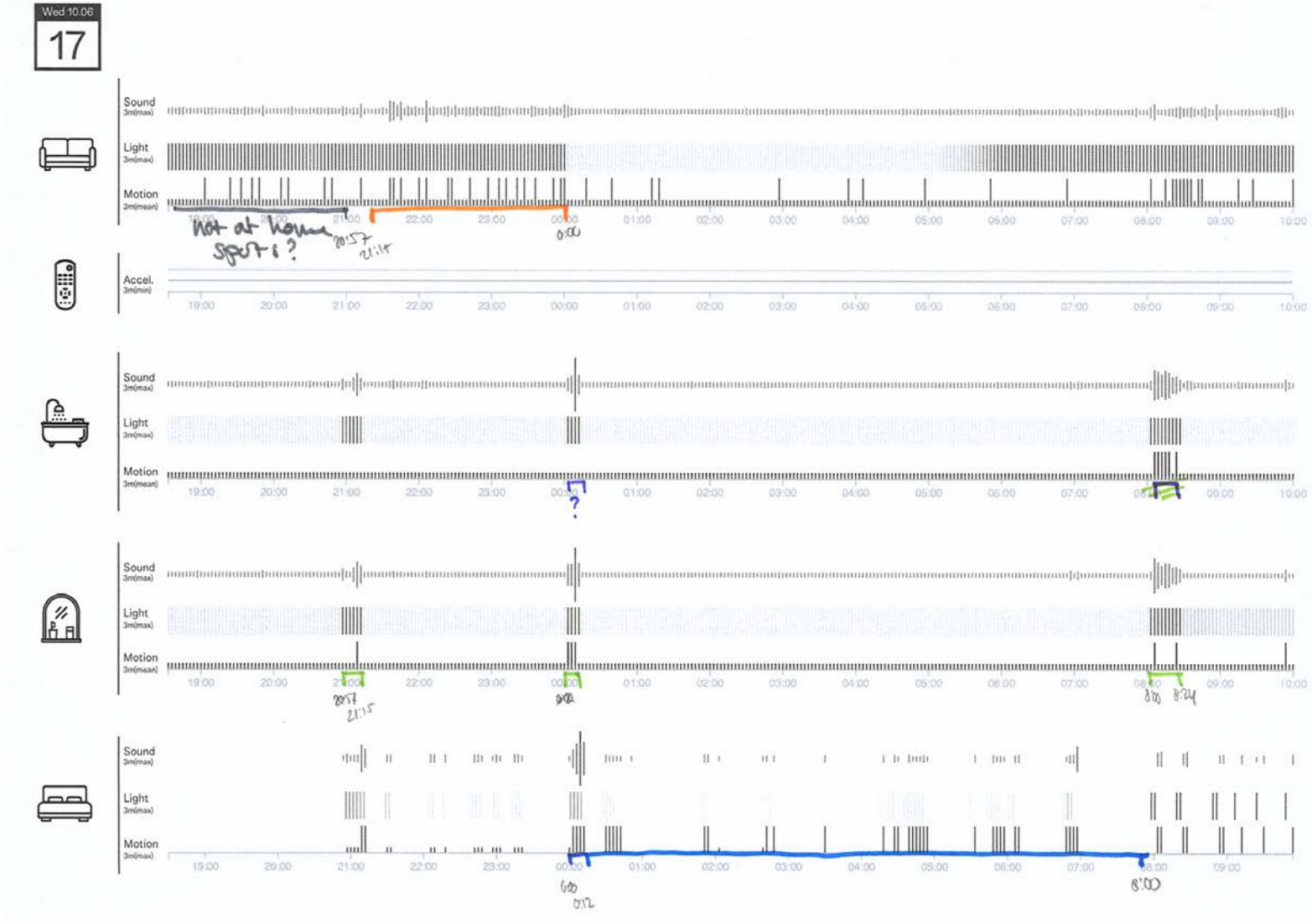

Fri 05.06
12
Sound
Light
Motion
Accel.
Not at home
unwinding
awakening
alarmed
11:00:50

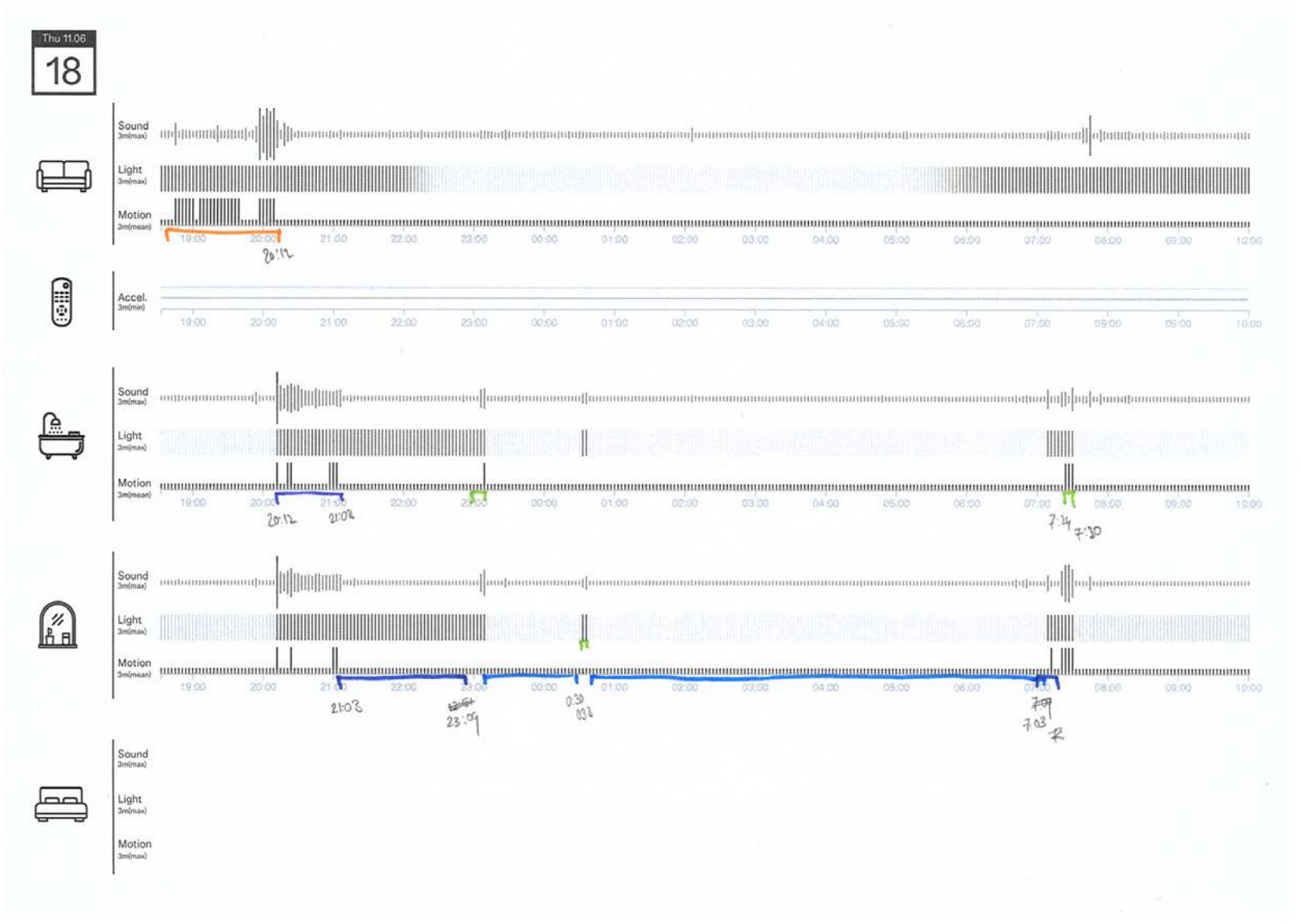

Sat 06.06
13
Sound
Light
Motion
Accel.
alarmed
awakening
slumbering
unwinding
reminding
idle
really, just ready?


Sun 07.06
14
Sound
Light
Motion
Accel
kept the light on
Sun 07.06
14
Glitches
transition.
slumbering
unwinding
unwinding
reminding
idle
idle
idle
22:30:09
07:00:50
07:00:50

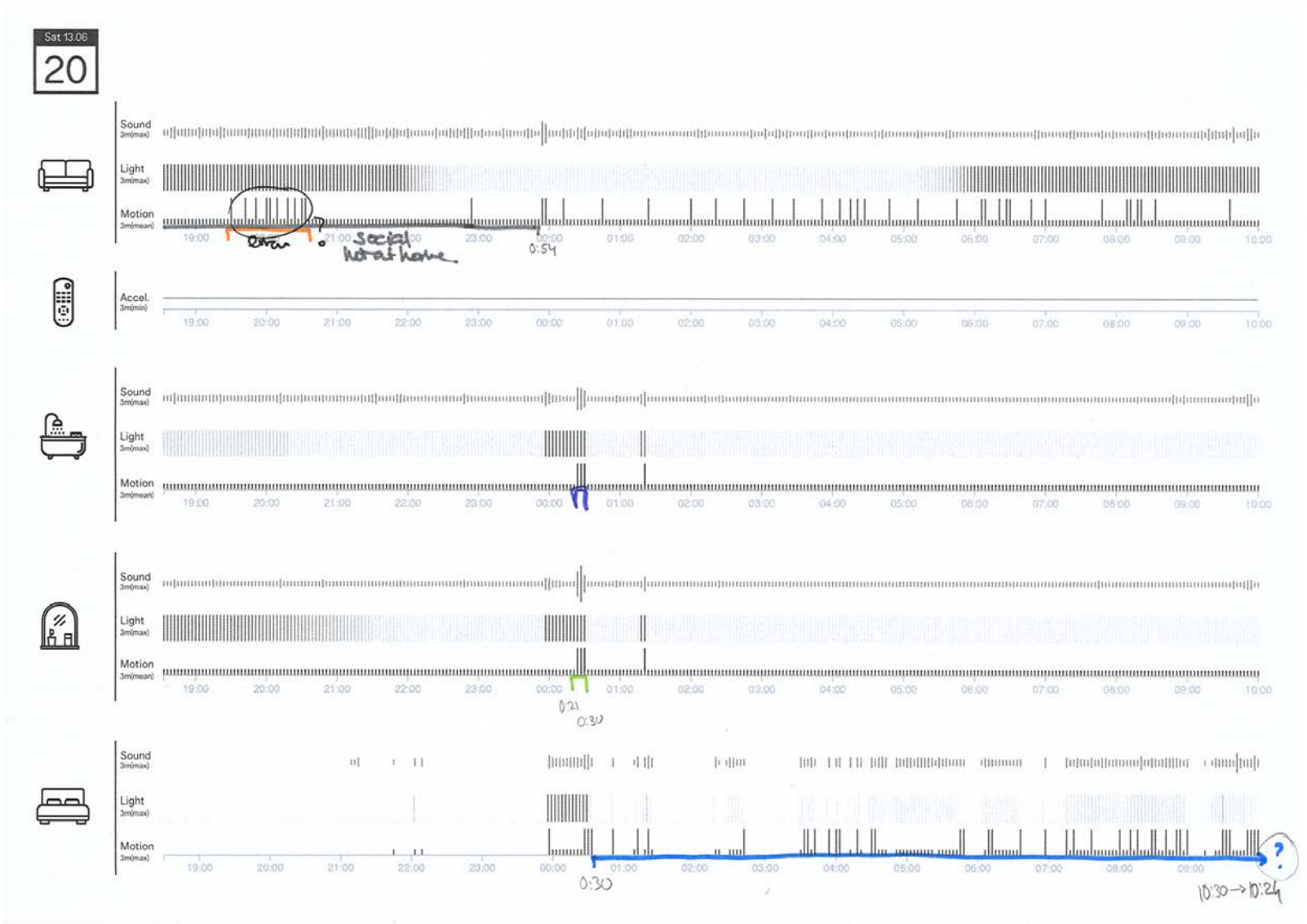

Mon 08.06
15
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
no artificial light used.
Accel.
3m(min)
left the light on
Motion
3m(max)

Tue 09.06
16
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Accel.
3m(min)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
21:30
22:00
23:00


Wed 10.06
17
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
not at home
sport?
Accel.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)

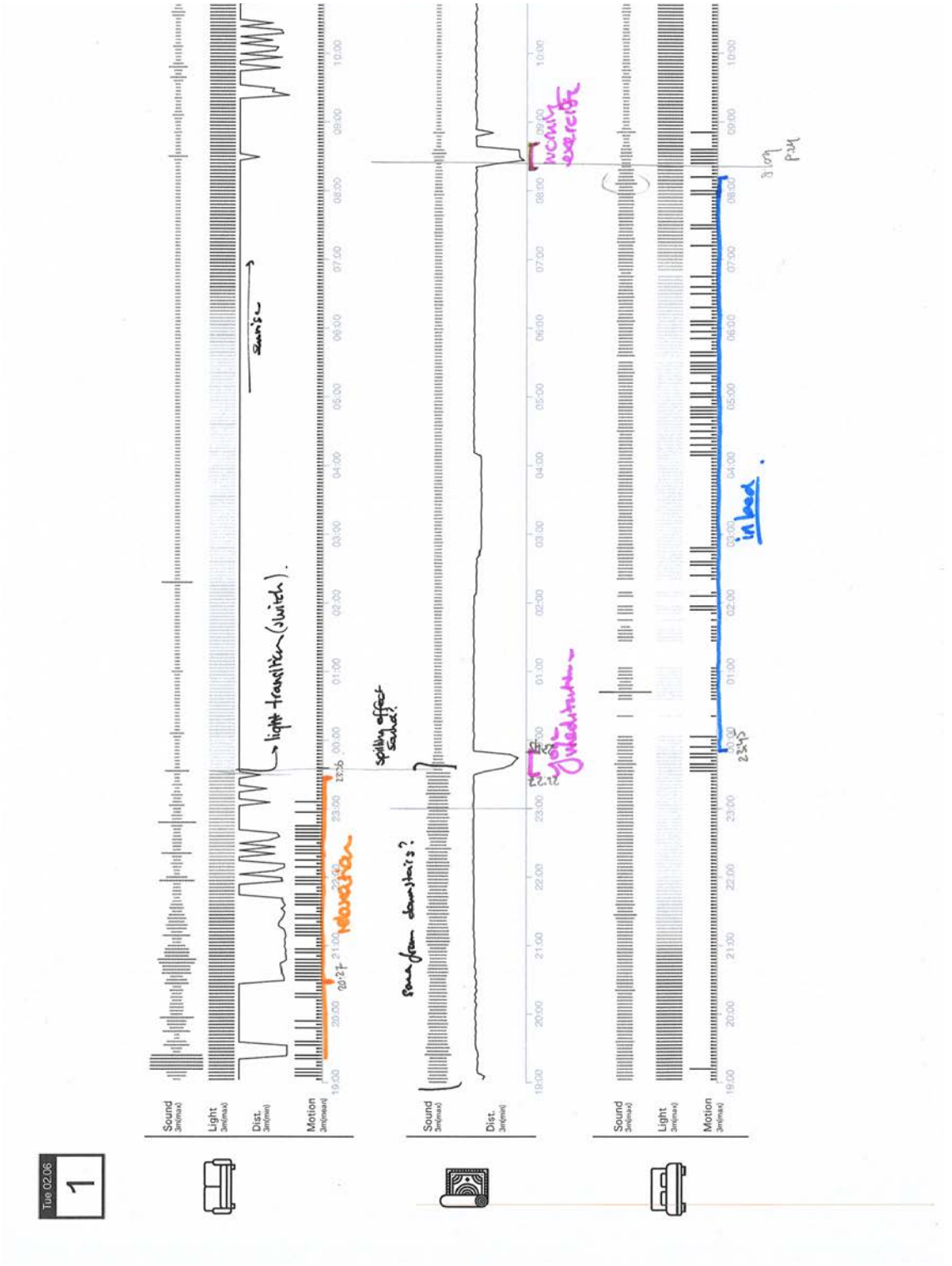

Thu 11.06
18
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
20:12
Accel.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
20:12
21:02
7:14
7:30
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
21:03
23:04
0:30
0:33
7:09
7:03
Sound
3m(max)
Light
3m(max)
Motion
3m(max)

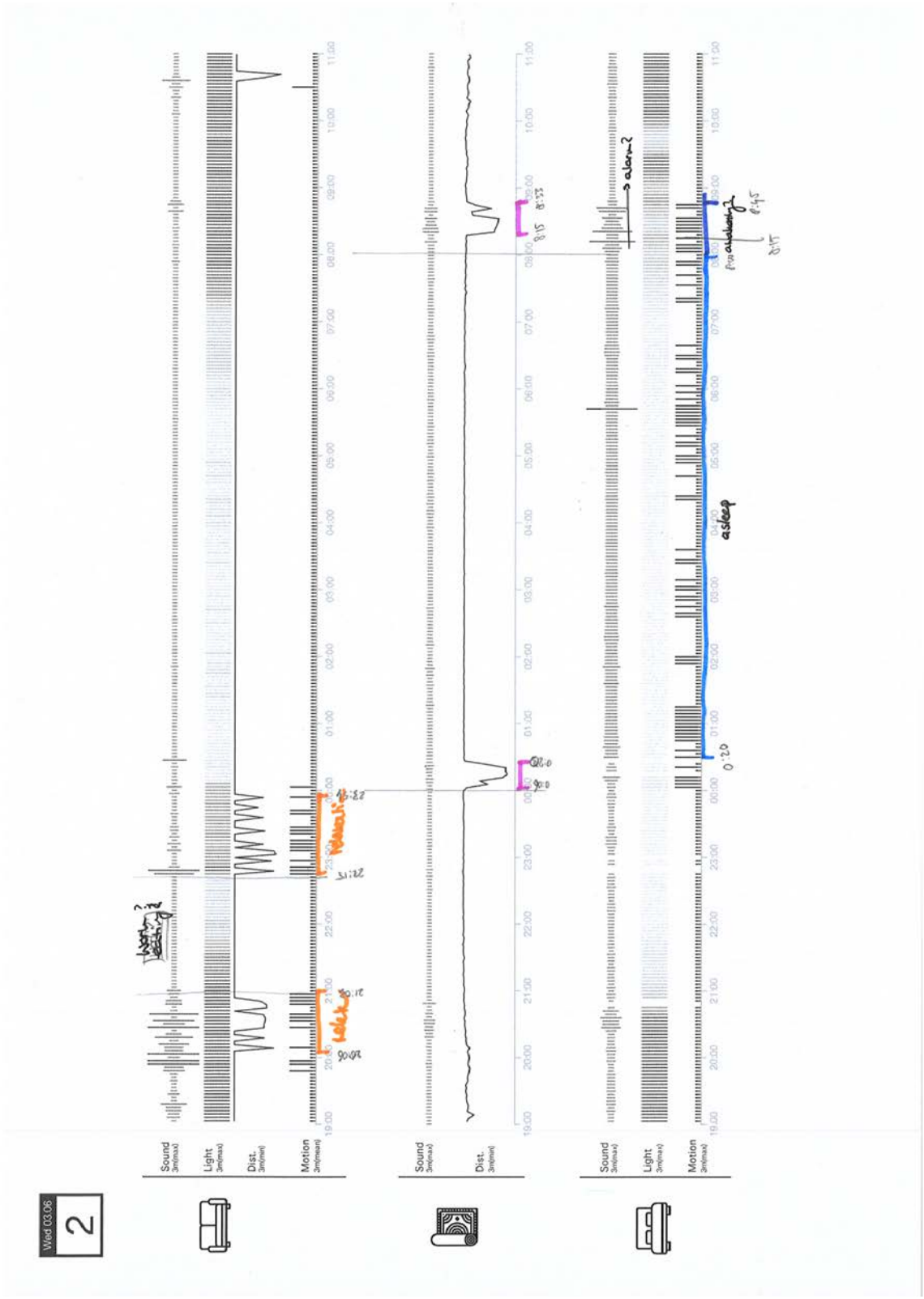
Fri 12.06
19
Sound
Light
Motion
Accel.
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00


Sat 13.06
20
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
0:54
Accel.
3m(min)
0:21
0:30
?
10:30→10:24

Sun 14.06
21
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Accel.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Sound
3m(max)
Light
3m(max)
Motion
3m(mean)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00

Data worksheets P2



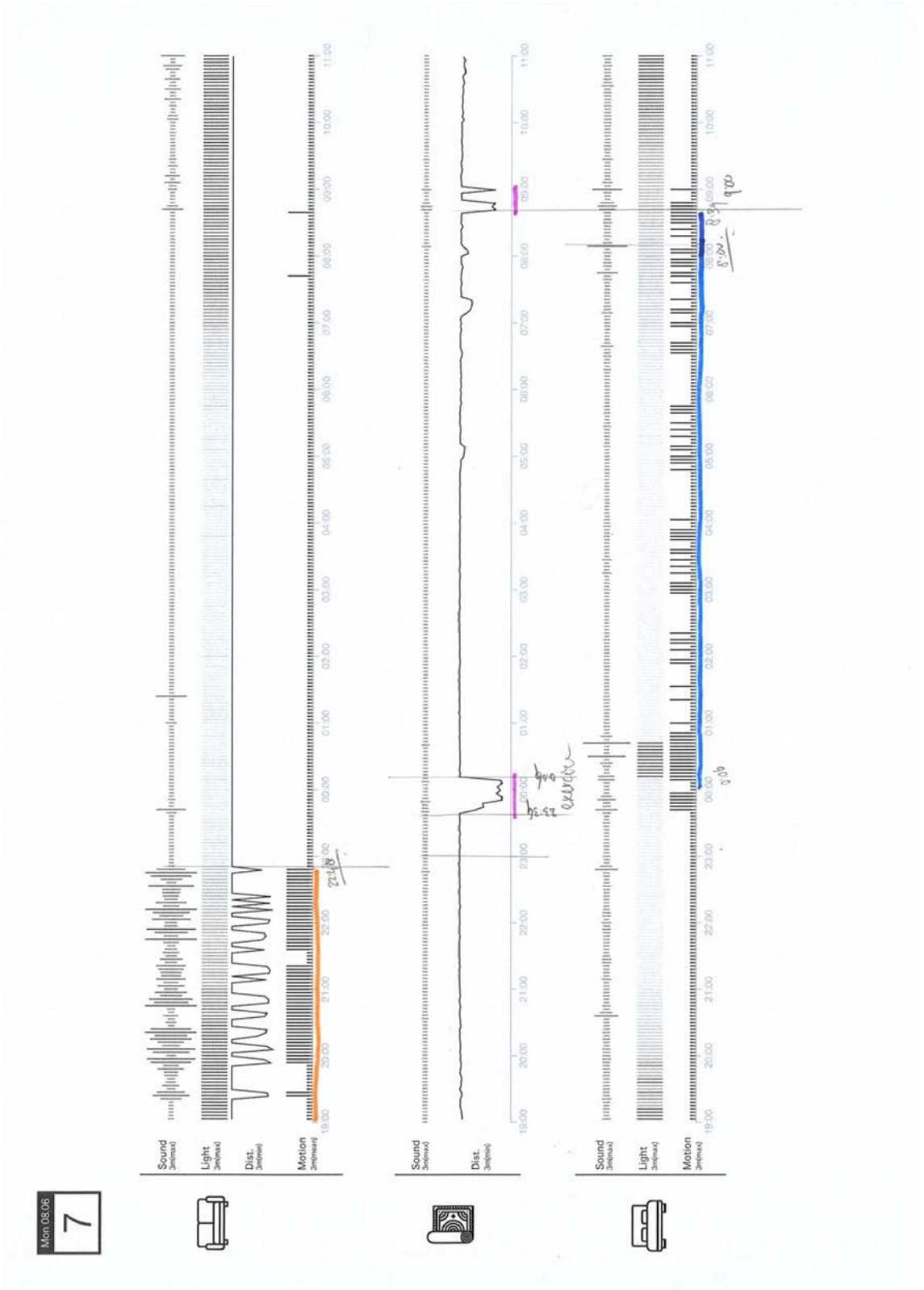

Wed 03.06
2
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
2m(mean)
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
2m(max)
asleep

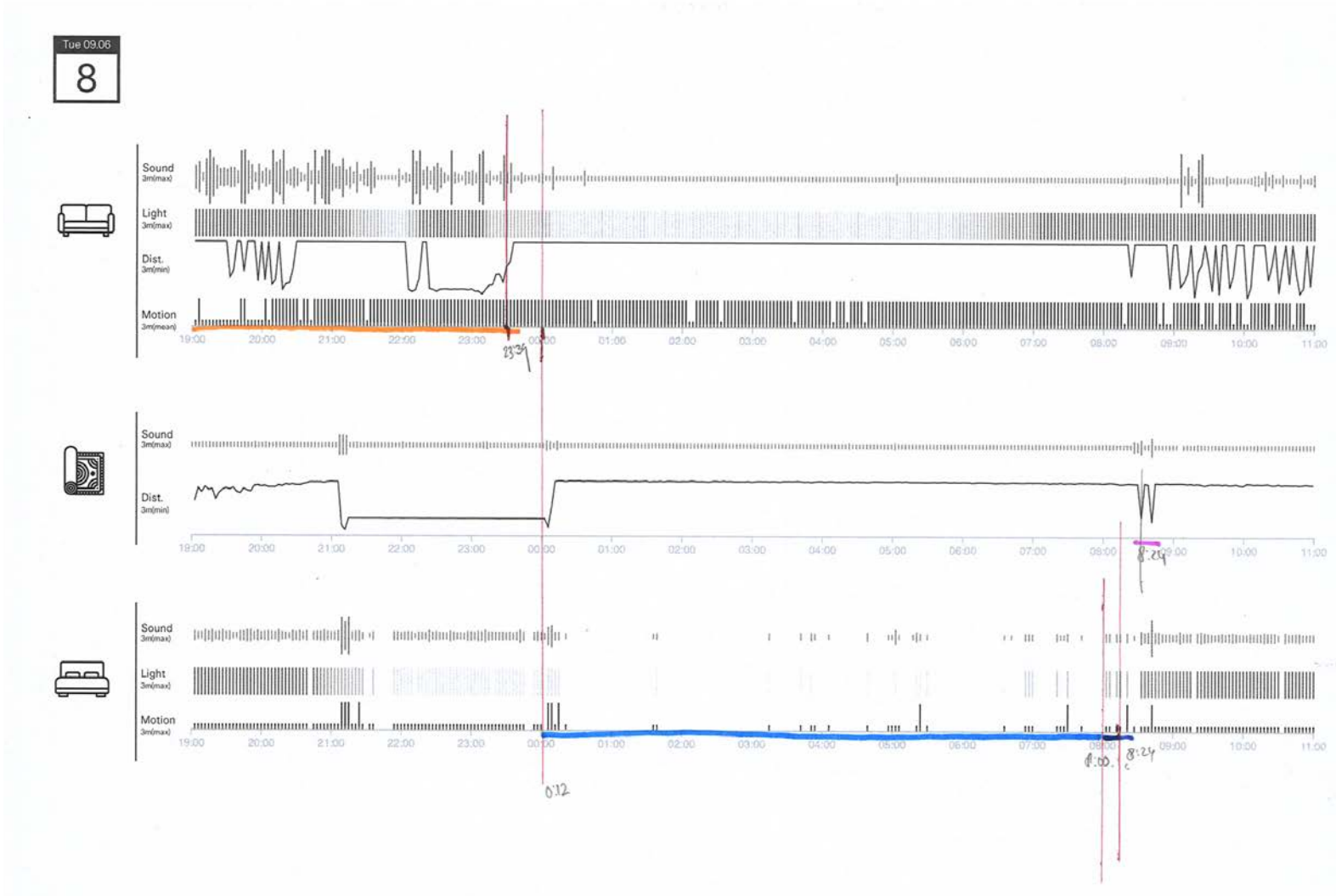
Thu 04.06
3
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(max)
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)

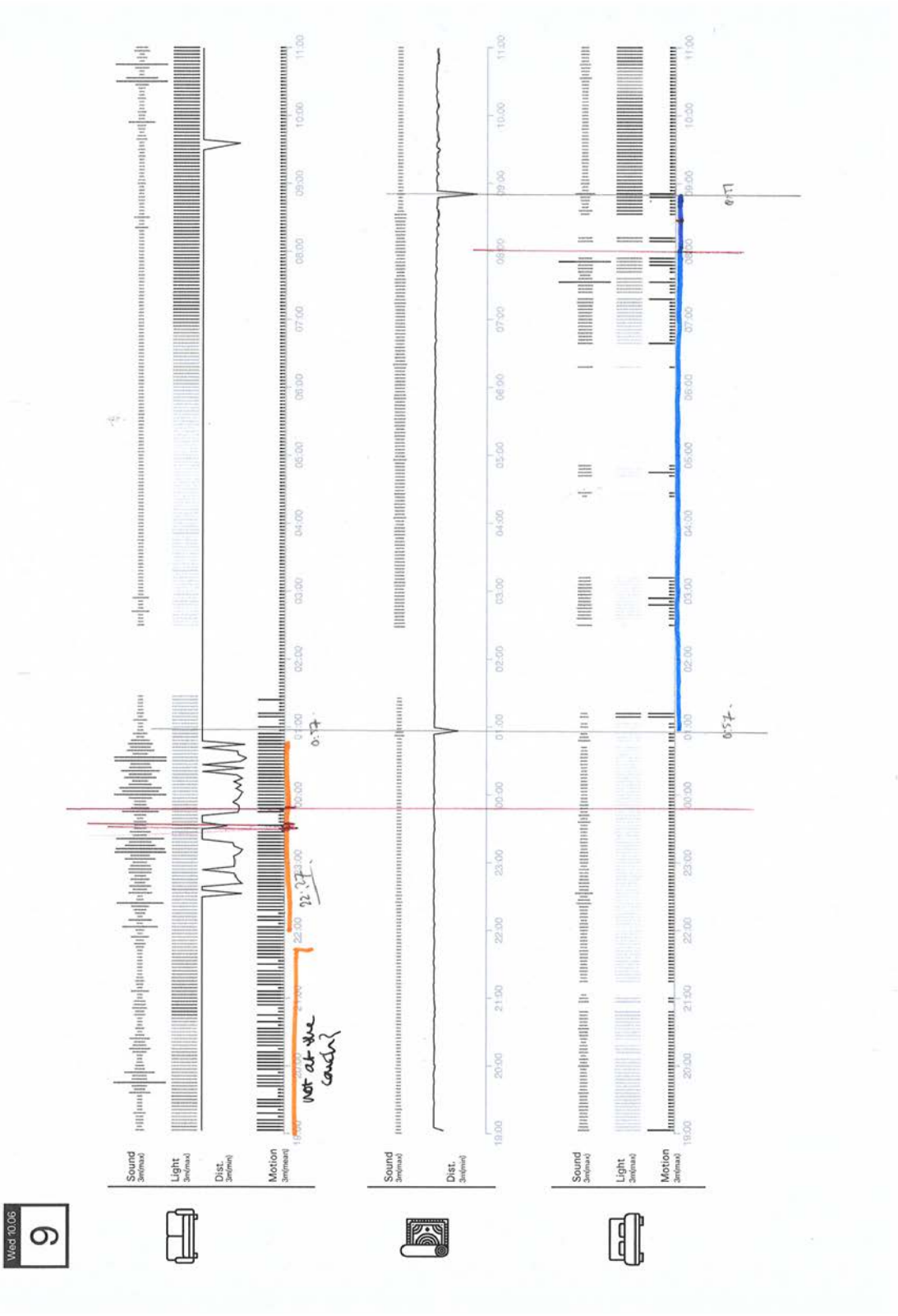
Fri 05.06
4
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)

Sat 06.06
5
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
23:21
4:23
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)
21:21
4:33
13:30

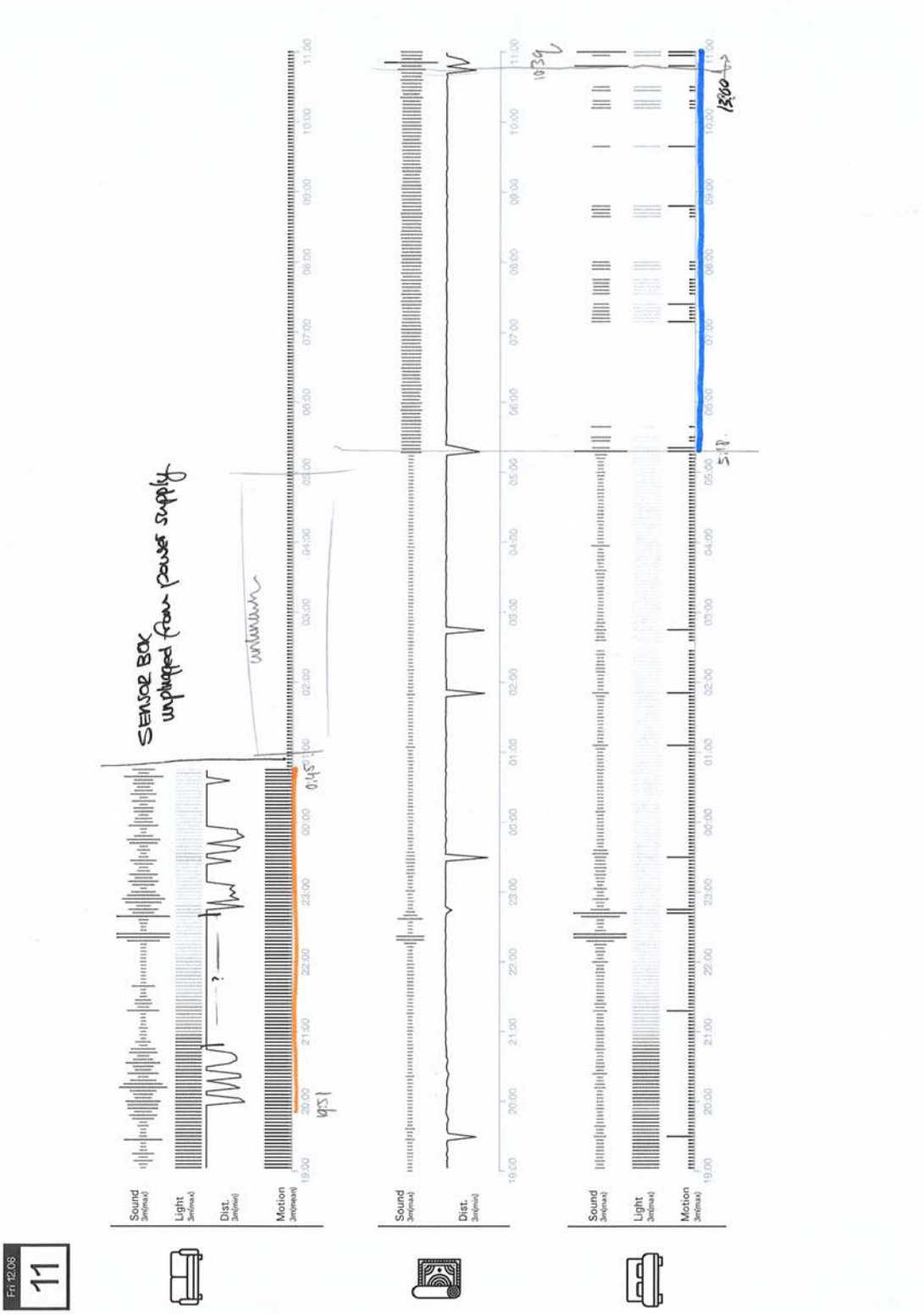
Sun 07/06
6
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)


Mon 08.06
7
Sound
Light
Dist.
Motion
Sound
Dist.
Sound
Light
Motion


Tue 09.06
8
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
23:34
Sound
3m(max)
Dist.
3m(min)
8:24
Sound
3m(max)
Light
3m(max)
Motion
3m(max)
0:12
8:00
8:24


Wed 10.06
6
Sound 3m(max)
Light 3m(max)
Dist. 3m(min)
Motion 3m(mean)
Sound 3m(max)
Dist. 3m(min)
Sound 3m(max)
Light 3m(max)
Motion 3m(max)

Thu 11.06
10
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)


Fri 12.06
11
Sound
Light
Dist.
Motion
SENSOR BOX
unplugged from power supply
Sound
Dist.
Sound
Light
Motion

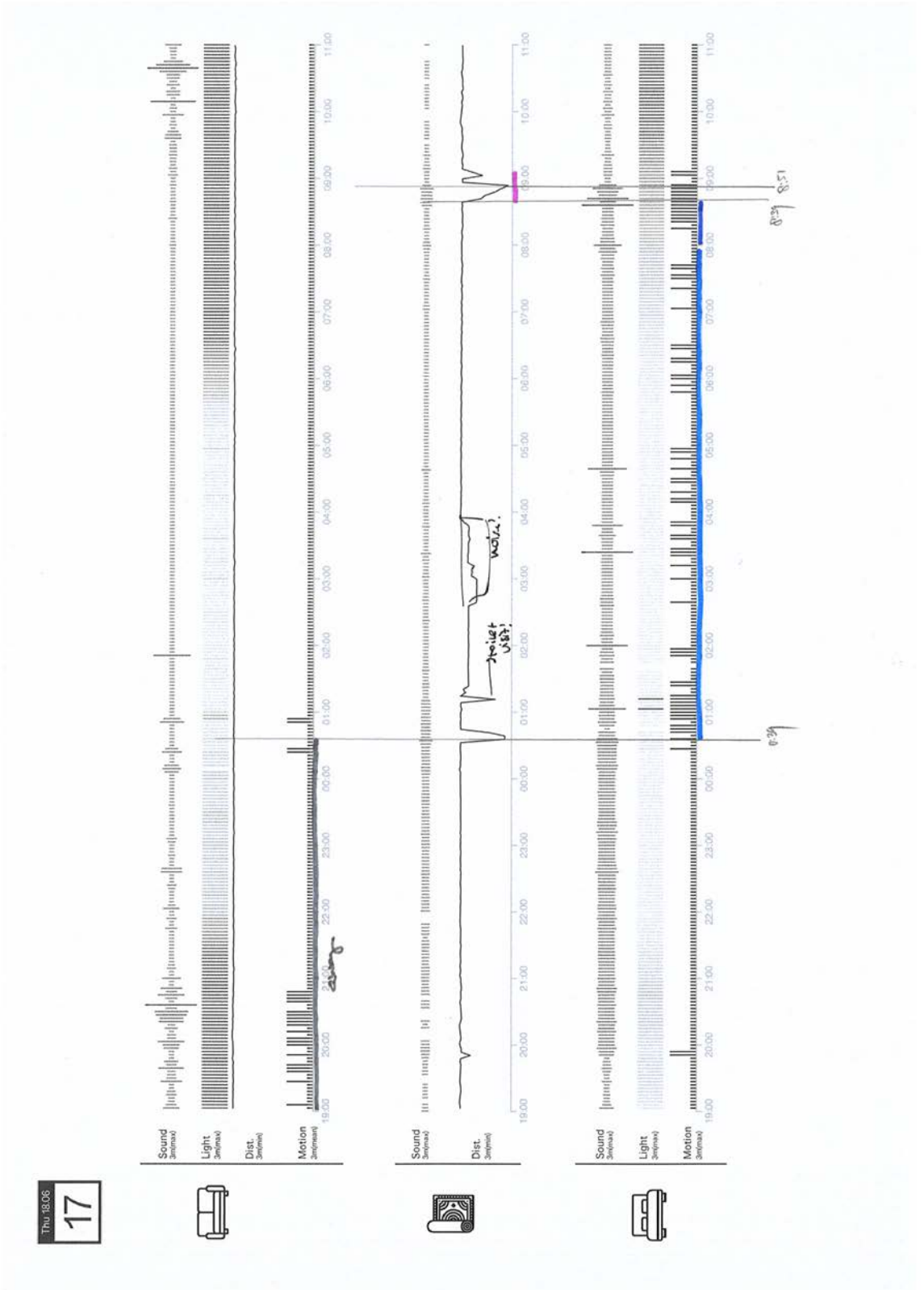
Sat 13.06
12
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
in bed?

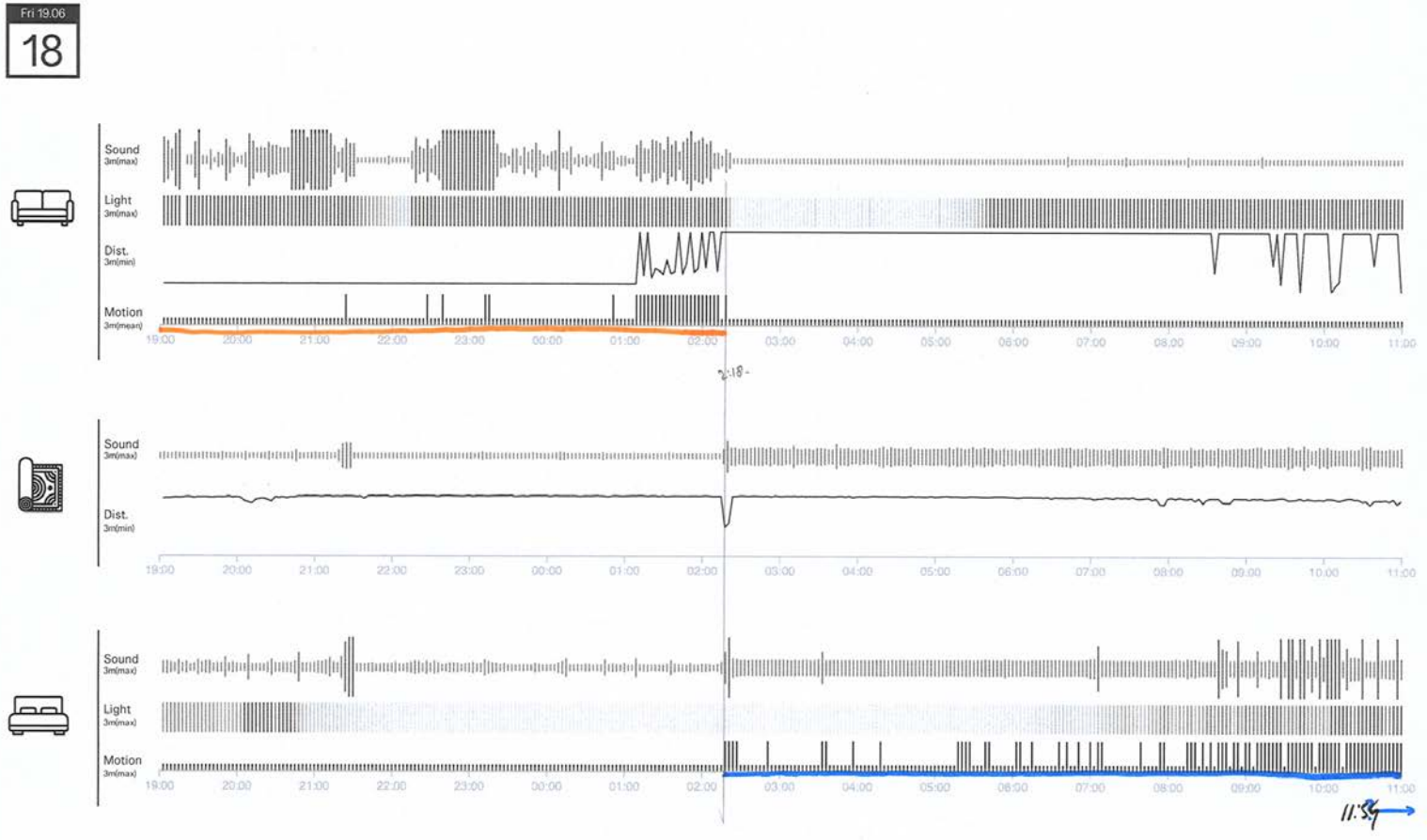
Sun 14.06
13
Sound 3m(max)
Light 3m(max)
Dist. 3m(min)
Motion 3m(mean)
Sound 3m(max)
Dist. 3m(min)
Sound 3m(max)
Light 3m(max)
Motion 3m(max)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
0:24
8:00
8:45

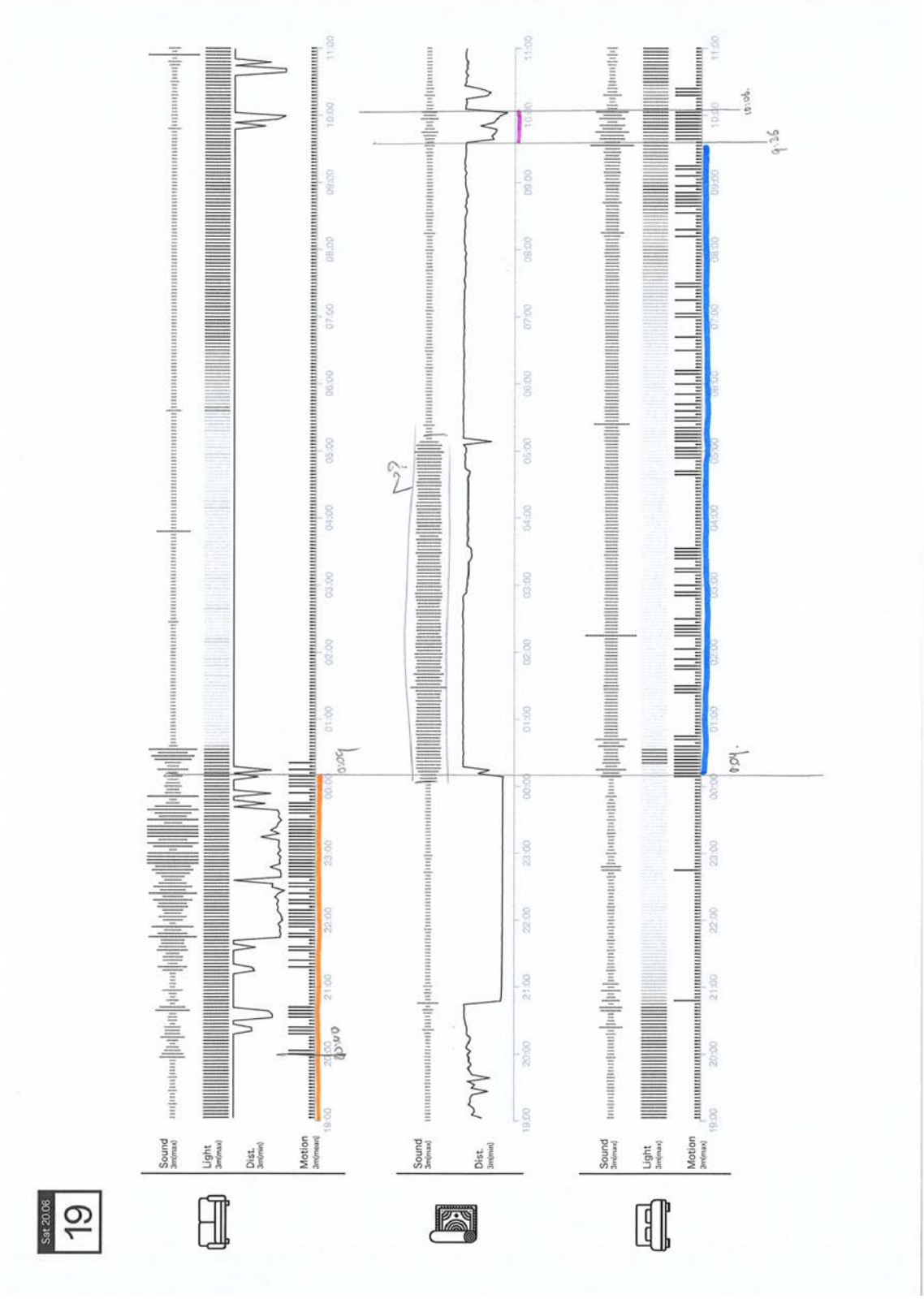
Mon 15.06
14
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)
8:12
9:00
0:12

Tue 16.06
15
Sound
3m(max)
Light
3m(max)
Dist.
3m(max)
Motion
3m(max)
Sound
3m(max)
Dist.
3m(max)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)

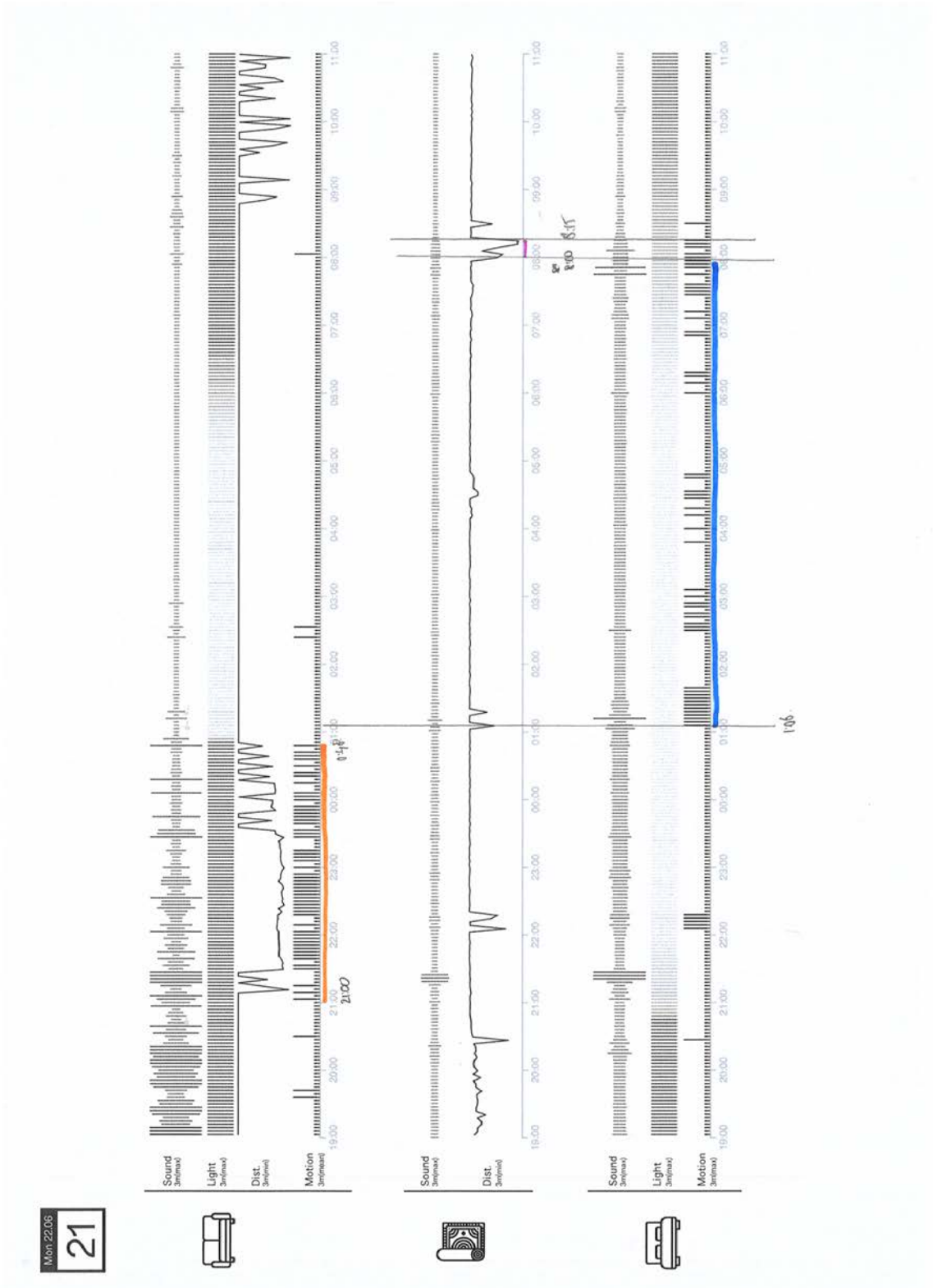
Wed 17/06
16
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)


Thu 18.06
17
Sound 3m(max)
Light 3m(max)
Dist. 3m(min)
Motion 3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00


Fri 19.06
18
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)


Sat 20.06
19
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)

Sun 21.06
20
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
20:32
0:06
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)
8:24
8:00
9:15


Mon 22.06
21
Sound
3m(max)
Light
3m(max)
Dist.
3m(min)
Motion
3m(mean)
Sound
3m(max)
Dist.
3m(min)
Sound
3m(max)
Light
3m(max)
Motion
3m(max)

Data analysis figures

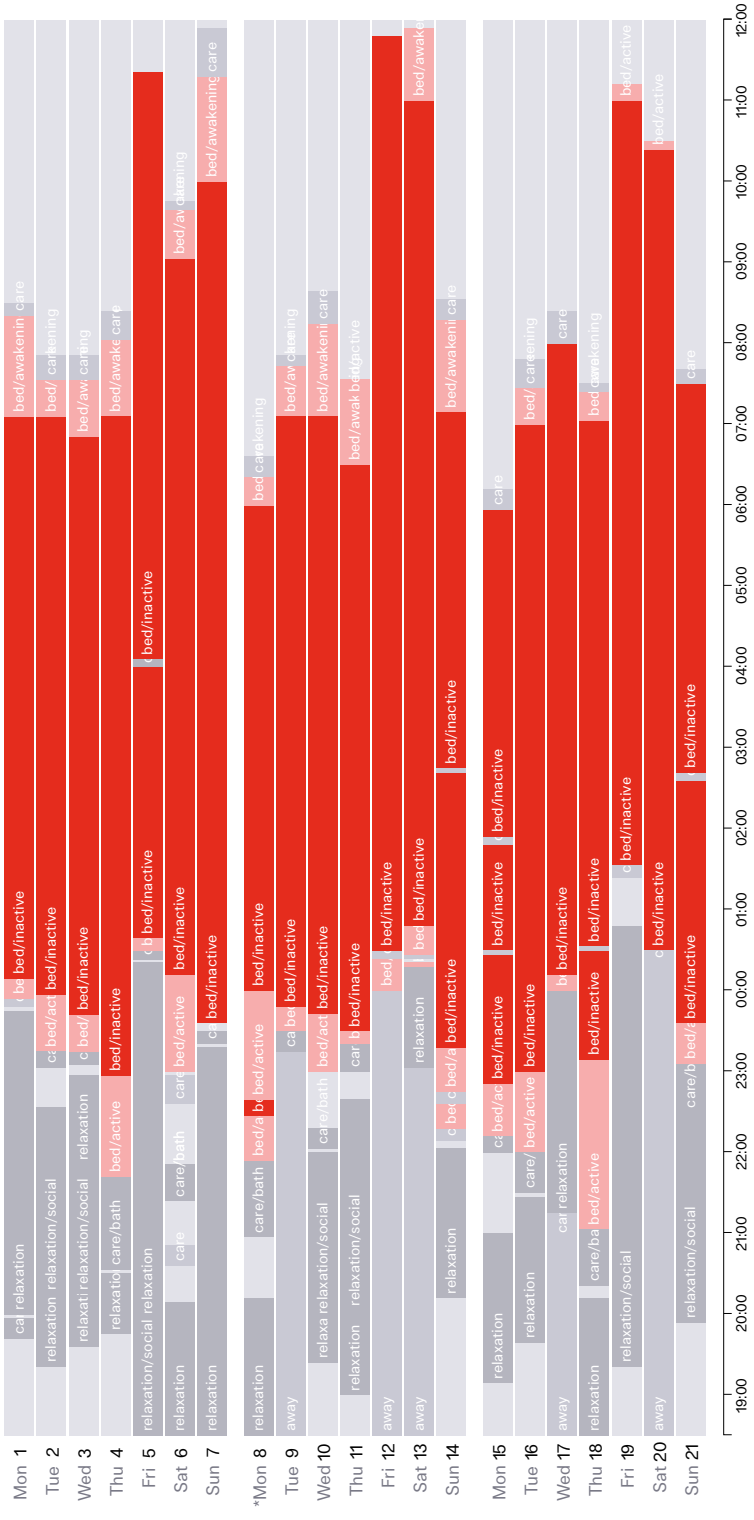


Fig. 53 Interpreted timeline of inferred activities for P1, showing the time in bed in red/pink and the other activities in grey. Note that only the evening routine was analysed during this experiment

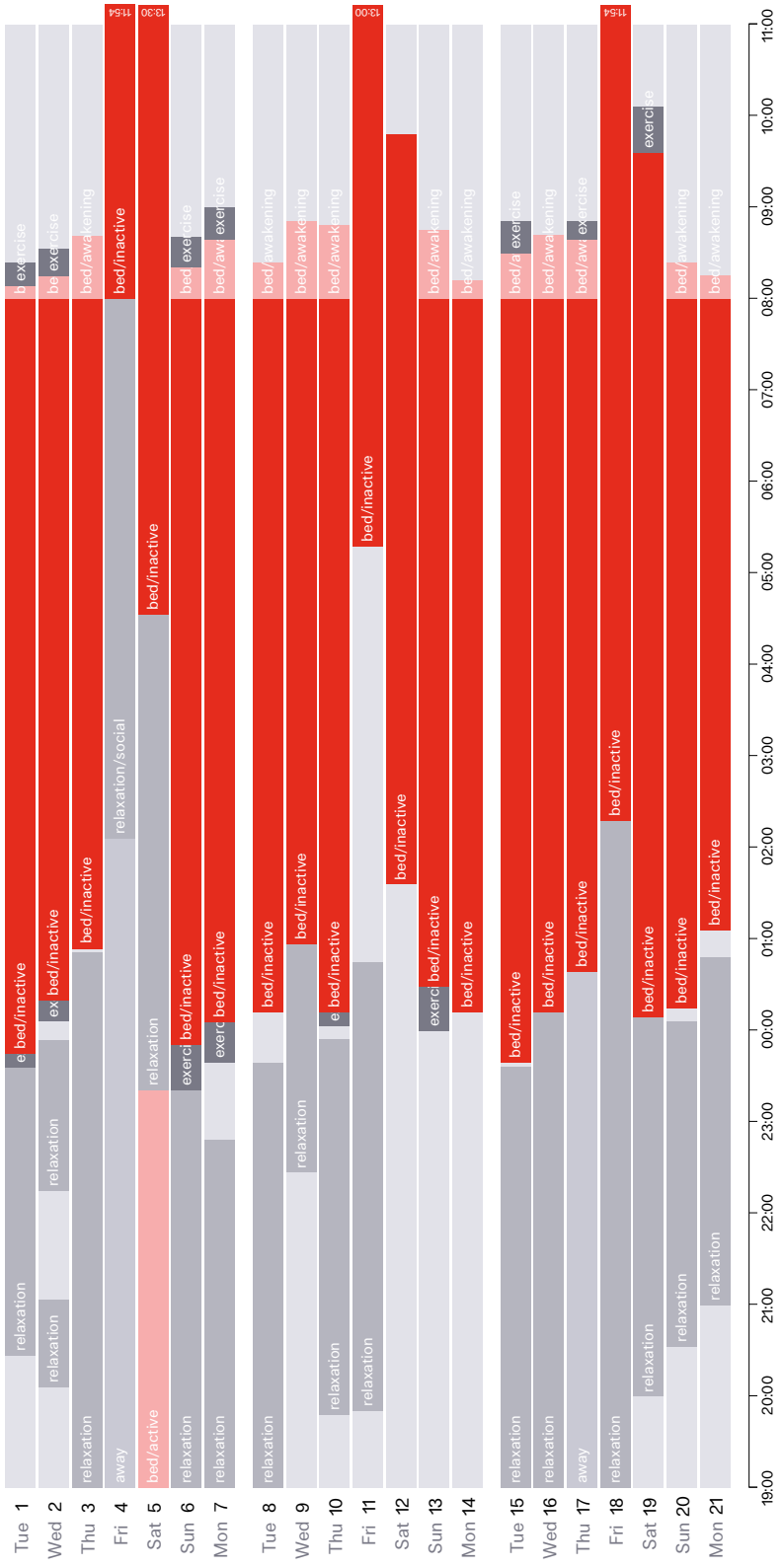


Fig. 54 Interpreted timeline of inferred activities for P2, showing the time in bed in red/pink and the other activities in grey. Note that only the evening routine was analysed during this experiment, and for the weekend days when the bar would exceed the edge of the graph the end time is provided at the end

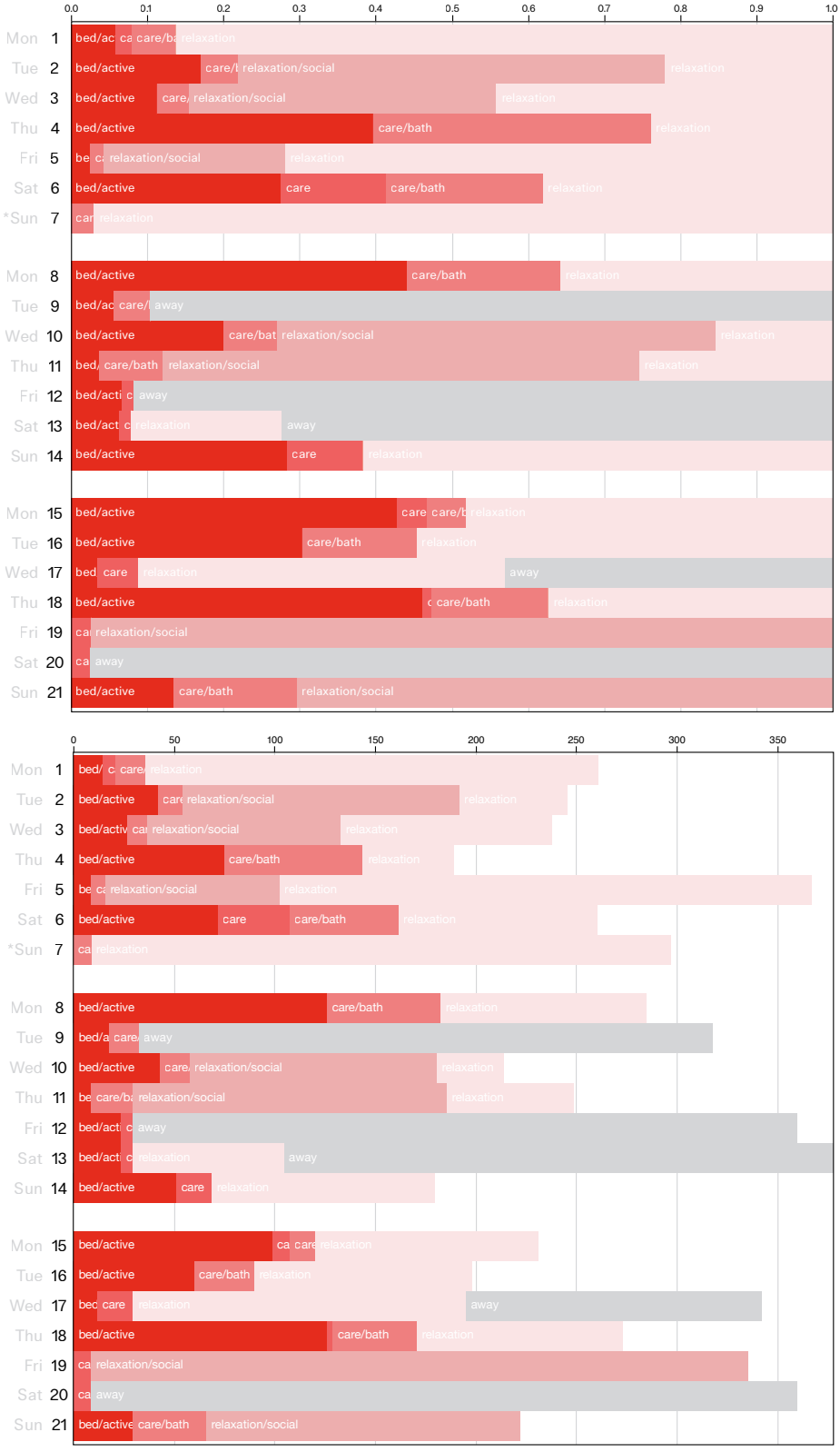


Fig. 55 Graphs showing the relative durations of activities during the evening for P1 (top) and the absolute durations (bottom)

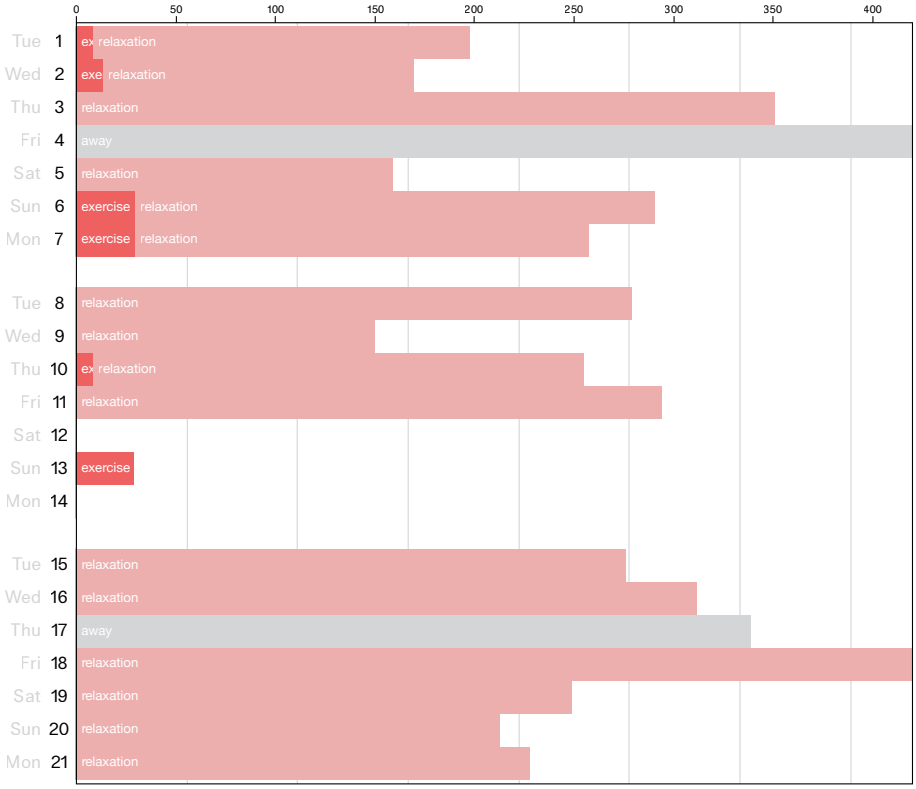


Fig. 56 Graph showing the absolute durations of activities during the evening for P2

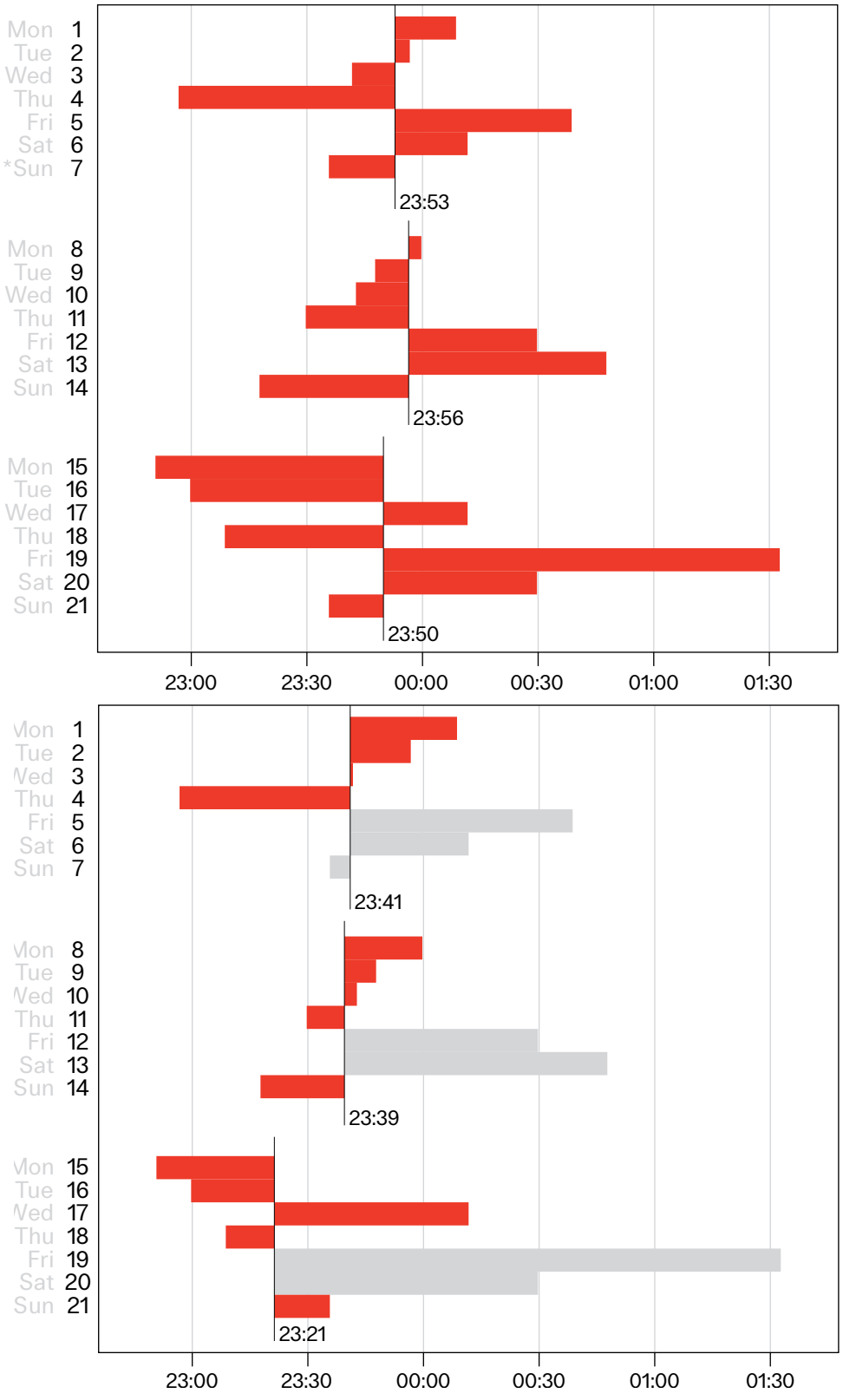
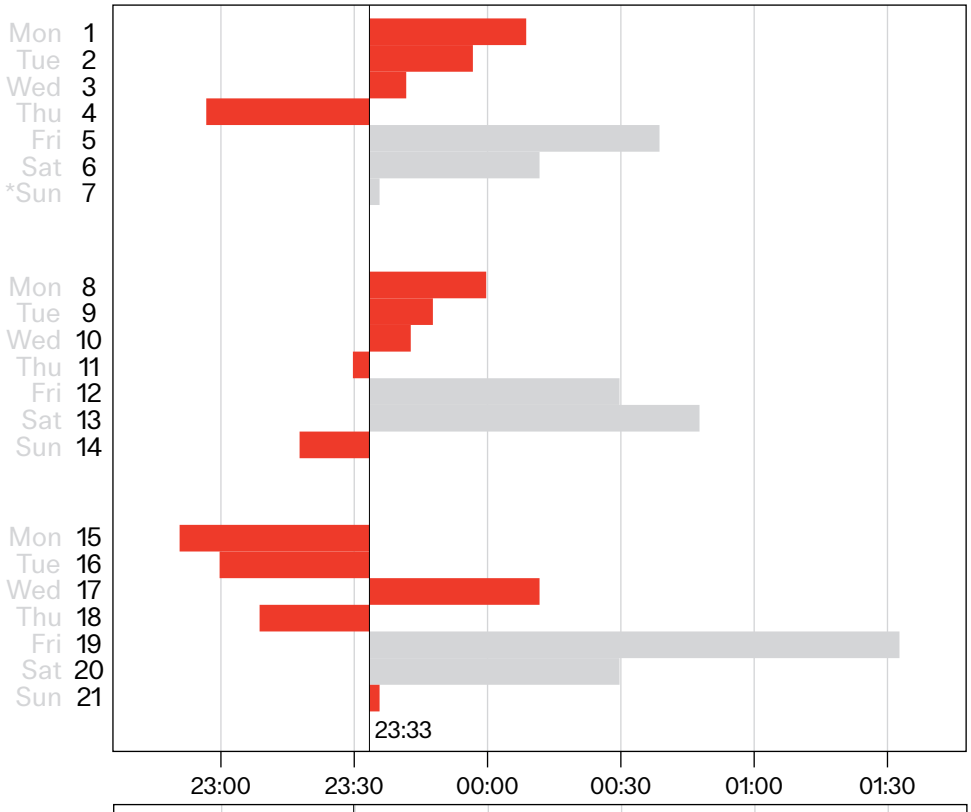


Fig. 57 Graphs showing the deviation between the bedtimes of P1 and the average per week including the weekend (top) , the average per week excluding the weekend (bottom)



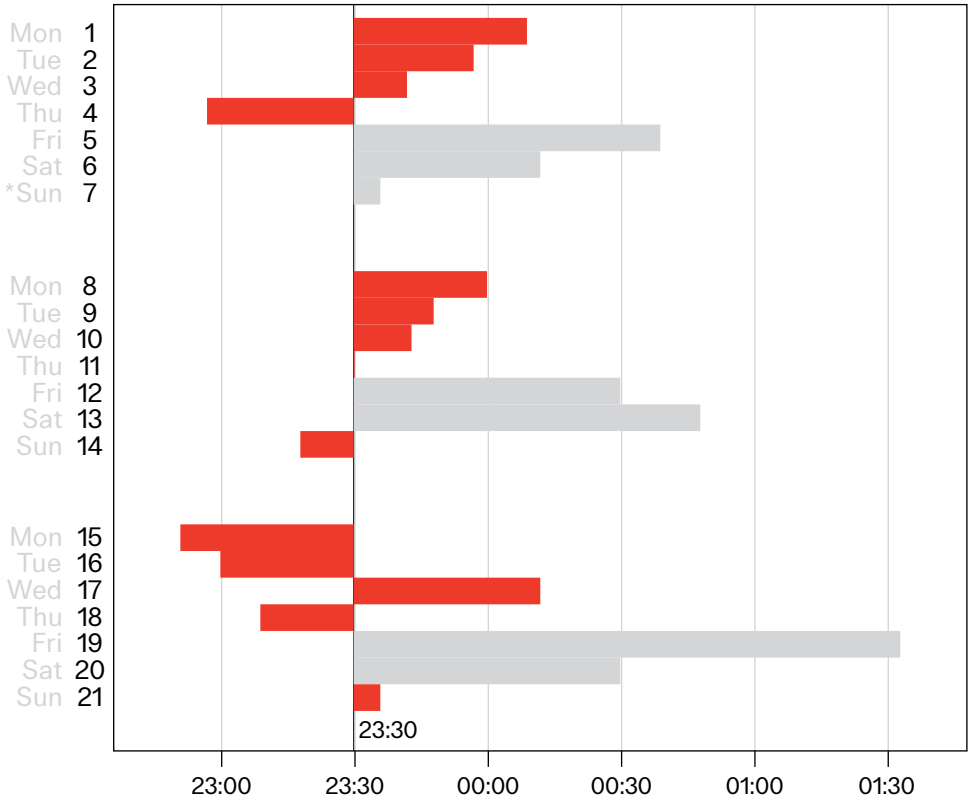


Fig. 58 Graphs showing the deviation between the bedtimes of P1 and the average across the three weeks (top) and the intended bedtime (bottom)

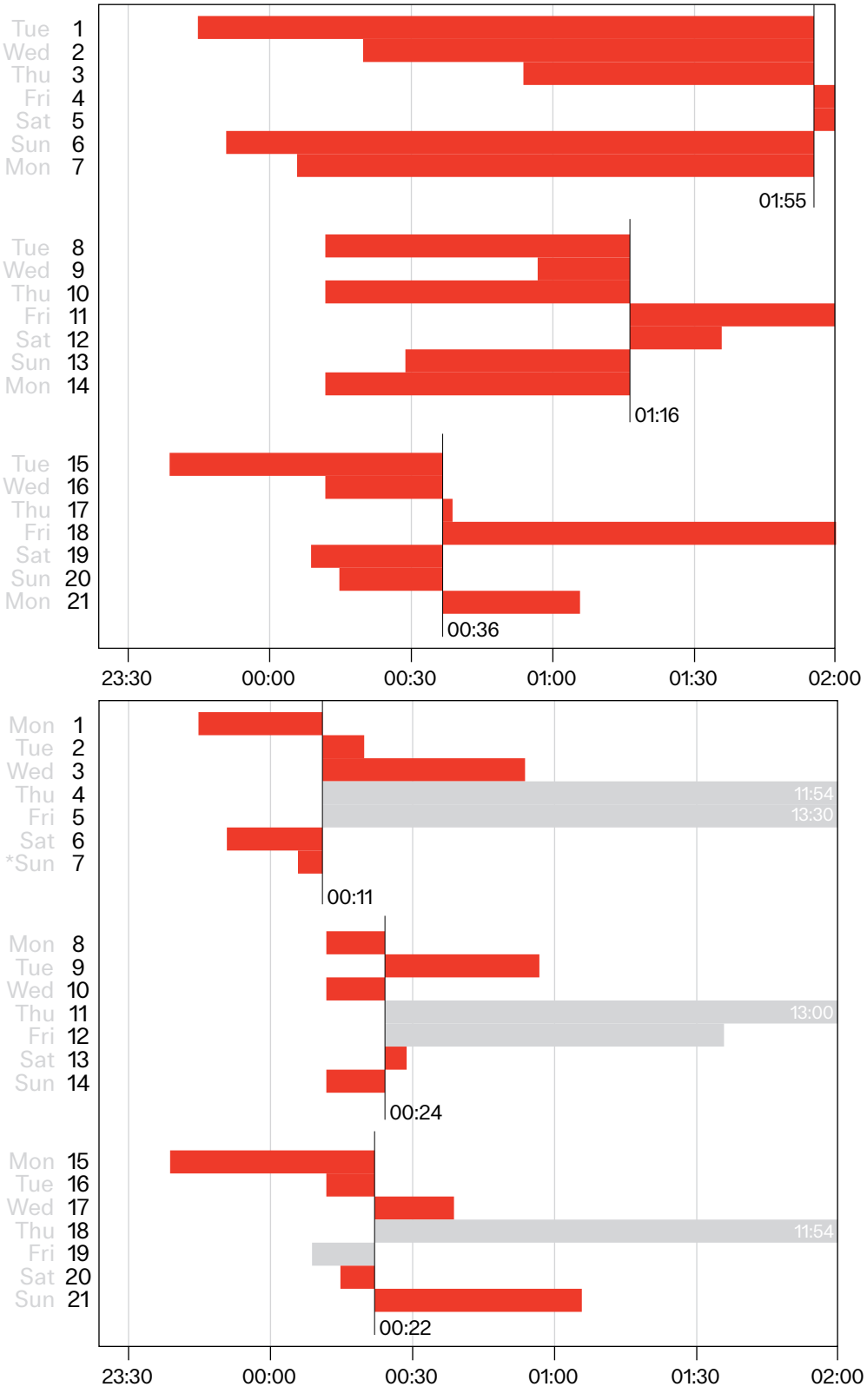


Fig. 59 Graphs showing the deviation between the bedtimes of P2 and the average per week including the weekend (top) , the average per week excluding the weekend (bottom)

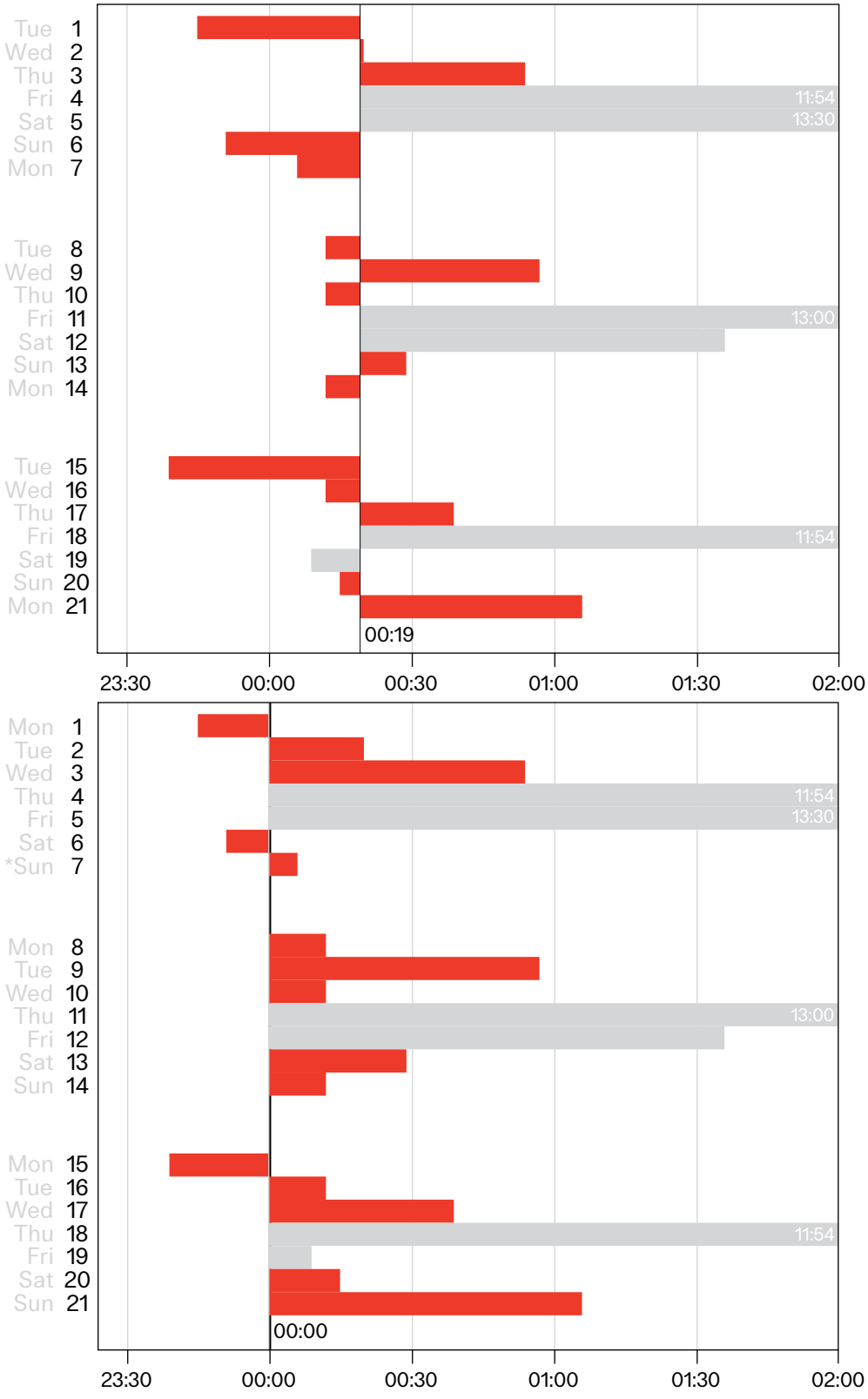


Fig. 60 Graphs showing the deviation between the bedtimes of P2 and the average across the three weeks (top) and the intended bedtime (bottom). For clarity the weekend bars are cut off at the end of the graphs