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Smart Home Control through the Correction of Automation Effects

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Lastly, I am grateful for that side of me which realized that no matter how high the wall, there is always a way over it.

Abstract

Previous work in the area of home automation shows that the inhabitants' comfort when interacting with a smart home can be improved by using an extended calendar view to present the user the effects of automation. By the means of an empirical study, literature review and an expert design workshop this work investigates how these effects are understood by potential users and what are the eventual corrections that they will like to make.

Findings show that users are often limited in their interaction by the well-established calendar mental models they have. Well known actions like dragging or editing events prove useful also in the context of home automation; however, more complex actions require design changes that address this psychological bias.

In the light of these findings, this work proposes a set of designs that will enable users to better understand and make use of the calendar as an interface between the human and the home. These recommendations consider the conceptual differences between the regular calendar and a home calendar and they are especially relevant given the ever increasing complexity of the systems that augment our environment.

Zusammenfassung

Bisherige Arbeiten im Bereich von Haus-Automation zeigen, dass der Komfort der Bewohner bei der Interaktion mit einem „Smart home" gesteigert werden kann durch die Nutzung einer erweiterten Kalender-Schnittstelle, welche der Benutzerin, bzw. dem Benutzer die Effekte der Automation darstellt. Mit der Durchführung einer empirischen Studie, Literaturanalyse und einem Experten-Design-Workshop untersucht diese Arbeit, wie diese Effekte von potentiellen Anwendern verstanden werden und was schlussendlich die Korrekturen sind, welche die Benutzer anbringen möchten.

Die Untersuchungsergebnisse zeigen, dass Benutzer in der Interaktion oft eingeschränkt sind aufgrund verankerter mentaler Kalender-Modelle. Sehr bekannte Handlungen wie das Verschieben oder Editieren von Ereignissen erweisen sich auch im Kontext von Haus-Automation als nützlich. Hingegen erfordern komplexere Tätigkeiten gegebenenfalls Änderungen am Design, welche die Voreingenommenheit des Benutzers adressieren.

Angesichts dieser Resultate schlägt die vorliegende Studie ein Set von Designs vor, welche Benutzer befähigen sollen, den Kalender und seine Anwendung als eine Schnittstelle zwischen Mensch und Haus besser zu verstehen. Diese Empfehlungen berücksichtigen die konzeptionellen Unterschiede zwischen dem regulären Kalender und einem Haus-Kalender. Sie sind insbesondere relevant aufgrund der permanent steigenden Komplexität der elektronischen Systeme, welche unsere Umgebung beeinflussen.

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1 Introduction

The Calendar is an organizing tool humans have been using for ages. Ancient calendars varied in their type and purpose (wikipedia.org, 2014). The Mayas used their calendar to determine important activities related to gods and human while the Greeks used it to keep track of festival dates. The calendar design and purpose changed with the time and it is today a ubiquitous tool that has recently suffered the latest of its transformations; that is the transition from paper to digital. This work contributes to the next possible step for this familiar tool.

Research conducted in the area of home automation showed that when it comes to human-home interaction there is plenty of room for future exploration (Brush, et al., 2011). In their recent work (Mennicken, et al., 2014) show how the intelligibility and control of automation could be improved by using temporal metaphors. In the same work they propose a calendar prototype that aggregates inhabitant's calendars with automation effects. The prototype called Casalendar provides therefore a familiar way for inhabitants to understand the effects of automation and the way these effects might relate to their personal schedule. The study showed that when faced with these information people are interested in adjusting certain aspects of the automation and its effects.

The current work contributes to the topic by further investigating the way people understand Casalendar and which are the adjustments they will like to make. Furthermore, design changes that will eventually enable these adjustments are looked at.

This introduction is followed in chapter 2 by an overview of the related work which has been studied in order to build an adequate understanding of the topic. Chapter 3 further explains the scientific context of this thesis, previous work and research goals. The research itself, the methods and preliminary findings are described in chapter 4. The final contribution of this work is detailed in chapter 5 by looking at each research question separately. Chapter 6 provides a discussion of potential future work together with a couple of design recommendations for Casalendar. Chapter 7 provides the summary and conclusion of this work.

2 Related Work

2.1 Calendars and home scheduling

Research work in the area of time and schedules and their eventual relationship to home automation goes back as far as the early nineties. Around those times digital schedules were making their way inside homes together with modern television sets and video recorders (Young, et al., 1995). Since the novelty posed a challenge for the users, proper representation of time and schedules in digital devices became a topic of investigation for scientist and interaction experts (Plaisant, 1991). In her 1991 paper, Catherine Plaisant describes the challenges users face with an ever increasing number of electronic appliances; all coming with their own user interface and set of controls. Her goal at the time was to investigate a single, consistent user interface and the necessary hardware to control all devices inside a home. The research looked at mechanisms to allow users to schedule events in an easy and correct manner and it considered an analog clock as an interaction metaphor (Plaisant, 1991). The use of the clock was in accordance with the principle of mental models as described by Donald Norman in his book *The Design of Everyday Things*; (Norman, 1988) however, the results of study show that while users are comfortable with these familiar concepts, the precision of the touch screens at that time made the interaction rather difficult. (Payne, 1993) informs the need for improved calendar usability and in an *indirect manner*, gives hints of how calendars could be useful to the home of the future by giving an example of a surveillance system that is aware of vacation times. In the same work, Payne touches briefly one of the challenges this current work encountered. That is, how can one design for calendar interaction in both past and future on a tool which is meant to support *prospective remembering* (PR)[1].

The use of calendars in the home environment is as old as the calendar itself. A survey published in 2002 found that only 17% of a set of 400 households use just one single calendar while 66% use two or even three calendars (Hutchinson, et al., 2002). The study also concludes that maintaining more than one calendar represents a problem for at least 20 of the 400 respondents. Other common challenges are the limited space available for text notes or compatibility issues with other software (Hutchinson, et al., 2002). A relevant aspect for this thesis that the study looked at is the recording of

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[1] Remembering to do things;

uncertain events. These are events which are expected to happen based on sensor prediction and learning. Ways to deal with these types of events include: making them visually distinct; record it somewhere else on the calendar or annotated it with a question mark or a *low priority* label (Hutchinson, et al., 2002).

A Microsoft study which was published in 2005 looked at how people manage their personal and household scheduling. The findings of the study showed that 59% percent of the respondents use a digital calendar and that the most important aspect considered when selecting a calendar is the ability to have all scheduling information in one place. Second most important aspect was the ability to access the calendar from multiple places (Brush & Turner, 2005). The study shows that forgetting to write things on the calendar and difficulty to keep track of other household members are the top challenges faced when scheduling (Brush & Turner, 2005). Home scheduling comes therefore with its own set of challenges and this is not surprising since moving design from the workplace to the domestic is not just a matter of technology transfer. Existing calendar research insights are constrained to the workplace and knowledge of calendar use inside homes is therefore absent (Crabtree, et al., 2003).

(Neustaedter, et al., 2009) defines the calendar as being crucial to families. In his work he identifies and categorizes a set of the most common calendars and the type of families that rely on them for coordination. The most used calendar is *Public Awareness Calendar* and this calendar type is placed in a highly frequented spot so that every member can see it. Interestingly, the study finds that calendars related to *Tasks and Chores* are better placed in areas conducive to planning (Neustaedter, et al., 2009). This raises an interesting question for the place a home automation calendar should be placed given that home automation encompasses a larger range of chores and addresses a wide amount of house functions. Additionally, the study lists a set of guidelines to support design of digital calendars. Out of these guidelines, one is of particular importance for this work: *Simple and Flexible Interaction.* The authors suggest that a calendar should support free-form events, which means that the user should be able to give a custom meaning to events by adding information to them. On a smart home calendar, this additional information can take the form of *End-User Programming* (Myers & Ko, 2005) (Myers, et al., 2006) and thus allow users to control and guide the automation without the need of complex rule sets.

The AwareCO Calendar described by (Kathryn & Sheelagh, 2005) shows an example of a home calendar which makes use of touch screen technology in order to facilitate awareness and coordination among the members of a family. The AwareCO is similar to the calendar studied in this thesis in the way it shows calendars of family members on a single view and it makes uses of symbols to further annotate events. Steps towards a *smart calendar* have been taken by (Tullio, et al., 2002) with their Augur calendar prototype. Augur was designed to predict event attendance and augment the calendar of the event organizer with visual information regarding estimated event attendance. Such technology can partially replace sensors in a smart home while still providing valuable presence predictions for the automation systems.

A thorough study on the representation of time in computer interface design has been conducted by (Mitchell, 2007). In this study, the author identifies two graphic representations which are required for every GUI that deals with time and which are especially relevant for this thesis: *something that differentiates the past from the future*; and if an event is predicted to happen in the future, *the degree of certainty of it to happen needs to also be represented*. Insights are given also on how the perception of flow of time is in fact related to the direction people read text on a graphical interface. On a vertical representation however, there seems to be no particular way of showing the flow of time and the representation will depend on the actual design situation (Mitchell, 2007). In their recent contribution, (Hund, et al., 2013) argue that calendar designs are actually nothing but digital copies of the paper calendars. These grid calendars are therefore replaceable by a more natural continuous view of days and events which is more suitable for today's touch devices. The results of this empirical study shows that while a list view supports faster navigation and search, 21 out of those 41 people surveyed will still choose a grid view for their calendar needs. Familiarity was stated as the reason behind this choice.

2.2 Smart Homes

Since the early 20th century, the Smart Home has been the topic of countless articles, movies and even world fairs. While for many, the term is nothing short of science fiction, research conducted in the past decades has looked in detail at how realizable *The Home of the Future* is and what are the social, technical and financial means required for implementing such a home. An ethnographic study conducted by Venkatesh et al. in 2001 looked at how the Internet and potential home automation technologies are

affecting our homes. This study carried out at what was basically the beginning of the *.com revolution* found that the ones interviewed were attracted to the potential benefits of automation. However, the study also give clues of early concerns towards the smart home and these concerns are in all cases related to loss of control (Venkatesh, 2001).

More recently, Menniken and Huang (Mennicken & Huang, 2012) confirmed these early concerns in a study which looked at existing automated homes and their inhabitants. The results of the study showed how there is a *"tension between comfort and control"* and how the increase in comfort is often mixed with the fear of becoming a *"prisoner of the system"* (Mennicken & Huang, 2012) The study also found that planning and installing the automation has actually a bigger impact on people's lives than using the automation once functional. Furthermore, automation is perceived only as a small improvement over the functionally available in *non-smart* homes (Mennicken & Huang, 2012).

On the topic of control (Lee, et al., 2006) takes a different perspective and suggests that a smart home should actually provide a family with more control of their lives. The study finds therefore two roles where the smart home can help improving the feeling of being in control. On one hand the home should help families avoid and fix breakdowns in their daily routine. On the other hand the home should provide opportunities for members of the family to give attention to each other. (Rashidi & Cook, 2007) consider a similar topic: *Adapting the Smart Home to the user*. Their work proposes a smart home system which is able to learn from its users by analyzing activity patterns. The system was tested with both synthetic and real data and the results show that the system can detect and adapt to user patterns. Similar work was conducted by (Heierman & Cook, 2003) which looked at how automation can be improved by detecting recurring patterns in a series of user-device interactions. High importance is also given to how noise can be detected and eliminated from this stream of device usage information.

(De Silva, et al., 2012) categorizes current smart homes by the their application: The first category is a kind of *care-homes* in that they employ automation technology for the well-being of the residents. In most cases these are the elderly, people with health issues or children. (Chan, et al., 2009) provides a detailed survey of this category of smart homes. The second category of applications targets the storage and retrieval of multi-media and experiences. In here, *media* does not necessarily refer to movies or the music stored on

the local NAS[2] but the term is more about the media which the house itself records with the help of installed cameras. These data can then be retrieved by the users which might want to learn information about previous activities or re-experience past moments (Nijholt, 2008). The third class of applications refers simply to surveillance and home security devices. Additionally, automatic shades, heating and energy applications can form a fourth group - the *eco-home* (Lonsdale, 2013). This type of home makes use of automation in order to allow users to increase daily comfort while in the same time provide savings on energy bills. (De Silva, et al., 2012)

For each of these categories, a couple of prototype homes have been developed. In them, scientists get to test their ideas and hypotheses while a few of us which are curious enough get to experience how is to live in a smart home. As the focus of this work is the electronic calendar and the role it plays in the home automation, these prototypes are not covered in detail, however, a few recent examples are mentioned below:

> *(1) Honda Smart Home; Eco Home* (University of California, Davis);
> (2) *BRE Smart Home; Eco Home* (Building Research Establishment);
> (3) *Openarch; open-living lab, domestic operating* system (www.openarch.cc);

2.2.1 Automation State of the Art and Focus

Increasing interest is given to home automation technology. What started as a vision and until not long ago was nothing but a topic of excitement among daring scientists and passionate techies, is now starting to take the form of commercially available products. Just recently, Google, the well-known internet giant made a formal entrance in the field by acquiring Nest, a small tech company which produces smart thermostats (Whitney, 2014). The value of the transactions says quite a bit about Google's size and power but also says a lot about the attention which is given to this emerging market. Increased attention emerges not only in the industry but also on the consumer side. In the wild studies (Brush, et al., 2011) (Mennicken & Huang, 2012), do show that people are ready to live with the automation. *But is the smart home smart enough to provide value for its users?*

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[2] Network Attached Storage

A structured and pragmatic view over the current state of home automation can be drawn by looking at the functionality currently available to the user. In this way, (Harper, 2003) identifies five types of smart homes:

(1) "*Contains intelligent objects*" - Homes in which some stand-alone intelligent devices are present. Smart TVs, cleaning robots, etc. are common these days;

(2) "*Contains intelligent, communicating objects*" – Homes in which intelligent devices are also able to communicate among each-other in order to increase functionality. Examples can include smart heating controllers which *speak* with the outdoor sensors and thermostats; wind and light sensors which control window shades;

(3) „*Connected home*"– These type of smart home is similar to the previous one with the addition of a home wide network to which all devices are connected. The connectivity of such a home does not have to be limited to the domestic network but it could reach out for global services. One such *outside service* could be provided by the emerging electrical *smart grid*[3] (Balta-Ozkan, et al., 2013);

(4) "*Learning home*" – Such a home will observe and learn from the behavioral patterns of the inhabitants with the scope of adapting to their needs. This type of home is also covered by (Rashidi & Cook, 2007);

(5) "Alert home" – Records all activities of the inhabitants and home devices with the scope of anticipating user needs. (Heierman & Cook, 2003) discusses a data-mining algorithm for discovery of "regularly-occurring interactions with a smart home".

One can easily notice that the taxonomy above provides a natural way for smart home evolution. We start with one, two *smart* devices, we than realize that some devices can form automation pairs for better functionality – light sensor to shades, thermostat to heating controller and so on. From there it is not far until we realize that actually all communication can happened on the already installed home network and so all devices get to use the same network. The next natural step will be to add a neural network

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[3] From Wikipedia.com - A **smart grid** is a modernized electrical grid that uses analog or digital information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.

somewhere in the picture and we have reached the *learning* home and from there on to the *alert home*… Unfortunately, that last step is not an easy one to make for now. There are of course an encouraging number of efforts that address the issue of learning (Dawadi, et al., 2011) (Botón-Fernández & Lozano-Tello, 2011) however, despite these efforts the industry seems to be stuck at level 3 – and this is ultimately the *state of the art* a consumer will have access to for now (Kastrenakes, 2014).

Smart home functionality; be it already available or merely envisioned is essential when investigating the potential use of Casalendar inside *the home of the future.* Categories (1) and (2) provide straight-forward uses for Casalendar. The more autonomous the home (3 - 5) the greater the challenges for a calendar interface. In a home where automation is no longer directly controlled by the inhabitants but instead by external services and complex algorithms, Casalendar can take the great challenge of keeping the user up to date with what happened while no one was at home. Additionally, it can provide an easy interface which the inhabitants can use to show their *approval or dissatisfaction* with the autonomous decisions the house has made.

2.3 Limitations and challenges of home automation

"How smart does your bed have to be, before you are afraid to go to sleep at night?"

The question above is just one in a long list (Gold, 1994) wrote for the Ars Electronica magazine. Using only questions, the author provides a wonderful image of the potential home automation has; but as one keeps on reading, the primitive state of today's automation becomes clearer and clearer. There is so much more to understand and so many challenges to still look at. It almost feels like the task at hand is building *Mount Everest* and all we have to start with is a handful of sand. A *time.com* articled published recently presents a *Tech-Infused Bed* which is packed with functionality one does not expect from a bed; sleep pattern monitoring, height adjustment, remote control and of course the now omnipresent, Wi-Fi connection and mobile app (Aamoth, 2014). This is nothing to be scared of yet but the parallel does reveal a great challenge that smart homes have and that is usability.

This *state of the art* automated bed comes with a button for "*Partner Snore*". When pressed, the bed will supposedly make your sleeping partner stop snoring. Very helpful function indeed; the only problem is that the button is actually an option in a list of options displayed on the screen of the remote control. Everyone can recall at least one

moment when the TV remote is nowhere to be found – what happens when the bed's remote goes missing? Should one stand up and go on a mid-night remote look-up?

(Leitner, et al., 2007) Explains that usability is often an issue when a new technology emerges on the market; it happened to the VCR, then to software programs and more recently with internet pages. In the wild studies mentioned a couple of times above have shown that usability remains an important factor in the adoption of smart home technologies. Other challenges are cost of ownership, inflexibility, poor manageability and difficulty achieving security. (Brush, et al., 2011) (Balta-Ozkan, et al., 2013)

Security risks are especially of importance in the context of the *Internet of Things* and the connected home. These two technological trends assume an increased amount of connectivity across all home devices. In fact, every object in a home will be a device with its own power source, microcontroller and web connection (wikipedia.org, 2014). The privacy and security issues emerging from this increased connectivity are summarized by the title of a recent ACM web article: *"Are Smart Homes Intelligent Enough To Keep Out Hackers?"* The US National Intelligence Council goes even further and declares *The Internet of Things* as a disruptive civil technology which may impact on US interests out to 2025 (wikipedia.org, 2014). In the academia, security is also an important topic and among the recent efforts focused on improving automation security, these works can be mentioned: (Maternaghan & Turner, 2013) (Hjorth & Torbensen, 2012)

The (miss) understanding of the potential benefits brought by automation can also act as a barrier to adoption. (Kim & Shcherbakova, 2011) as cited by (Balta-Ozkan, et al., 2013) point out that when it comes to the potential energy savings regular users might not have enough understanding of the way electricity markets work. Because of this they cannot fully appreciate the benefit of automatic load-shifting. On the other hand when users have a certain understanding of home automation it is often the wrong one. (Harper, 2003) argues that what home automation can do the best is process information and this is a misfit to the popular perception of the smart home. That is, a *machine-house* that can do everything, from preparing breakfast, fold the laundry and chase away the burglars at night.

3 Scientific context and Motivation

This thesis is based on previous research work conducted by PhD candidate Sarah Mennicken and bachelor student Jonas Hofer at Zurich People and Computing Lab (ZPAC). Their research has shown that the ease of control and understanding of automation effect are of high importance to the comfort of the inhabitants (Mennicken & Huang, 2012). Preliminary findings call therefore for a better understanding of the smart home environment and the relationship between user and home. As part of his bachelor thesis work (Hofer, 2013) investigates the use of a calendar as a temporal-metaphor interface which supports an intuitive user-home interaction.

3.1 Casalendar

Casalendar is a software prototype that takes the shape of a calendar interface similar to a few of the commercial calendar products available today online. In its current state, Casalendar acts as a smart home interface that allows inhabitants to observe the effects of automation. In non-technical terms, this means that the calendar is a representation of smart home events and the times at which these events took place. Additionally, Casalendar displays events fetched from the personal calendars of the inhabitants. The intention behind this simultaneous representation of both personal and home events is to allow the users to easily draw eventual correlations between their personal activities and the actions of the smart home. The home events are represented with a distinctive color and they provide a graphical representation of the trigger behind an automation event on one side, and the effect of that event on the other side. (Mennicken, et al., 2014) This provides the viewer with a quick understanding of what happened and why it happened at given moment in time. By tapping on a certain event, the viewer is provided with a text explanation of the event.

3.2 Research Questions

The evaluation of Casalendar showed that when presented with the effects of the automation, users are interested in correcting or modifying them if needed. This work aims to find what are the actual corrections users will want to make and how can Casalendar support them with their intentions. For this purpose, the following research questions have been explored:

RQ1 – What kind of changes do users want to make in the calendar interface?

First, the kinds of changes users want to make need to be understood. This high level question can be answered by looking at the various aspects and types of presented information on the interface that relate to the smart home schedule. E.g.: differences in the estimated effects and the events which are displayed retrospectively. Second, what kind of modification do users want to perform? Do they want to delete the events entirely; do they want to move them around the calendar? Do they want to connect them with other events?

As the information on the interface does not represent configuration, rules sensors or actuators but the temporal projection of its effects, we need to get a better understanding what changes of the effect imply for the underlying configuration. In the case of recurring events on the calendar, we need to understand how changes performed on one event affect the entire series. Additionally we need to investigate, what kind of information does the user need or want to provide to the automation in order to adjust its settings or affect its performance.

RQ2 – How can the design of the calendar interface allow typical home occupants to easily make changes?

Informed by the insights of the first research question and the derived requirements, the actual design of the interface and interaction needs to be explored further in order to understand how it can support inhabitants to achieve the desired results.

RQ3- To which extend can the calendar make autonomous changes in order to increase user convenience and how do the users need to be kept in the loop?

As existing research shows that users appreciate a certain level of system autonomy but also the existence of a fine line between convenience and loss of control we need to understand how users deal with an interface that can adjust on its own (Venkatesh, 2001).

3.3 Research Boundaries

While related calendar research is relevant to this work and it has been looked at closely, the focus of this thesis is on Casalendar as a home automation interface. Despite its novelty, Casalendar is in many ways similar to a common calendar and it is exactly this potential familiarity which gives the value for the user while posing a great challenge from a research perspective. Casalendar does take this ages old organizing

tool and brings it right at the top of today's state of the art automation. When investigating the way people will like to interact with such an interface it was observed that users require an understanding shift from the tool that helps them not miss a dentist appointment, to the same tool that now tells them when and why the doors were locked. This ability to shift ones views of the calendar was perceived as a limiting factor during the study but further understanding of the psychological aspects that affect the way people interact with the calendar interface is out of the scope for this work.

4 Research

In order to best answer the proposed research questions, this study is organized in four phases. At first, an initial literature review was undertaken with the focus on calendar research and general home automation aspects. The intention behind this phase was to get accustomed with smart home principles and understand the current state of the art, in preparation for the next phase. While existent calendar and automation studies did provide valuable insights, it was not enough to provide a glimpse in the way people might interact with a calendar as a smart home interface. It was therefore decided that a user study which will investigate potential user interactions is the most suitable next step. During the user study valuable knowledge of the understanding and the attitude of the user towards the Casalendar will be gained. During the third phase of the study, a second literature review was carried as to understand to which extend the results of the study correlate with existing literature. The insights gained from this comparison were then translated into design changes for Casalendar. These design changes were paper prototyped and exposed to an expert workshop during the last phase of the study. In this workshop, the feasibility and the usability of the design were investigated. The remaining of this chapter describes the user study and the design workshop.

4.1 User Study

The user study was conducted with a total of ten people with both technical and non-technical education and with an age varying in between 23 and 51. Having a relevant number of *non-technical* users was important for the study as previous research shows that home automation is almost never managed by people without technical background (Mennicken & Huang, 2012). A wide age range is also highly relevant as it can be assumed that older users are on one side a challenge for the design of the interaction as they might be less technically fluent; and on the other side the older users are often the ones to benefit from automation (Chan, et al., 2009). The study took the form of ten *Cooperative evaluation* sessions were users where asked to perform two interaction tasks on a paper version of Calendar. The reason for selecting this type of evaluation was the flexibility which the tester is given. Once the tester was informed of the task, she had complete freedom to identify and perform the steps that will lead to the execution of the task. The testers were asked to speak aloud their steps as much as they are comfortable. By observing and listening to the execution of the task a constant stream of ideas was

generated. The most important of these ideas were further investigated after the task was completed. By giving all testers the same two tasks it was ensured that all sessions follow the same general structure but by giving users full freedom to execute the task important quantitative data was gathered. If these data would show that for e.g. 6 out of 10 testers identified and followed similar steps it was known that these steps could represent an interaction with which a majority of users are comfortable.

The calendar was fit with movable parts that the testers could move around while performing the tasks. Each walkthrough lasted between 30 and 40 minutes and the actual hand-interface was video recorded.

4.1.1 Study protocol

Before introducing the tasks below, a level of familiarity was attempted by asking the testers to look on the calendar and ask for eventual clarifications. To verify the understanding of the interface, questions such as *"Can you think of a reason for which event X is placed here?", "Can you tell what the current represented time is?"* were asked. Once all questions were clarified and the tester seemed to have a comfortable understanding of the interface and purpose of the calendar, these two tasks were proposed:

T1 – "*Assume that you are at home on Monday evening and you realize that the home temperature is lower that you will desire. For this reason, you will like that starting with tomorrow [Tuesday] the temperature to be one degree higher. Using the visible interface,*


Fig 1 - User performing T1

how would you go about implementing your wish?"

The intention behind this task is to find out how people relate to and make use of past events. To which extent can events which are already displayed be used as part of a new interaction?

T2 – "Assume that it is Friday morning and the shades went up at 7am as scheduled. Because it is already November, it is still dark outside and you are uncomfortable with the thought of people looking in. How would you use the current interface in order to adjust the schedule of the shades?"

The intention behind this task is to see what type of correction patterns might arise. Clearly, the home did something which the user does not like, how will the user correct this and what are the expectations towards the house once the correction was applied.
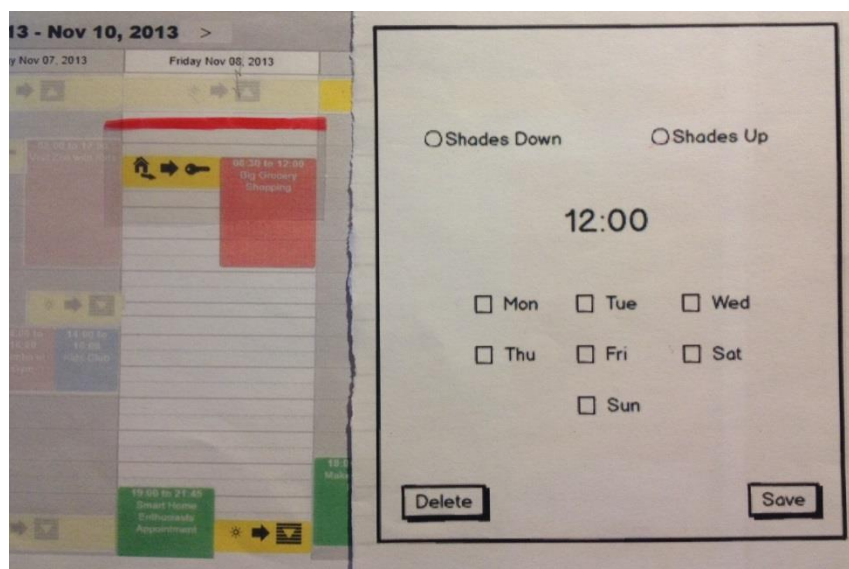
Fig 2 - Task 2 start point with additional menu

4.1.2 Data Analysis

The recording of all evaluation sessions were transcribed in detail and the data was analyzed using *Affinity Diagrams*. The processes of analysis involved scanning through every single note of the transcript and write the observation, quote or question on a small piece of paper. While creating the notes, emerging insights or design ideas were written down. All recorded notes were placed at first without any relevant relationship in between them. As a second step, the notes were grouped and the groups were labeled. The groups formed in between notes which were tackling a common idea or issue. The reason for choosing this type of analysis was the ease with which the recorded notes can

be organized and reorganized multiple times and the natural way similar themes eventually emerge. Examples of themes that emerged are: "*confusion about event duration*" or "*correction of a current event*" Once all notes have been interpreted and commonalities became evident, not only the areas in which design work is required become clear but also the user needs between these design changes were visible. The data was reanalyzed for a second and a third time in order to make sure that all user intentions and needs are captured.

Fig 3 Evaluation notes on an affinity diagram

During the second analysis the more *technical* insights of a theme were looked at with the intention to reorganize them in a more abstract manner that captures a broader range of user needs. By more *technical insight* is meant an idea/comment which is specifically addressing a technical aspect of the interface. For e.g.: "*Testers described the grayed area as being hard to read, unimportant or inactive.*" This and other similar insights were organized in a more abstract manner, such as: "*People avoid initiating interaction with controls which are grayed out...*" Of course, no one to one relationships were created as one technical insight it is not enough to justify an abstract need as the

one above. The third phase of the analysis re-grouped all insight in function of the research question to which they relate the most. This allowed for a meaningful parallel view of the changes users want to make on one side and required design changes on the other side.

4.1.3 Findings

This chapter offers a brief summary of the user study results. As such, the study revealed that testers go through a learning curve before fully understanding what are they seeing and what is the purpose of the calendar. From an interaction perspective 4 testers mentioned that they find it hard to interact with past events as the blur makes them seem inactive. On the same topic one tester suggested that only the background should be of a different color instead of rendering the entire past surface with a blur effect. For task one, all of the testers tried to adjust the temperature by introducing a new heating event similar to the one visible on Monday. With extra guidance, 8 people realized that the adjustment can be produced by reusing the past events. The same users, acknowledged that this is actually an easier way to create new events. At the same step, 4 testers asked for a menu from where they can select new events and add them on the calendar. 2 people pointed out that one cannot rely on the past events exclusively as some events will eventually not be available in the past. - *"In the summer I need the air conditioning, from where I put it?" – P6,* assuming that we are just at the beginning of the hot season*.* The same user claimed that the easiest way to add a new event is to make use of search box with an auto complete function. *"I need something where I can write Temperature for e.g."* This is indeed a relevant request given that a smart home calendar has many types of events as opposed to the common calendars that only have one single type of event.

During task one, user's attitute towards autonomous events was investigated with the help of the *"Heating started because…"* event shown in Fig 4. This event would shown on the calendar with a variable amount of time
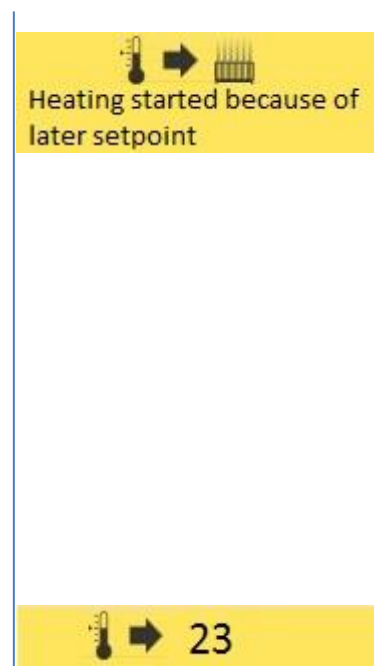
Fig 4 User set point and autonomous event.

before the temperature setpoint. The amount of time in between the two events represents the time the heating system needs until the house can reach the requested temperature, 23 in this example. The users study found that 4 out of 10 specifically mentioned that they are not particularry interested in this extra information as long as everything works fine. P8: *"So if everything went well and the temp is 23 at 5 clock I dont need any other information; if there was something wrong then please tell me house what did you do."* A similar remark was made by P2*: "If I am not a tech geek I do not care much about it. I don't care what my xbox does in the backround. I am just interested in the playing."*

These type of remarks seem to point out that information about abnormal behavior could be appreaciated more that details on a behaviour that is to be expected. On the other hand, P6 remarks: *"Just tell me that it is going to turn on. For me is okay? No - Then delete. Yes? Then I do nothing"* implying that this extra event can be taken as a pre-notice which will give users a chance to agree or disagree with what is about to happen. When asked how will she exactly delete the event, the tester replied that dragging it out of the calendar should suffice. In fact, dragging was often associated with copy/cut or delete. *"I will just drag it and expect a menu, it will probably say something like copy..." – P7.* In the context of task two, adjusting a recurrent event was seen either as a correction required due to a change in the home envirement such as change of seassons or daylight saving, or either as a correction applied to an executing/active event. Corrections on active events was done because the execution is not actually required or it was bothering at that time. When asked, what would be the expected effect on the entire series of events; testers pointed out that changes on a series of events should trigger a menu asking if only this instance or the entire series should be changed. This type of interaction is commonly found in todays calendars. As part of this task, only 2 people mentioned that learning from this spontaneous corrections will be useful. P9*: "I want the calendar to ask me when I do it a 2nd or 3rd time in a row... Like if I am adjusting this [an event] every day. I would expect the calendar to ask me or change things by itself".* Along the same lines, P10 suggests autonomous behaviour but also points to an eventual loss of control. This fear of control seems to confirm findings reported in the related work, however, in this example, the user suggests that will nevertheless give it a try as long as the home *behaves* in a trully intelligent manner.

*"I don't want you[the home] to take control over me but on the other hand, I am kind of...
Why not... If you are smart enough... I ll have to try it."*

4.1.4 Conclusion

The user study provided a good amount of insight into the way people might look at and interact with such a smart home interface. In was noticed however, that the familiarity of the common calendars provides a bias which is hard to overcome in a 40 minute session. It looked indeed as if the participants were only interacting with Casalendar in a similar way they will do with their personal or office calendars. While T1 was designed with the intention to make users realize that there is a certain potential in reusing past heating events, it actually happened that participants ignored the past event and tried to recreate a new one. While this might have had extensive impact on the results of the study, realizing the existence of this behavior is an important finding by itself and ways to overcome this bias are discussed in chapter 5.

4.2 Design Workshop

The results of the user study were captured in a set of design adjustments for Casalendar. These proposals were paper prototyped and exposed to a group of HCI experts with the intention to investigate their usability. This study was organized in the form of a design workshop where experts were shown proposed changes one by one and then encouraged to
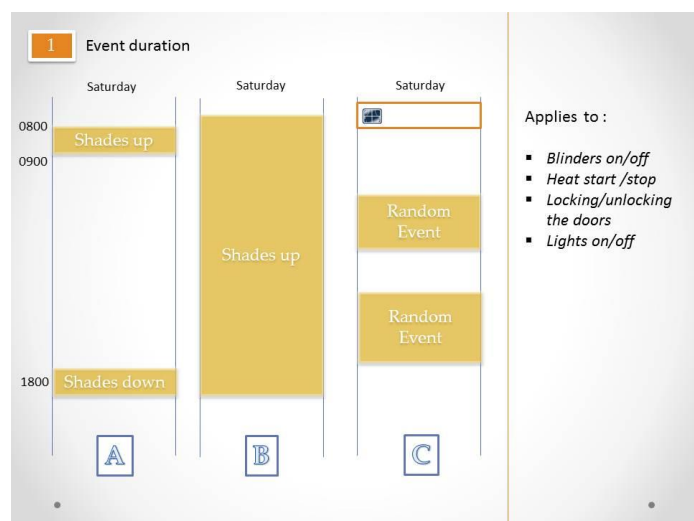
Fig 5 Example of design proposal

discuss the eventual issues or improvements. This type of workshop was chosen because it allows the verification of a design by HCI experts while giving room for open discussions out of which further valuable data can be withdrawn.

The workshop took place in the design lab of the People and Computing group at the University of Zürich and it lasted for an hour. During the session, the six invited HCI experts were introduced to 8 design areas, each containing 2 or 3 design proposals marked from A to C as shown in Fig 5. For each design area, an explanation of the

challenge and the need behind the design were given to the experts. Each topic was discussed for 5-8 minutes. The data collected during the workshop was organized in the grid format shown below.

Time	P1	P2	P3
734		I thought google will show the block as an hour long but it will then show a line at the top.	There is a distinction between appointment and an event. [In C
806	The issue is also where do you put the label.		
905	Keep in mind that the tranparency was planned to represent uncertainty on the calendar. For planned events. But there are of course other means of representing transparency. Outline or shaded outline.	I think you could use transperancy. You can have a tick line on top and then just a transperent text.	I dont think I am bothered that hour long. I understand the nee showing an associated event. Li started here but where did it fir
1000	Maybe you can use an icon that shows that there is a related event. ShadesUp could indicate that there is another event that connects to it. And then indicate the		
1240		I have a problem because I don t know why is Up and event and not the Down. [Talking about shades]	
1346		I think that if you want to show changes of states. Maybe you need a different way to visualize that. If you are looking for the events I think A works but for a change in states you may need something	
1420	An all day event that indicates the state throught the day. The permanent event or something...		
1600			I am not crazy about sort of click details just because in order to assume that the relavent unit o day. When you extend it to othe

Fig 6 Workshop data organized in a grid for analyzing

This format provided an easy way to overview, scan and make connections among all notes. Looking over the data revealed that most comments are short and always to the topic and this simplified data analysis considerably. Aside from the technical notes and suggestions, two prominent topics are found among the feedback. On one hand there was the degree to which the calendar can be used to show change of states for automated services like heating; on the other hand, the *manual feeling* the calendar seems to have was brought up. An additional view for displaying running services was mentioned countless times by the user study participants and it looked like some of the experts make a similar suggestion. The *manual feeling* of the interaction refers to the users being constantly requested to make inputs and adjustments. Previous observation made during the user study suggest that this refers to the need of dragging, adding editing events as opposed with the automation making these adjustments by itself. Since the design workshop was the last of the research phases the results were merged with previous literature and user study findings and presented in chapter 5. Additionally the two topics discussed above are addressed with two design proposals in chapter 6.

5 Final Contribution

This chapter brings together the findings from the literature review, user study and the design workshop in order to form the final contribution this work makes to the future design and understanding of Casalendar.

I – In order to discuss the potential corrections users might want to make on a calendar interface we have to look first at how people understand the calendar. Indeed, the conclusions drawn from the user study show that the changes people think of are mostly the same changes they would make on their personal or work calendar; create event, drag events around the calendar, deletion and so on. This phenomenon seems to not have been thoroughly studied in the context of user interfaces but it a well-known effect in psychology and it is described by the *familiarity heuristic*. The familiarity heuristic specifies that when faced with novel yet familiar situations, places or things, people tend to rely on past schemas or actions as a base for their behavior in the new situation. (wikipedia.org, 2014) In the case of Casalendar this will mean that the familiarity of the interface acts as both a friend and a foe. It is a friend to the user in that it provides a familiar view, something people have knowledge of how to use but it is a foe because on unconscious level it might lead people on a path of interaction which is minimal in comparison to the true potential of Casalendar.

II – Theory shows that calendar events are nothing but a formal reminder for our *intentions*; every event placed on a calendar represents in fact the intention to perform an action at a given time in the future (Payne, 1993). On a home automation calendar, people do not necessarily formulate intentions that they will execute themselves but instead, they formulate intentions which will eventually be executed by the home. This breaks the inherited connection between intention and execution and it adds an extra level of complexity to the way people interact with events on Casalendar.

 Considering these two psychological aspects of interaction but trying to bring and understand the results of the study from the perspective of home automation, the following insights and ideas can be drawn:

5.1 Q1 and Q2

Since the first and the second research question are strongly interrelated, the results from the two are shown together in this section. That means that for every sub-section bellow the first part represents the change that users will like to make and the second part describes design adjustments that could support users in make the correction they need.

I – On the Casalendar interface as it looks today, there is a need for a better understanding of how the heating events work and what are affordabilities and constrains of the interaction. People seemed confused by the idea of scheduled heating events because it was contradicting their understanding of heating as an ongoing process: *"Well that is interesting; do we have somewhere a base temperature set? [when the heating event is done] It might fall back to this base temp."* - P10, not exactly knowing what happens when a heating event reaches its end. To avoid this confusion, the calendar interface could be adjusted to display heating as an all day long event. Fig 7 shows that the heating is set to 22 degrees for the entire day. Exceptions from this temperature can be made by creating a set point event. Tapping on the all-day event will eventually take the user to a separate view where additional information can be seen. Such an additional view was often requested and it is discussed in chapter 6.1 Design Recommendations

Even if in most of today's homes heating is an ongoing constant process, people have understood the advantages brought by the ability to schedule heating events. As such, people have shown that they would like to place heating events in order to customize the heating system and adjust the temperature in function of different factors; sometimes, even a couple of events per day. This need for customization was often extended towards energy control – a need to understand and optimize energy consumption. P6 speaking on the topic of energy consumption: *"It is useful because about energy you spend a lot of money"* User interest in the topic is also found by related research, where energy conservation applications are found to be the most appealing among smart home inhabitants. (Brush, et al., 2011)
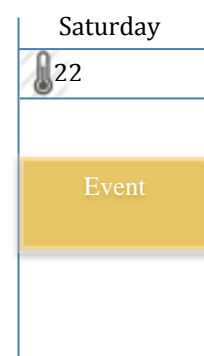
Fig 7 Representing heating as an all-day event

II – Recurrent events are beneficial in a home setting. They cater for user's regular needs like for e.g. weekly plant watering, daily robot vacuuming and so on. However, on certain occasions these regular needs are subject to exceptions; Season changed and the shades schedule must be adjusted or you have guests and you don't want the loud vacuum robot to wander around the home. The study found that users' needs are versatile and so it happens that often scheduled events are not needed anymore at the time of their execution and the user wants to change them. In some instances, the

Fig 8 editing a series of events.

change is a one-time case but other times an entire series needs to be changed in order to match newer needs. Ideally, when a change is performed, the calendar needs to ask if the change applies to just this time or if the event is part of a series, to the entire series (Coppinger, et al., 2006). While this type of dialog is well known by users from regular calendars, many have mentioned that the true value of such corrections will be uncovered only then when the calendar will be able to learn; P9: *"I want the calendar to ask me when I do it a 2nd or 3rd time in a row... Like if I am adjusting this [an event] every day. I would expect the calendar to ask me or change things by itself".* In order to properly balance autonomy and control however, users have suggested that the calendar could display learned behavior ahead of time in the form of *anticipated* events. The visualization of such events should also give an indication of the degree of certainty of these events to actually take place (Mitchell, 2007). For example, different levels of transparency could provide such information if more transparent will mean less change to happen and more opaque will equal higher changes for an event to happen.

III – Today, even automated appliances are mostly controlled by the good old wall switches. Whenever there is a need for an adjustment, be it lights or window shades this is done easily with the help of the switch. Installing a calendar as an interface between the house and the human does not mean getting rid of the wall switches but users have shown that being able to act quickly on the automation is very important to them. P9: *"I would use the calendar when I want to plan or when I want events to reoccur but for spontaneous decision I will want normal stuff [like buttons by the door]"* In order to help the user make spontaneous changes, the interface should be modified to highlight the current executing event. This will allow the user to easily see the event and an eventual
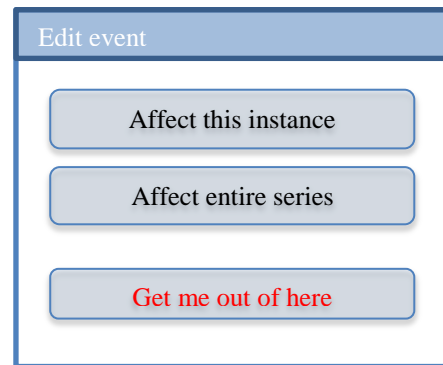
tap on it should allow function as *stop/undo* or *edit rule* in case the user wants to change the rule that triggered the inopportune behavior. An undo function has often been requested during the user study but also during the design workshop: Expert 1: "*An undo button will be awesome!*" The undo would give the user the ability to reverse an automation action which it is not required anymore like for example shades going down unnecessarily. Spontaneous changes of active events can be recorded and used by the same learning system described in the previous chapter.

IV – Visually, calendar events are understood as a representation of both the time an event starts and the duration of an event. Casalendar makes a step further from this established model by introducing events which only show the start of an event without the actual duration. At times, this seemed to be confusing for the testers which could not grasp the real duration of an event or if a scheduled service has stopped or it is still running. This type of event visualization crowds the view and in turn it reduces the browse-ability of the calendar. Results from the user study and design workshop suggest two distinct design approaches to this issue. On one hand the calendar design could break the connection between the size of the event as seen on the interface and the length in time of the actual scheduled action. This can be achieved by representing an event not with the typical rectangle but with a shape similar to the one in Fig 9. This kind of representation will give a clear understanding of when an event started while not necessarily pointing towards the duration of the event.
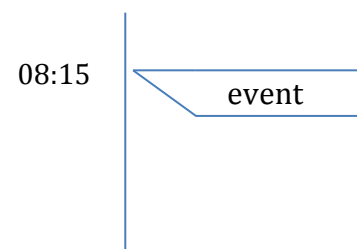
Fig 9 representing the exact start time of an event

The other way to address this visualization challenge is by representing one long event as a pair of two associated events:

"I don't think I am bothered that it shows as one hour long but I understand the need of showing an associated event. Like I know it started here but where did it finish?" – Expert 5

Fig 10 shows the start of an action which also makes a visual reference to the end of the same action showing thus that this particular event is part of a start-end couple. (Mitchell, 2007) explains that there is a strong connection between the written language and the perception of flow of time in computer graphics.
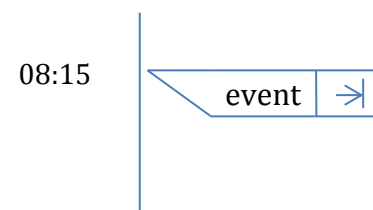
Fig 10 referencing the end of an event at the beginning of the event

As such, research shows that generally people perceive the flow of time in the direction they read, that is from left to right in western cultures. This is why visual objects are often oriented to represent the flow of time, e.g.: progress bars, copy-paste dialogs. The approach taken in Fig 10 shows the start of an event at 08:15 (left side) and which ends at an unknown time (right side). The flow of the event is therefore perceived as from left to right – in agreement with both the user need of seeing that an event has a start and an end and also with Mitchell's recommandation for time flow represenation on computer interfaces. This visualtion can be further extended: when tapping on the right side arrow the view will jump at the end of that event; For an event which is still in progress, like robot cleaning for e.g. a "*in progress*" icon can be displayed instead of the arrow.

V – In day to day calendar use we rarely reuse events. However, in Casalendar events are not of just one type but many and when trying to add a new event the user will probably have to choose the event type from a list of many events. In order to avoid this extra work and facilitate interaction it was hoped that testers would recognise the benefits of reusing past events. That means dragging an old event to the future. The possibility of reusing events did not seem to be as obvious as initially thougt; whenever faced with the occasion, testers first though of creating a new event instead of dragging one from the past to the future. This is again because of the different mental models that apply for a smart home calendar as opposed to a regular calendar where events that have passed are almost never looked at again. Observations made during the user study seem to indicate that when a tester needs

Fig 11 Visualization of a drag&drop popup

to place a new event on the calendar his attention is on the moment in the future when the new action should take place. Consenquently the past is completely ignored. This observation is an accordance with the concept of *prospective remebering* described by (Payne, 1993). In his research over the *Understading Calendar Use*, Payne suggests that the central task of a calendar is to support prospective remembering, that is, remember users to do something at a certain time in the future. With this task at the core of every calendars design it is clear why users would not easily recognise a relationship between past events and future intentions. Nevertheless, testers pointed out that reusing past events is indeed simplfying the interaction but the more familiar *tap and hold* event

adding should also be supported. Additionally, during the design workshop experts have confirmed that drag&drop actions should trigger a popup dialog that asks the user what the intended action is. Commercial calendars like *Google Calendar* execute a move action by default when an event gets dragged. While the design of Casalendar should consider the behavior and actions people are used to, one expert points out that having move as a default action will limit the user since sometimes there is a need to copy events: "*I like this better than google. I would not mind to have this on my personal calendar[talking about the menu in Fig 11]*" – Expert 3. Fig 11 shows and example of a popup where the user is prompted for the exact action that will be executed: Selecting *Move Here* will delete the old instance and create a new one with the same parameters, this will apply only when both the original event and the moved one are in the future. Moving an event from the past should not be alowed since theoretically the past cannot be altered. *Copy Here* will keep the original event and create a new one with the same attributes. *Create new* will trigger the creation of a clean instance of that event type for which the user will have to enter the event data.

5.2 Q3

I – The topic of autonomy has been often mentioned during the study. In all of these cases it looked like users are giving clues of their real expectation towards a smart home and that is to be able to learn from their behaviors and actions. In agreement with related research (Brush, et al., 2011), the finding of this study is that people appreciate a level of autonomy but only then when there is no risk of *losing control.*

"*I don't want you[the home] to take control over me but on the other hand, I am kind of... Why not... If you are smart enough... I ll have to try it.*" P10

5.3 Other findings

This section provides an overview of findings and observation which are not necessarily supported by sufficient number of occurrences or by related work. Therefore, the following ideas should be seen as potential issues or opportunities for future investigation.

I – Casalendar at its current development stage is used to provide smart home inhabitants with an overview of the effects of automation. By trying to extend this functionality, Casalendar lends itself for a double purpose. During the user study P8 mentions that *he is not interested in what happened in the past* and this attitude

contradicts with the initial purpose of Casalendar. It could therefore be the case that by allowing correction and scheduling, the calendar is not any longer seen as the place to turn to when one wants to see what the house has been up to. Future investigation would need to be carried in order to better understand the attitude of users and to also find the right place for Casalendar as a smart home interface.

II – From an interaction perspective it was noticed that people have difficulties initiating interaction which controls which are grayed out or covered by other controls. Without further proof it is assumed that the reason for this is that contemporary UIs show inactive controls as grayed out or blurry.

5.3.1 Regular vs. Casalendar

 (Crabtree, et al., 2003) remarks that reusing personal and workplace calendars in a home setting is not just a matter of technology transfer. This work alone shows that while people might be fluent in scheduling meetings and appointments on their personal calendars they are not always comfortable with scheduling home events. That is because home calendars like Casalendar are considerable more complex than a regular calendar.

I – One obvious difference is the way events work in these two types of calendars. On a regular calendar an event is merely a reminder of something that the user needs to do. On Casalendar an event represents a future action that one or more devices will be executing in order to serve a user need without any further intervention of the user. This concept is similar with that of a VCR recording scheduler, where one can schedule the VCR to start recording automatically at some time in the future. In a regular calendar however, an event is something that the scheduler itself will have to execute at some point in the future.

II – One other key aspect is the type of events available in a Casalendar as opposed to regular calendars. While a common workplace or personal calendar will feature a maximum of two event types that is appointment and meeting request[4]; Casalendar features a larger amount of events, all with different input arguments and execution effects.

III – *Calendar Notifications* represent also a difference between the two types of calendars. While in a regular calendar notifications are critical to the purpose of the

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[4] This example is based on Microsoft Outlook Calendar 2010;

calendar as an organizing tool, in Casalendar notifications are probably not required since the user does not necessarily has to take part in the execution of a scheduled action. A form of notification could however be used in order to alert the user of eventual errors in execution.

P8: *"So if everything went well and the temp is 23 at 5 clock I dont need any other information; if there was something wrong then please tell me house what did you do."*

6 Discussion

6.1 Design Recommendations

I – One key observation of this work was that people find it difficult to schedule automation events. Findings and related work presented above suggest that the reasons for the difficulty to schedule lays in the fact that people are not used with scheduling intentions which do not belong to them but in this case, to the home (Payne, 1993). In fact, Casalendar makes a clear distinction in between personal events and home events. To overcome this mental barrier, a deeper merge of the two types of events is proposed. To facilitate easier interaction and event scheduling the inhabitants need to be freed of the burden of scheduling both personal and home events; instead the home should be able to schedule its own intentions that complement the intentions of the inhabitants. If for e.g. a rule exists that states that the robotic cleaner should clean when the house it's empty it should be enough for the inhabitant to note its intention to not be home by scheduling an appointment. In this example, if a clean is due the home should autonomously schedule a vacuum run at the time of the scheduled user appointment. Other example: Inhabitants schedule *ski get away*, home schedules *surveillance on; heating down; automatic plant watering system; etc.* This type of behavior has been often directly and indirectly proposed by users and research:

"I suppose the house should realize that I am cold and adjust the temperature by itself." P2

"Perhaps the next step in intelligent environments will come from environments that stick their virtual nose in our business." (Mozer, 2005)

A common concern among smart home inhabitants is *loss of control* (Brush, et al., 2011) (Mennicken & Huang, 2012) People are simply afraid that the home will take over their lives or fear that uncontrollable behaviors would emerge out the whole complexity. Such fears can be addressed by making the user feel in control and with the system described above this is always the case. Even if there is a considerable amount of learned behavior, the automation is only activated when the user schedules trigger events. The feeling of control could be further increased by displaying foreseen automatic events on which the user can immediately act by changing time, deleting and so on.

The examples above assume a rather automatic, smart in fact, approach to home control. This is line with the needs many users expressed and it also addresses a major concern that experts had during the design workshop; that of the interaction being overly manual. However, research shows us that smart environments and sensing technologies are far from reaching the level of intelligence required to correctly deduce and learn user behavior. (Chan, et al., 2009) (De Silva, et al., 2012) Assuming a cleaning event somewhere on the calendar, evolved learning algorithms will allow Casalendar to eventually interpret the intention behind this event and adjust the automation in order to support the user in the cleaning process. Unfortunately, such learning technology is yet not available today and while *waiting* for the *smart home to get smarter*, Casalendar could employ a manual and yet usable approach to interaction. This could be achieved by allowing the user to create *automation routines.* An *automation routine* could be defined as a custom made event that the user builds by dragging individual events on top of each other in order to merge them in a group. The group is then given a name and so it becomes a routine. The custom events are similar to the *free-form events* proposed by (Neustaedter, et al., 2009). A *Free form event* is described as an event to which the user had given a custom meaning by annotating it with extra information. The example bellow shows the building events of a *Cleaning the House Routine.*
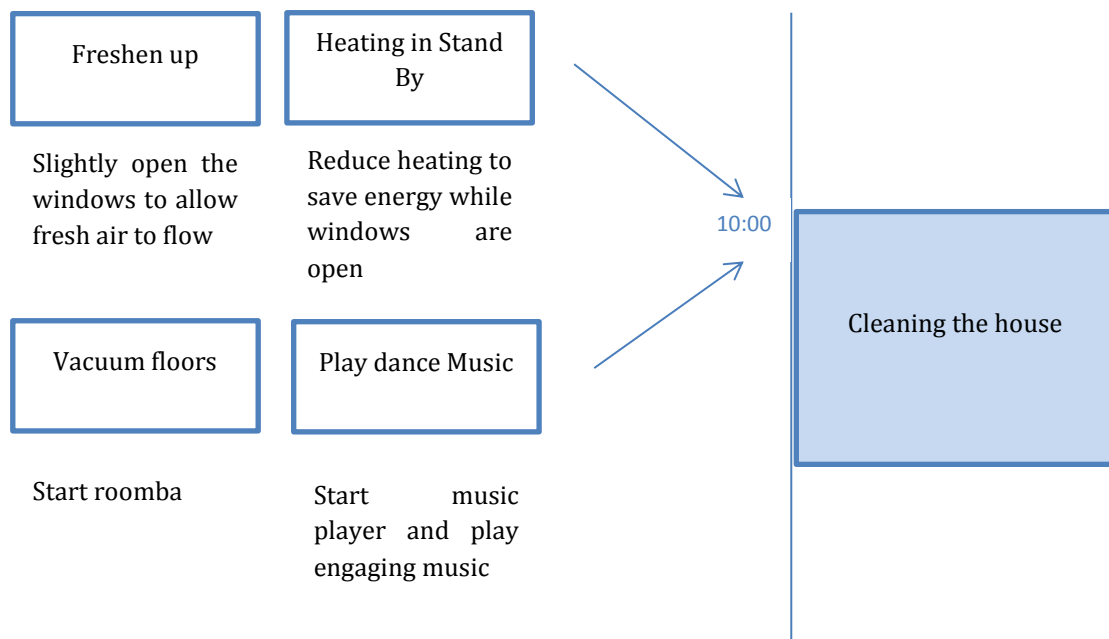
Fig 12 Joining four individual events into a routine

This example assumes the existence of these four events and the equivalent automation effects which the users finds useful while cleaning the house. In order to avoid multiple scheduling of individual events, the user joins these four events in a routine which can be scheduled whenever a house clean is intended. This concept can help users better formulate their intentions since a routine has a broader meaning and effect. Simple events can have a rather technical feeling to which users do not always connect (Mennicken & Huang, 2012).   Allowing people to create their own events further increases the feeling of control over the automation by providing the user with the freedom to connect events in the most meaningful way they conceive. When the house cleaning routine is extended with a *lawn mowing event* which is added, let's say by the husband of the family, Casalendar moves a step further towards becoming a house coordination calendar (Neustaedter, et al., 2009). Family coordination is achieved by having family members together schedule a family activity, that is *house cleaning* in this case.

II – A secondary view displaying detailed automation was a common request during the user study. Correspondingly, design experts requested an additional view where change in the state of a home service can be seen. The actual calendar interface provides a familiar way for inhabits to oversee and correct automation effects but its restrictive grid layout does not allow for additional information to be displayed and it can easily become crowded. Modifying this well-known interface runs the risk of decreasing the usability and so it alienates users instead of better serving their needs (Gough, et al., 2006). Therefore, while the grid view would remain as the main entry point for scheduling and correcting home events, an additional view taking over the task of showing more detailed information is described below.
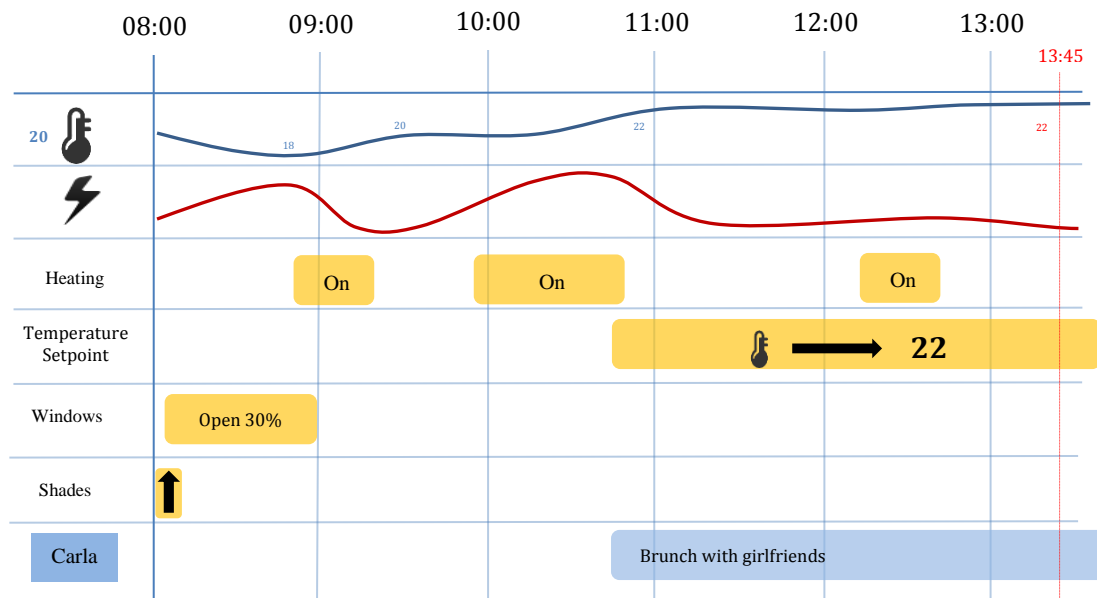
Fig 13 Horizontal event view

The *horizontal event view* is a different and arguably better way of showing automation effects in that it aligns one hour long time blocks one under another and thus provide a clear view of which activities take place simultaneously over a given time span. In the example above, this extra view shows how the automation effects related to users events and the other way around. For instance, in preparation for her friends arrival on this Sunday morning, Carla opens slightly the windows of the home in order to allow the flow of some fresh Spring air throughout the home. The opening of windows is recorded by Casalendar and a look on the detailed view shows how the fresh air lowers the temperature indoors and triggers the heating system to kick in and thus increase energy consumption. Once the windows are closed, the temperature stabilizes at the set default value of 20 degrees and the energy consumption is also reduced. Only for a short while however, because minutes later the home anticipates the upcoming temperature set point and it starts the heating system again in order to reach the temperature Carla wants to have while having her friends over.

Providing users with an easy and intuitive way to elicit meaningful correlations between home inhabitant routine and automation effects is one of the main functions envisioned for Casalendar. Aside from this, this visualization addresses a good number of common remarks, complains or needs that users have pointed out during the study, among these:

- more detailed energy consumption information;

- view and details of running services at any time;

- frequent change of states without crowding the calendar view;

- better representation for events duration;

In addition to these, by allowing continuous scrolling towards the right, this view is well in line with the current touch screen technologies and contemporary user interfaces like the Windows 8 Metro view (Hund, et al., 2013). The left to right visualization is also thought to be the natural way people perceive the flow of time on a computer interface (Mitchell, 2007).

6.2 Future work

I – *Do people have the same understanding of a regular calendar event as opposed to a Casalendar event?* Section 5.3.1 suggests that there might be a difference in the way people perceive the two types of events and this topic could be investigated by a future study.

II - A *personal calendar* is called personal for a good reason. It is used by a person and the events listed on the calendar belong in most of the cases to that person only. Since Casalendar is more than that in the way it brings several calendars together, future research should consider more this psychological aspects of the calendar. The first design discussed above suggests that people should not be required to deal at all with technical information like: *dim lights* or *play music*. Instead, the human need behind this kind of events needs to be investigated in order to facilitate a more human like interaction. Perhaps, what the inhabitant actually wants is to schedule an hour of *book reading,* without bright light and with smooth music. Furthermore, what are the rules and constrains of this behavior, should the house learn by itself or the inhabitant is more comfortable with specifying its own customs events as shown in Fig 12?

III – Smart *Energy Grids* is currently a *hot topic* among research groups. In the context of global warming and the immediate need to cut energy use, a power grid that is able to smartly balance demand and production is needed (Balta-Ozkan, et al., 2013). Home automation systems will make use of the smart grid in order to optimize energy consumption by for e.g. starting and stopping electrical devices in function of the grid

load and energy prices. Since this behavior is automated and influenced by factors external to the home, the inhabitants need to be kept up to date with what happened while they were gone. Since showing automation effects is one of Casalendar's main tasks, the use of Casalendar in connection with the smart grid could be investigated. What is that the users want to be informed of? Can Casalendar help further with energy savings, and if yes, in which ways?

7 Conclusion

This master thesis work looked at how people will like to interact with Casalendar, a proposed home automation calendar-like interface. The work was structured in the form of an empirical study where a number of ten people have been observed performing a set of two tasks on Casalendar. Results from the empirical study have been looked at throughout the prism of related work and then made in a set of design ideas. These ideas were exposed to a group of HCI experts during a design workshop where the focus was on usability challenges and potential improvements. One of the main findings is that before diving into specific aspects of interaction, the way people understand Casalendar is by itself a challenge. Findings show that there are only a limited number of corrections users think of when interacting with Casalendar. These corrections are without many exceptions the same changes one will apply on a personal or work calendar. Out of these, editing active events is often used and that is in order to cancel or stop the effect of an executing automation event. This behavior is understood as an emphasis of the need for control users require from an automation interface. Reusing of events by dragging them from the past to the future was assumed as a quick way to request the repetition of an automation effect as some point in the future. Interpretation of the data showed however that users might be uncomfortable with reusing events but do recognize the potential once they are explained the advantages of reusing. Further investigation of related work revealed a couple of reasons for this behavior, among these it seems like the common view of the calendar as an aid to remember things prevent users from considering past days and events.

This study finds that users have an established view of what a smart home is; that is a system which is truly capable of behaving smart by learning and remembering user behavior. Learned behavior can then be used to anticipate user actions and eventually provide support for them.

The study further recommends two prototype designs which address the differences in between regular calendars and Casalendar. The first design proposes to reduce the difference in user perception between a home event and regular appointment. It is suggested that by diminishing the technical feeling of automation events inhabitants will be given a way of scheduling and correcting events which is more personal and thus

more usable. Second proposed design addresses the recurrent call for a better way to visualize continuous home services which cannot be represented efficiently on a regular calendar view. This design brings together the calendar of the inhabitants and automation effects with relevant home information like temperature values and energy consumption. Furthermore these three relevant information sources are organized vertically one under another in order to facilitate the elicitation of meaningful correlations in between events and home *stats*. By recognizing these correlations users will be able to easier identify the areas where corrections are necessary in order to improve the automated behavior of the home.

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Appendix A – Paper prototype used during user study
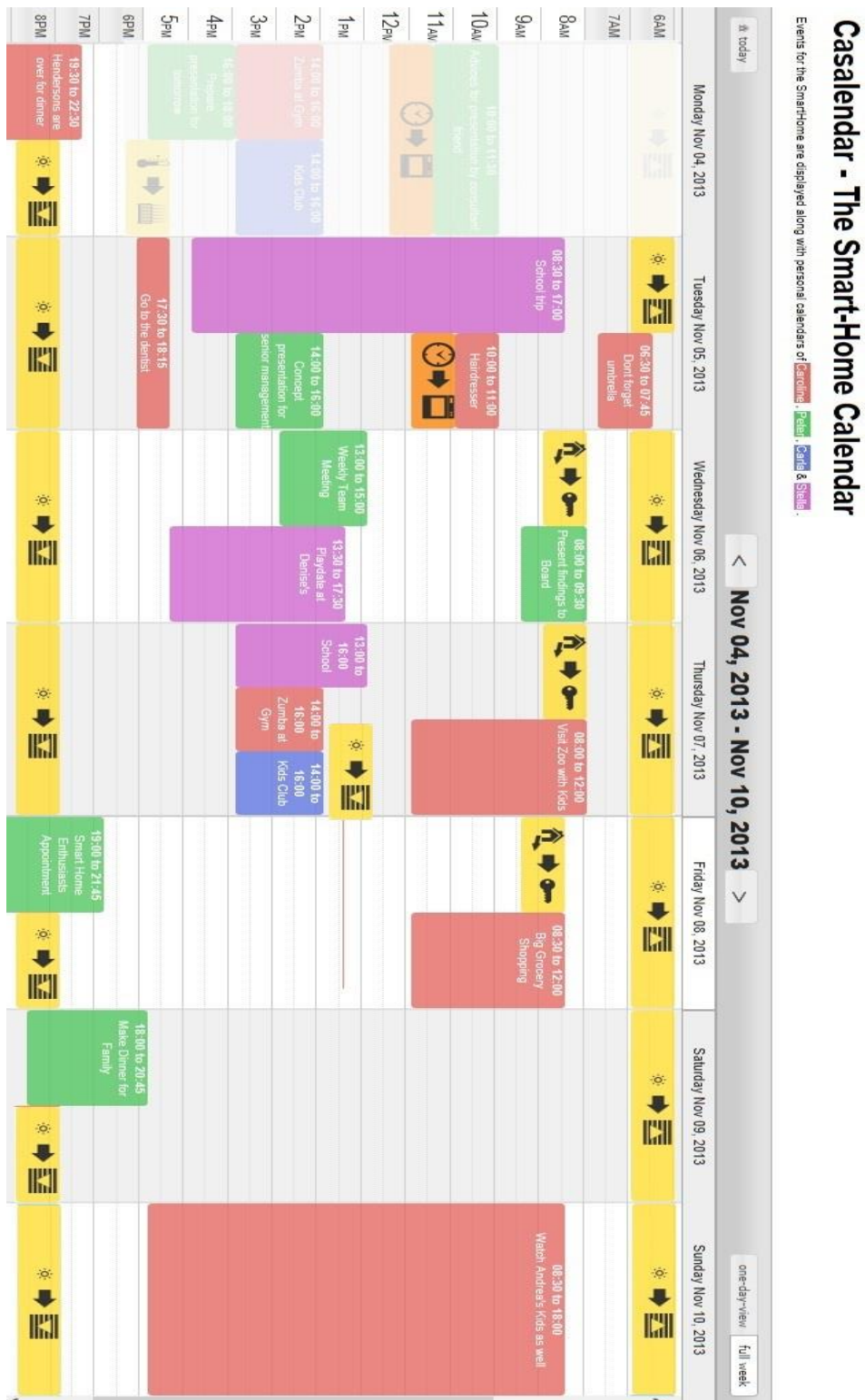
Casalendar - The Smart-Home Calendar

Events for the SmartHome are displayed along with personal calendars of Caroline, Peter, Carla & Stella.
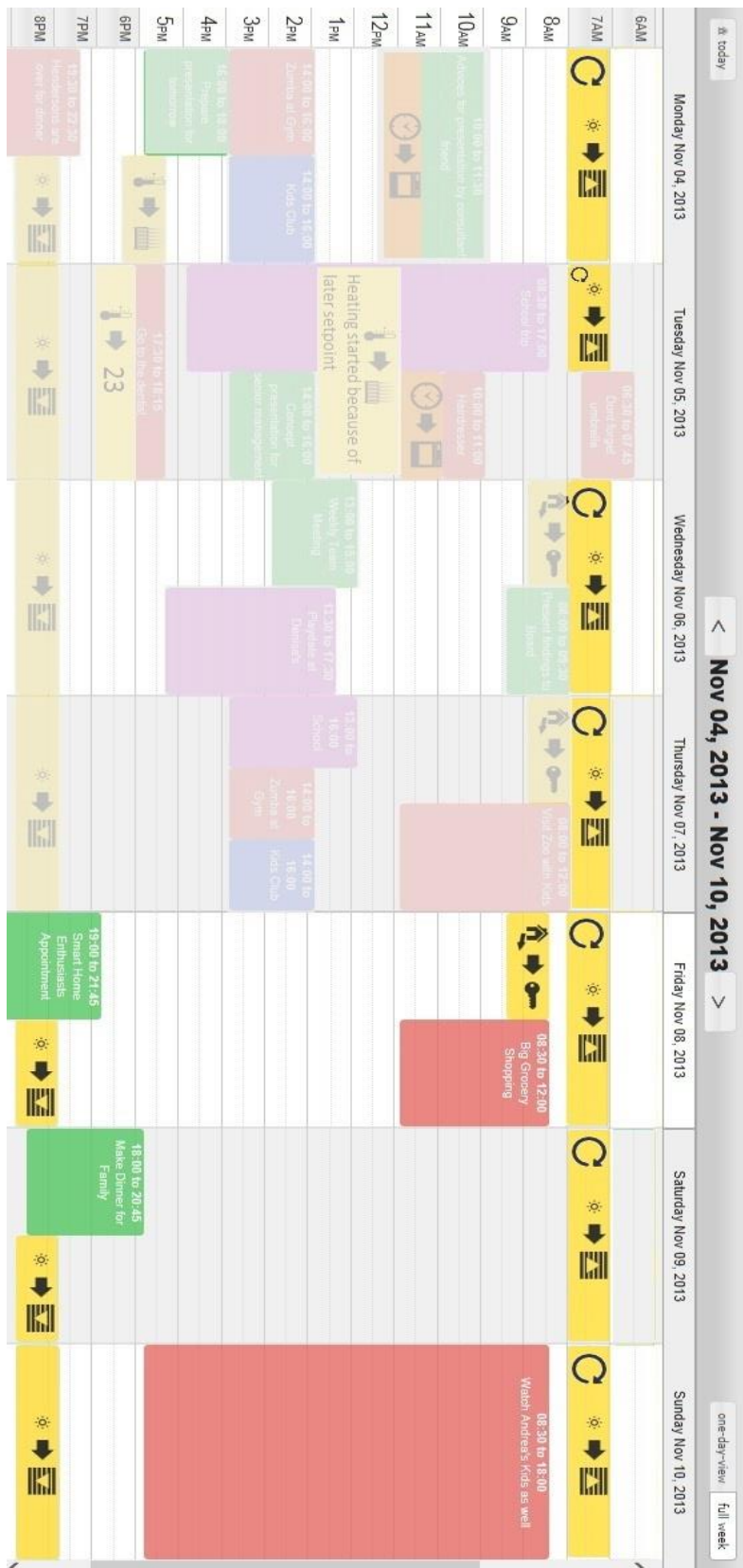
Maintain Temperature

17:00 to 19:00

△ 22 ⊕

☐ Use current temperature

Current indoor temperature will be selected

☐ Mon   ☐ Tue   ☐ Wed
☐ Thu   ☐ Fri   ☐ Sat
        ☐ Sun

[Delete]   [Save]

Start Washing Maschine

Wed: 09:00

☐ Ignore time and consider costs.

The maschine will start whenever the energy is cheaper on Wed.

[Delete]   [Save]

○ Shades Down   ○ Shades Up

12:00

☐ Mon   ☐ Tue   ☐ Wed
☐ Thu   ☐ Fri   ☐ Sat
        ☐ Sun

[Delete]   [Save]

Appendix B – User study transcripts

Notes P1 (33 Male, CH)
0215 Tester has difficulties finding what the current time is and it points towards the oven start event.
0425 Tester associates sensor input with the heating event on Monday. The sensors detect that the house is cold so the heating starts.
0436 Tester makes an easy difference between past and future events.
0554 Tester mentions a defect as a reason for a mid-day shades event on Thursday. Weather is also mentioned.
0630 "Can we see which events are manually and which events are automatically triggered?"
0803 "Don't forget the umbrella, is this an automated event?" 0825"It can also be automated by checking the weather and recommending you to take an umbrella"
1011 "I don't know how I will use the calendar for this." [Talking about changing the temp]
1210 "Now depends which temperature I have today, I mean on Monday." [when thinking of changing the temperature.]
1300 Tester seem to think that the heating->23 event means that the house will then start heating.
1411 The tester rethinks its previous ^^ assumption when the heating started even is shown.
1456 [Talking about placing a temp set point event] "Depends how specific we are... If I know I will be home at 8, I will start heating at 5"
1530 "If there will be a legend I would know what this is." [Talking about the symbol confusion]
2026 "Maybe on Sat and Sun I will like to sleep anyway longer" [Talking about scheduling shade events]
2113 "What now happened, It took also all days before now" [Talking about recurring events visualization] 2130 "What is missing there [on the menu]... I should have indicated that I want to make the change from Friday onwards"
2250 Tester explains that the recurring symbol is an indication that the event is repetitive.
2606 [Getting back to weekends] The tester mentions that she will need two separate rules for the shades. One for the weekdays and one for the wend.

Notes P2 (29 Female, CH)
0208 "I am not sure what this symbol is supposed to mean.[Talking about the shades symbol]"
0304 "This is a bit confusing too, the shutters going up here and then down again"[Talking about the extra shades event on Thu]
0523 The tester notices the heating event on Monday and it wants to click on it in order to make adjustments.
0545 "Can I just tap on the time where I want something else to happen?"
0850 "I am almost wondering is I need to be seeing this..."[Talking about the temp set point]
1010 The system tells me that it needs to start in order to get the temperature ready.[Talking about the heating started event]
1144 "This is interesting for me if I want to know how much energy I am using."
1303 Tester talks about how the house should give energy consumption information.
1530 Tester talks about how affecting the heating event was not intuitive. [Dragging]
1617 Tester suggests that one should be able to do both, click and drag.[to create/adjust an event]
1647 Tester seems like it wants to act on the shades right now.
2030 The recurring event icon is mistaken for an undo button.
2230 The tester suggests an eventual connection of the shades with the personal calendar. "The shades should know if I am still asleep and not wake me up."
2449 It is confusing that the changed events appear bright even though they have already passed.
2502 "I would still expect these to be grayed out because the day is in the past."[Talking about the shades event]
2613 Tester proposes the calendar to always have the current day in the center.
2653 "I hardly ever look at events that have happened."
2830 The tester comes back to the energy topic and suggest a dashboard for visualization instead of the calendar.
2950 [Talking about the events in the past] "If I am not a tech geek I do not care much about it. I don t care what my xbox does in the background. I am just interested in the playing."

Notes P3 (38 Female CH)
0454 - Tester is unsure if the heading goes on after the heating event on Monday.
0455 "Normally it stops during the night, but I don't see this on this calendar. If it stops or starts again." [Talking about heating]
0900 "I will create a new action/event and tell the house that I want the heating to be on"
0904 Tester tries first to tap in order to create a new heating event.
1153 Tester realizes correctly the use and purpose of the "Heating Started Event"
1253 "I only pushed save and then I have to believe that it worked." [Talking about creating new items]
1440 Tester suggests that the two heating events can be merged in just one.
1544 [Talking about dragging an event] "I did not drag it because I did not see it, it looked like it is behind."
1622 Tester explains that dragging one event from one day to the other should mean that that event gets copied.
1720 Tester seems confused about the recurrence of the heating event.
1940[On the shades event] "I would prefer to have one button that tells me from now on"
2135 Tester seems confused at how to schedule events that happen once and events that happen many times.
2349 [Talking about a recurring event - In the past] "This should be gray"
2549 Tester points out that change on recurring events should be reflected only in the future.
2645 "I want to see what is next week, not last week"

Notes P4 (23 Male, Ru)
0207 Tester confuses shades event with light event.
0353 The past events on Monday are seen as inaccessible. A public holiday is given as a reason for this.
0453 [Talking on the shades event] "There is no difference between the sun going up/sun coming down."
0800 The tester makes strong correlations between the calendar of the users and the house calendar. E.g. Peter seems to have a day off so he might be sleeping so this is why the shades are down in the middle of the day.
1033 "I will hold my finger so maybe a windows pops up."
1108 The user describes a list of events from which one can select a new event to be added. In this case, a temperature event.
1149 "I don't know, I have IPhone and there you do it exactly like that, you tap and hold."
1228 "You have to create new event for tomorrow" [talking about heating events]
1432 "It looks like it will be 23 from 6 to 7 pm." User seems confused about event start and finish.
1735 Tester suggests merging the two heating events on Tuesday.
1717 "Maybe there should be a window where you can see all running systems." [Talking about visualizing the heating events]
1805 The tester suggests that there should be a difference between important and not so important events.
1944 "This temperature event should be a little bit shaded away."
2130 The tester suggests a default heating plan since on Wend there seems to be no heating active.
2218 The tester suggests again an extra visualization for current status of the house. Energy, Water consumption...
2450 When you just drag it is not clear, is it just for this week or for the next week as well." [Talking about dragging shades events]
2645 Tester confuses the recurrent icon with a cancel/undo button.
2753 The tester explains the color of the recurring shades event with: „Maybe it occurs every week" 2902 "It is a bit confusing" [On the same topic]
3011 The user points out that the recurring symbol should also appear on the shades down event.
3600 Tester extresses concern that in the future the interface might get crowded with events.

Notes P5 (27 Male, FR)
0210 The tester correctly points out the current time and the past event representation.
0339 "I will tap on it, expect that something might happen"
0356 "I will ask the person that knows how to work with this" [speaking when confused about the interaction]
0551 "At six it will begin to heat to 23 degrees."
0621 Tester corrects her previous assumption. [The one that the heating starts at 6 only]
0806 The tester suggests that the heater starting event should be already be shown the day before [On Mon when the change was made]
0909 The tester seems to understand that the heater starts at the beginning of the event and the desired temp will be reached at the end of the event.
1015 Tester suggest a dotted line along the day to indicate that the heating started earlier.
1150 [Talking about changing the shades event] "I will tap to create a new event."
1423 Tester suggest using two buttons to define that events are single or multi occurrence.
1435 "I will say the standard one will be single occurrences and if you want more you can press repeat every week." [Talking about scheduling events]
1545 "Changes are replicated for all days, but this is already past so it does not really matter if they changed."
1633 "If I were an user I will ask myself why are these not grayed" [talking about recurring events in the past]
1919 On another topic, the tester suggests that deleting a door lock event should mean that the house should stay open at that time.
1950 [speaking about a future house lock event] "It means that I have to leave the house before 9a, because the door will lock"
0800 Tester mentions that the door lock event should be shown when the door is also locked with a regular key "Maybe someone has the key comes in and you did not expect this"
0640 Tester mentions that it might be a problem if you shortly go out of the house without a key and the doors lock automatically.
2230 The tester suggests that having a door lock event might be useful when your maid does not own a key. The house can automatically unlock shortly before the maid arrives.
2426 Tester suggest a security issue when an unknown has access to brief access to the system. She can then schedule the door to open at a later time and come in uninvited.

Notes P6 (30 Male, IT)
0303 Tester seems confused about the current time.
0500 The tester suggests that she will use the heating controller to change the temperature. [In relation with T1]
0800 "I just go in the menu, I choose the radiator and say at this time, this temp" [Talking about adjusting the temp for the next day]
0823 Tester does not drag the event as intended but it does call it an easy way of once it finally becomes aware of it.
0842 The tester points out that if one relies just on dragging than all options must already exist in the calendar.
0913 "In the summer I need the air conditioning, from where I put it?" [Talking about changing events]
1115 "I need something where I can write Temperature for e.g." [Suggesting a fast way to add a new event.]
1214 "This is really easy and I think it is really useful" [Talking about dragging the shades one hour later]
1320 "On the weekend I wake up at different times" [Talking about T2]
1418The tester is confused by the recurrent event symbol.
1508 "It's like I moved it in the past" [Talking about future events in the past]
1722 The tester suggest that the house could learn that usually at a certain time no one is home and the door should be locked automatically. The tester sees this not an autonomous behavior but as a manually created event.
2253 "It is useful because, about energy you spend a lot of money" [Talking about the house informing that the heating is running]
2309 Tester suggest that dragging the heating event out of the calendar should stop the heating?
2425 Tester explains that he will set multiple temp set points during the day. For when the house is empty and evening.
2720 "Just tell me that it is going to turn on. For me is okay? No - Then delete. Yes? Then I do nothing [Talking about heating will start event]"

Notes P7 (25 Male, CA)

0225 The tester assumes that the past is not tap able "It is probably because this section is not available"

0250 As a reason for the unavailability the tester suggests that the person that is looking at the calendar might not have the permission to affect the event.

0400 "It is probably the heating going on or turning off..." [Talking about an heating related event]

0550 "I ill just drag it and expect a menu, it will probably say something like copy..." [Talking about dragging an event]

0620 "It is replicating the event I just dragged but it always me to..." [Talking about the TI menu]

0730 [Talking about using the current temperature] the tester asks what if the temperature is currently increasing in order to reach a later set point? "I will be a bit confused using the current temp, I don't know it is from the event or... "

0900 "I think after 7pm, the heating will turn off" [Talking about the temp after the set point event had passed]

1030 "I know that the heating started here but I don t really know why..." [Talking about the heating started event] "I don't understand the later set point"

1210 The tester clarifies that his understanding is that the heating will start there where the set point is placed.

1330 For T2, tester acts of shades event on Saturday morning. (Most testers acted on Friday)

1500 "I assume that if I move just one event, it will move just that one event" [Talking about acting on recurrent events]

1620 "Here, something is reloading so I will tap there and see what happens" [Talking about the recurrent symbol]

1830 "I would say that the gray part is for what it happened and because this is a recurring event it is not grayed out. It still represents future information."

2100 Tester says that when dragging an instance of a recurring event she expects the change to be done without further dialogs. [Not clear enough]

2350 "Does the end of the event mean that they will close [the shades] when the current time overpasses the event?"

User suggests that there should be an indicator that make a difference between event like heating and shades since shades event cannot last for an hour.

2540 "Maybe you can represent only when the blinds come down because this is most unusual" So then during the night you will have an event that stretches during the entire night.

2700 tester suggests that an active event should be grayed out right away thus being inactive to tapping.

Notes P8 (29 Male, DE)
0621 The tester correctly assumes that the events that show an watch are scheduled events.
I ignored the transparent Monday because I would assume that we are now on Monday evening and I am not interested in what happened before.
0735 "How does the house know that at that time no one will be there." [Talking about the doors lock event]
0909 "Because it is grayed out it is not that important anymore" [Talking about a heating event placed in the past]
1130 "I will drag something from a menu" [Talking about adding a heating event]
1150 [Talking about dragging something] "It is more visible to me, it is not hidden".
1320 "Will I be frozen everyday, or just today?" [talking about scheduling events]
1407 [Talking about heating event duration] - "I am not quite sure."
1505 "There is this standard temperature" [talking about a fallback temperature independent of calendar events]
1620 "Normally I will use my normal thermostat" [talking about adjusting the temp]
1720 "Somehow it is irrelevant for me because I am interested in the result" [Talking about the additional temp information]
2010 "That confuses me now a little bit" [talking about when the heating starts; before or after the set point event]
2200 Tester suggest using a clock symbol to symbolize the start of the heating. "I associate the clock with the point when something starts."
2420 "So if everything went well and the temp is 23 at 5 clock I don't need any other information; if there was something wrong then please tell me house what did you do"
2600 "I will long press or double tap and then I will expect something to open"
2640 "First thing on my mind: There is nothing selected" [Talking about changing the shades event by using the side dialog]
2900 "I am obliged to re-click all days" [Talking about selecting days for a shades event]
2940 Tester assumes that the recurrence symbol shows that there is something in progress.
3008 "I cannot really explain why this indication is given to me" [Talking about the recurrence symbol]
3030 "Is it on purpose that it seems that the yellow shades event are not grayed out?" [Talking about shades events in the past]
3100 "For me, what happened in the past stays in the past and I can only change what is in the future."
3430 "It feels like I will move the entire bar, it feels more strenuous." [Talking about dragging recurrent events.]

Notes P9 (28 Male, PL)
0234 "One think that strikes me a bit is that you have one time shades up and then again shades down in the middle of the day." [Talking about the extra shades event on Thu.]
0240 "There is a little in inconsequence for me because on one side I am setting the time but on the other side if I understand correctly this one [a shades event] will mean for me if the sun is down put the shades down - so it does not have to happen at a particular time."
0324 [Talking about previous note] "What it means for me is that at that time [time of the event] check if the sun is down and if yes, then put the shades down."
0350 "The calendar might have some knowledge about when the sun goes down and it is just informing me about what is going to happen."
0550 Tester assumes that the extra shades event on Thu is somehow related with the calendar of the house inhabitants. "Peter seems to be missing, I don t know what Peter does on Thursdays"
0600 "Its today or it is the past... Okay, now i see this [current time line] so it is the past".
0706 "One idea I have from other calendar is to keep my finger down [on an event] and then some options are coming up. Like new event..."
0850 "Dragging means for me.... Moving; I want to move that event."
1050 "Well, that is what I have expected. It does not surprise me at all." [Talking about set point 23 event]
1115 "I would not assume the system to be that clever; to start warming up when it is actually needed"
1214 "That surprises me lets say... " [when seeing that the heating starts earlier in order to meet the setpoint]... So it is that clever...
1315 Tester describes an personal idea of how to represent that the heating starts earlier than the setpoint.
1440 "hm... Before, I was think it is the heating up moment [the setpoint 23]; If it was the heating moment, I would expect the home to keep the temp to 23 but since [the setpoint] says from 17 to 19 than the temperature should be lower than 23 [the next day] "
1529 "I would expect to have something like a default value... There is a special condition at that time [at setpoint time] I want it to be warmer"
1625 The tester suggest to have a dynamic colored background which indicated the current set temperature at each time.
1645 "If I consider myself at home... I never know what temp I have. I don t need that temp actually."

1800 "I will probably just dragging down [one shades event] and if it is a normal calendar, it would ask you Oh... I do you want to change just this event or all of them"
1840 "If I want to see a menu maybe I ll just click and hold for a menu to show up"
2050 "I will expect the past to be untouched and the future to change." [Talking about recurrent events]
2250 "I will assume it will be a message to the house: get adjusted to my preferences"[Talking about changing an event while the event is active]
2400 "I would not expect them to get down even if I change the event" [Talking about changing a shades event while the shades go up/down]
2500 "I would use the calendar when i want to plan or when i want events to recur but for spontaneous decision I ll want normal stuff [like buttons by the door or a different view]"
2600 "I want the calendar to ask me when I do it a 2nd or 3rd time in a row... Like if I am adjusting this [an event] every day. I would expect the calendar to ask me or change things by itself"
3000 The user talks about human recurring behavior and suggests that the calendar could learn this behavior in order to support the user with routine tasks.
3400 "Learned behavior should be shown on the calendar and I should be able to change "

Notes P10 (51 Female, CH)
0300 "That is a bit strange to me" [Talking about the grayed out area]
0330 Tester mentions that the events in the past are not as easy to read anymore.
0500 "Yeah, I would like to know what happened before but it is irritating that I cannot see it."
0530 "Why not have just gray behind the days in the past and white behind the future days". [Talking about past/future]
0620 "It took me a mom to realize we are here" [at this current time] Tester suggests a different representation for the current day and time maybe something with a different color or an arrow above pointing at the current day.
0730 Tester suggest that she will like to be able to interact with past event. Ex. Copy events from past to future just to avoid re adding them.
0930 "I will expect some functionality that allows me to set the temp and the date" [talking about ways to adjust the temp]
1000 "I ll look around the whole calendar and see where can find an icon" [talking about adjusting the temperature] "But I ll probably click on this [the heating event] this is the most obvious"
The tester also suggests that she will probably go back and look for a heating related event.
1140 *"You know, something is strange here. Do I need to set it for every day?"* [looking at the temperature event dialog]
1230 The tester understands that the temp is going to be at 23 starting from 5pm - "The house will need to calculate how long it needs to heat up."
1300 "Well that is interesting, do we have somewhere a base temperature set? [when the heating event is done] It might fall back to this base temp"
1430 "It would be nice if somewhere on this dialog [temp set dialog] I could see the default temp and decide how will I be adjusting it. "
^^ 1430 "and the next step will be, when I go in vacation I will lower my base temperature..."
1600 "I would not need to see it on the calendar. It might only be interesting if I am a total freak... Techie " [Talking about the additional heating event on Tuesday]
1620 The tester suggest that ^^ is useful only when one likes to analyses details and be in total control. "*I am more that type: I trust it!*"
1825 "Intuitively I will tap on that one [The shades event on Fri morning] very strange..."
1840 "I will like to correct the one that in my perception did something I did not want to happen" [Talking about the shades that just went up]
1930 [on the shades event menu] "I will like a date, from when on it should be like that..."

2128 "Will I know it will last like that or did it change in general then forever into the future?" [talking about recurring events]
2150 "Maybe it will be nice if it will remember one of my favorite settings"
2400 [Talking about autonomous behavior] "I don t want you to take control over me but on the other hand, I am kind of... Why not... If you are smart enough... I ll have to try it."
^^ "The house could also suggest that I adjust my profiles... Based on my behavior"
2730 "If i drag something in the past it does not really make sense but if i drag one [recurrent event] everything coming should be adjusted"
2800 Tester suggests that for recurring events there should be the option to affect just one instance or all of them
2930 "I have the picture, I am in bed and I see the shades go up and I want to move them right away to a later time" Tester suggest that if an event gets adjusted while it is happening, the event should be cancelled and reversed. [shades]

## Appendix C – Slides used during the design workshop

Design A

Visually, calendar events are understood as a representation of both how long an event will last and when will that event start. Casalendar makes a step further from this established model by introducing events which only show the start of an event without the actual duration. At times this seemed to be confusing for the testers.

Home automation need: None specifically.
Visualization needs: The user needs to be able to visually understand how long and event will last; The interface needs to stay clean;

Alternatives:
     -A - Box for start and box for stop
     -B - One big box representing the start and ending it at stop
     -C - An all day event at the top of the day. Tapping on the symbol will show the
         related events on the calendar while shading away the other events.
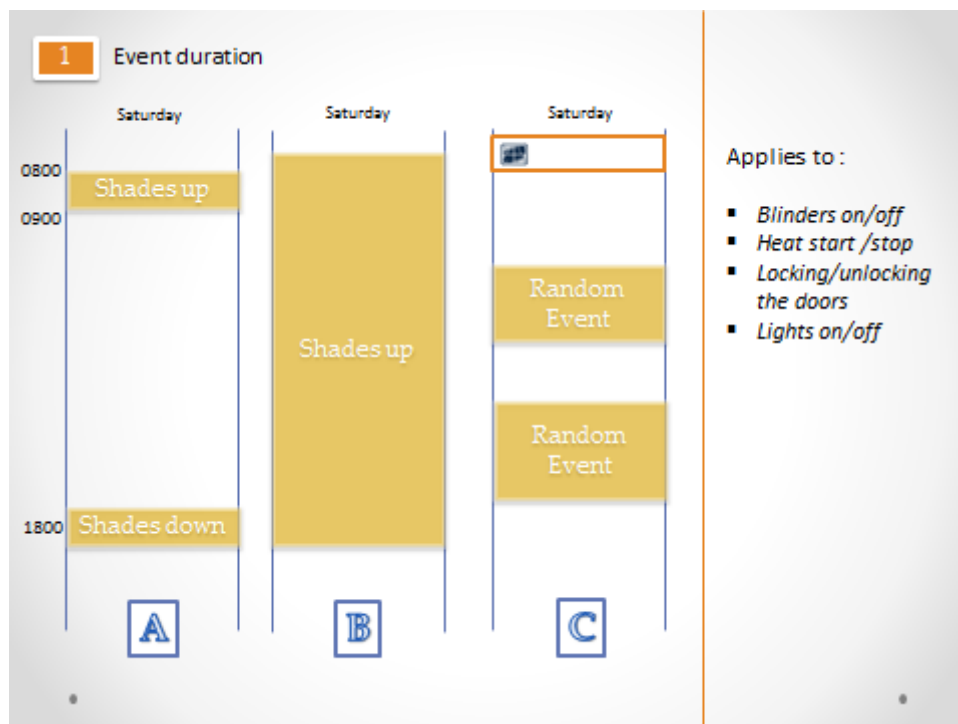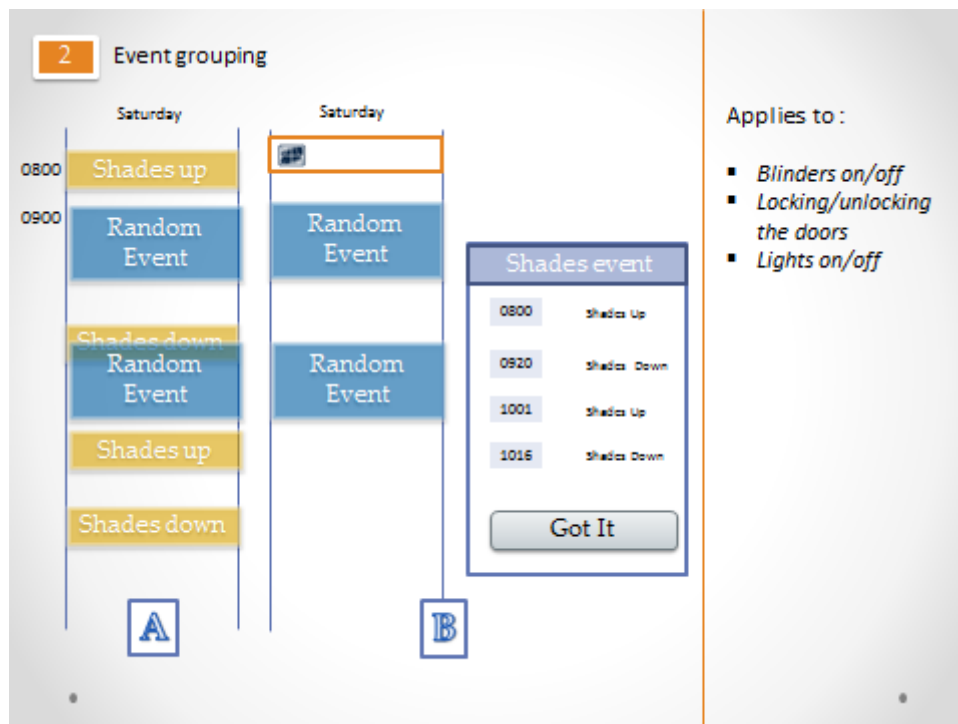
Design B

Home automation systems have their problems, and for e.g. when during a sunny but variable day the shades are activated and inactivated a couple of times; the calendar visualization of that day, gets crowded. Testers have expressed the concern that the calendar will therefore be hard to read and it looks messy.

Alternatives:
-If there are a small number of identical events, than let them as boxes in the calendar.
-If there are many events, make it an ALL DAY event and add at the notes the log when the events happen.
-Group them as one event at the position where the first event happen and when the user clicks the others will appear

Home automation need? = schedule events multiple times
Visualization problem? = how do I keep the calendar clean
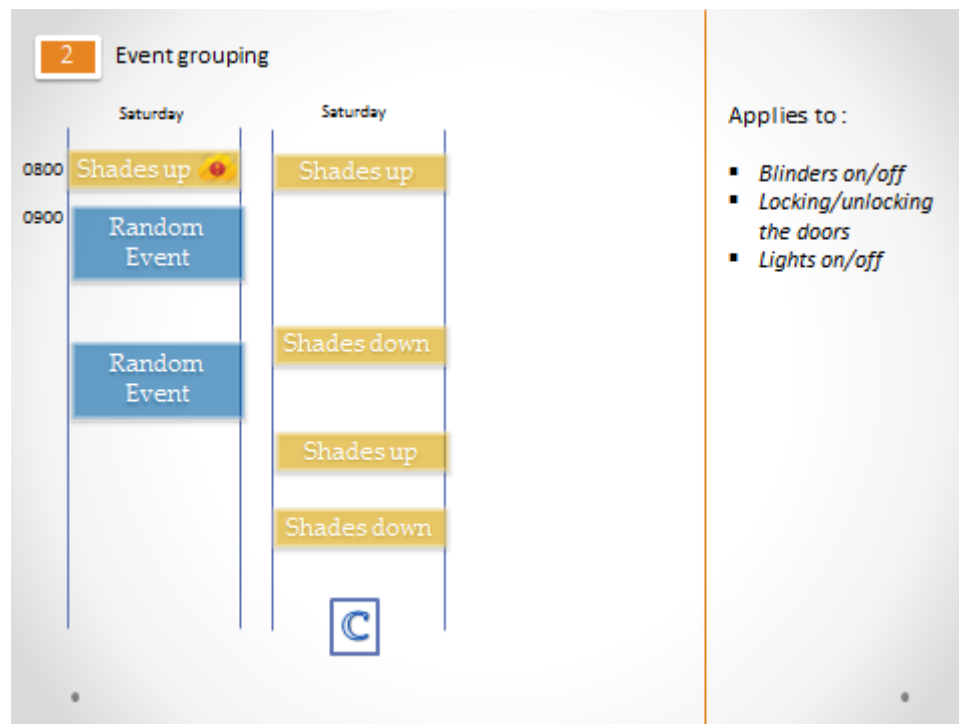
Design C

In the context of a home environment testers have recognized that aside from the daily, short duration scheduled events there must be events which are scheduled once and run for a long time; Stretching over days, weeks or even months. While such events were not covered by the previous interview session, testers have pointed out the need and for e.g. tried to stretch an event over multiple days.

Home automation need: I would like my house to be warm all the time starting with a specific time. "I would like to extend this event over multiple days"
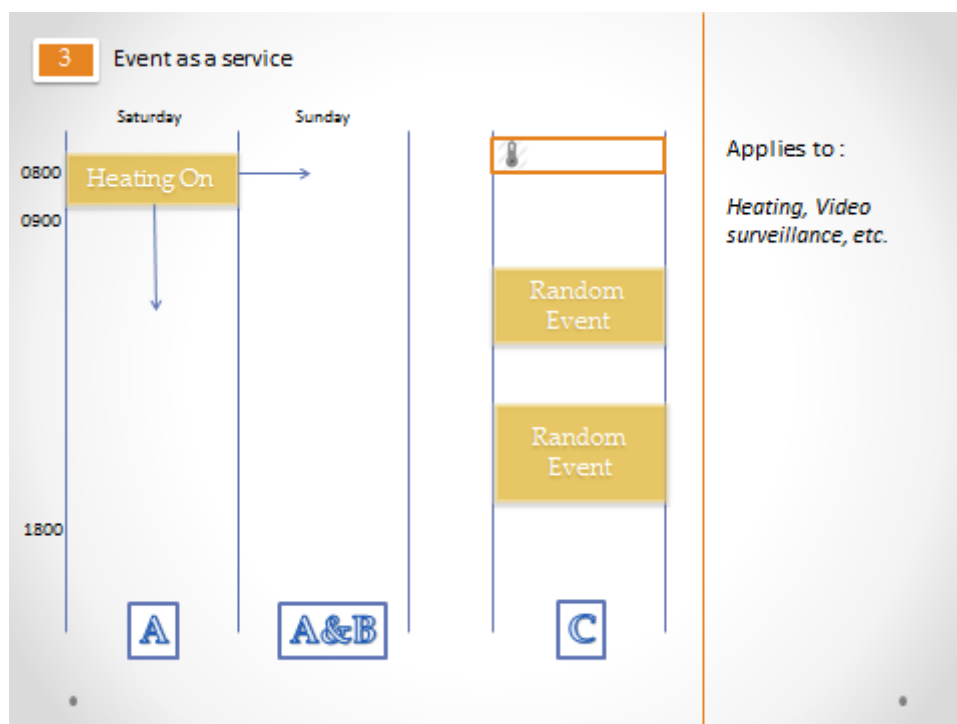Visualization problem: A heating event will be represented as one small item when the heating starts but in fact the heating is ON the whole time;

Alternatives
A - Displayed as big boxes across all the days
	-Displayed as one small box when it started and having as a note when it should stop
	-As an ALL DAY event in the sense of a service

Design D

In day to day calendar use we rarely reuse events. However, in Casalendar events are not of just one type but many and when trying to add a new event the user will probably have to choose the event type from a list of many events. In order to avoid this, testers have pointed at the benefits of reusing past events. That means dragging an old event to the future.
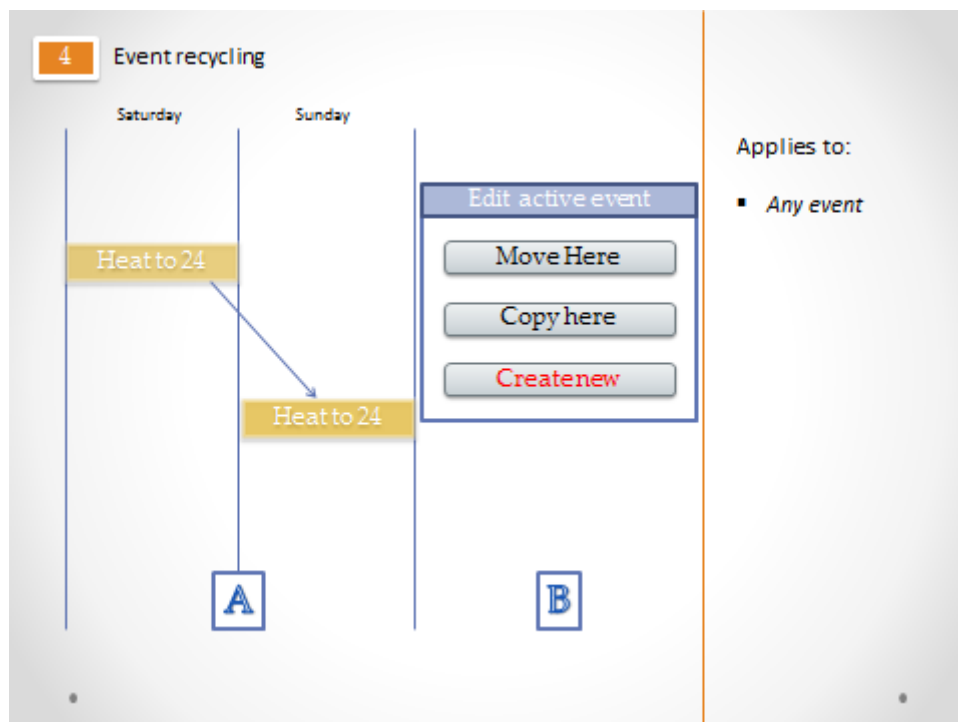
Home automation need: People want to reuse events rather than create and configure new ones.

Visualization problem: drag and drop to? reschedule or create new one?

Alternatives
A - Default copy on drag. Changing of details requires tapping?
B - Show a popup asking for possible options.

Design E

Recurrent events are beneficial in a home setting. They cater for user's regular needs like for e.g. weekly plant watering, daily robot vacuuming and so on. However, on certain occasions these regular needs are subject to exceptions; Season changed and the shades schedule must be adjusted or you have guests and you don't want the loud vacuum robot to wander around the home.
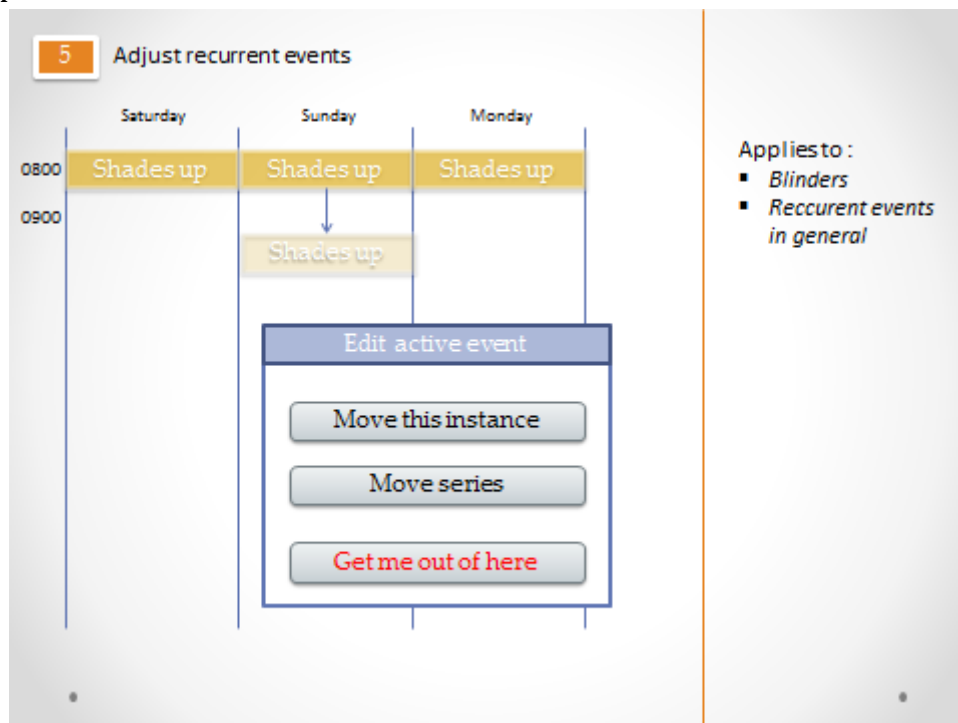
Home automation need: Adjust recurrent events and cater for both one time exception and recurring exceptions.
Visualization problem: None.

Alternatives
A – Drag and a popup provides options.
B – Other

Design F

Testers have shown that the execution of an event is sometimes inopportune and the user might want to stop the execution.
Home automation need? The user has schedule an event but the result bothers or it is not needed any longer.
Visualization problem: How should the UI allow for these spontaneous changes?
Alternatives
    -On tap, a popup with the options: Cancel, Exclude from series?
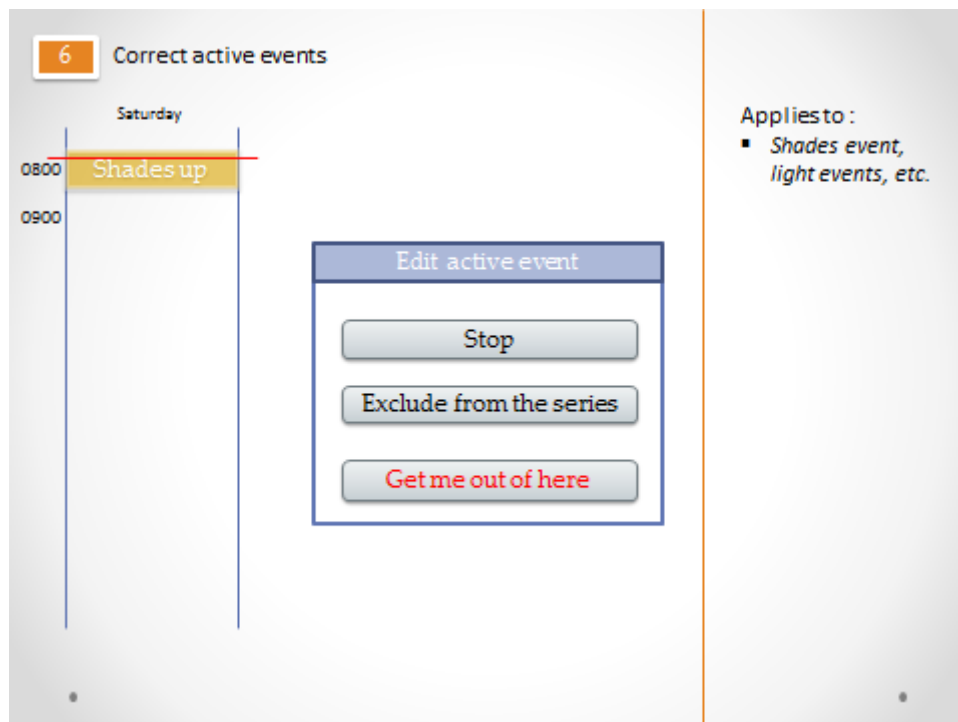   -Tap and pause without a popup.
    -Other?

Design G

Testers have shown that the execution of an event is sometimes inopportune and the user might want to not only stop the execution **but also reverse the effect**. For e.g. you are planning to sleep in and you forgot to adjust the shades, therefore, the shades will go up as scheduled. When that happens you jump out of the bed and you drag the shades event down to an hour later. The shades go back down and the shades up event is rescheduled for an hour later.
Home automation need: The user has scheduled an event but the result bothers or it is not needed any longer. Therefore the event result should be reversed.
Visualization problem: How should the UI allow for these spontaneous changes?
Alternatives
      -Reverse and reschedule window?
      -Reverse and reschedule by default with no window?
      -Other?
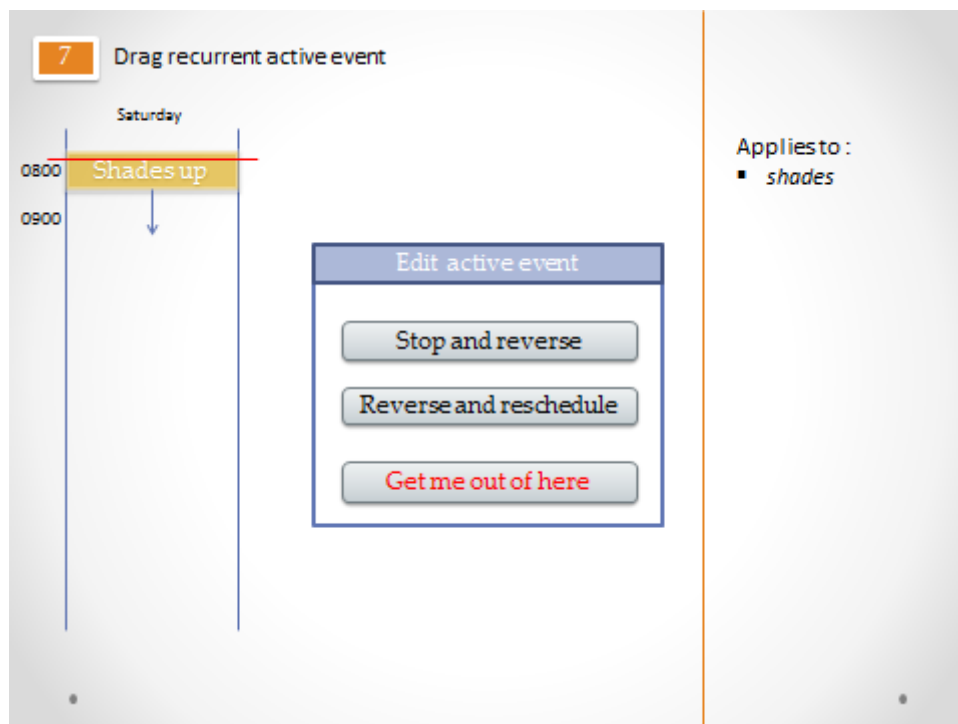
Design H

In day to day use of calendars there is at times the need to adjust the details of an event. In a similar manner, testers have pointed out that event in Casalendar will have to be updated and the interface should allow for quick event editing.
Home automation need? The user's needs have changed and he wants to adjust the parameters of an already placed event.
Visualization problem: How should the window look like? In normal calendar events are all the same so the edit window can be standard, in Casalendar event types differ...
Alternatives
      -A standard edit popup for every event?
      -A custom popup for each of the event types?
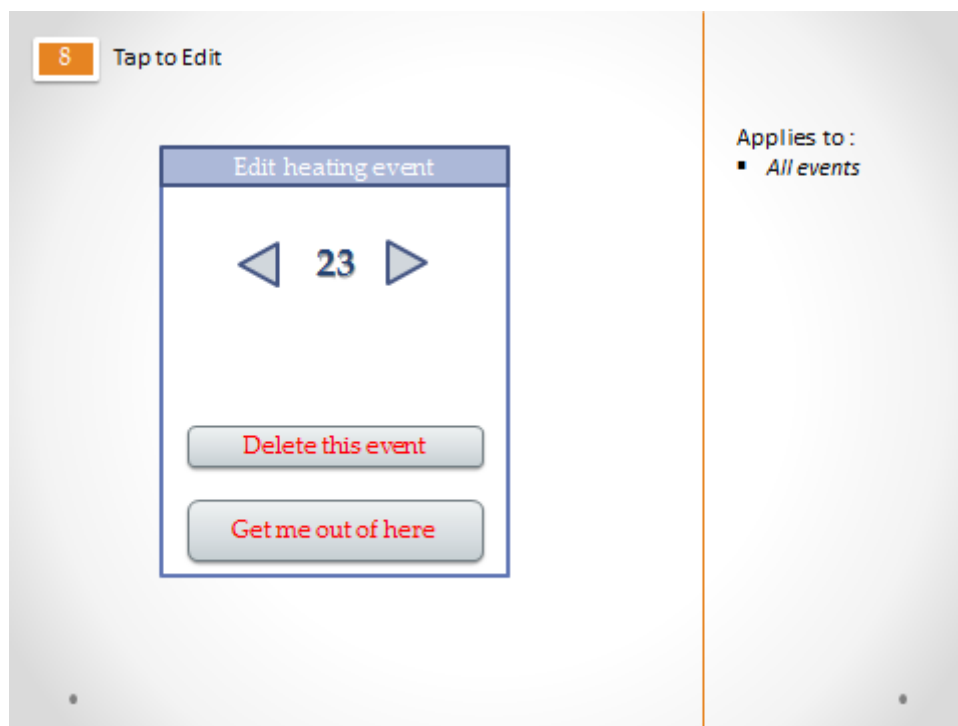
Appendix D – Design workshop transcript

Time	E1	E2	E3	E4	E5
734		I thought google will show the block as an hour long but it will then show a line at the top.	There is a distinction between an appointment and an event. [In Google]	It is an interesting issue and it looks like google did not find a way either.	
806	The issue is also where do you put the label.				
905	Keep in mind that the transparency was planned to represent uncertainty on the calendar. For planned events. But there are of course other means of representing transparency. Outline or shaded outline.	I think you could use transparency. You can have a tick line on top and then just a transparent text.	I don't think I am bothered that it shows an hour long. I understand the need of showing an associated event. Like I know it started here but where did it finish?		
1000	Maybe you can use an icon that shows that there is a related event. Shades Up could indicate that there is another event that connects to it. And then indicate the duration.			What if you cut out a corner of the event? In this way the event indicates only the start time. Challenge with many events.	

1240		I have a problem because I don t know why is Up and event and not the Down. [Talking about shades]			
1346		I think that if you want to show changes of states. Maybe you need a different way to visualize that. If you are looking for the events I think A works but for a change in states you may need something else...			
1420	An all-day event that indicates the state through the day. The permanent event or something...				http://www.infovis-wiki.net/index.php?title=Visual_Variables
1600			I am not crazy about sort of click on to get details just because in order to do that you assume that the relevant unit of time is a day. When you extend it to other events it may be that a day is not the right unit of time.		

1650	I agree that there needs to be some kind of filtering but we have to be careful because we are very interested in seeing the colocation of the personal routine and the calendar. And if they are always filtered you will have to say I am interested in this functionality and we don t have this connection between the two cal anymore.			
1750				I think event grouping is not a bad idea but then I ll do it like google does it. Have different calendars for different events. One calendar per event category.
1820			Or maybe just have the ability to click of the personal cal. It would seem to me that you want to see events together.	
1900	I have to figure out different types of filters. Maybe not on functionality but on the room. It is difficult to say, oh they belong to this calendar because then you			

	reduce the opportunity to connect them meaningfully.				
2050			What is the dif between video surveillance and heating?		
2220	The heating is optimized based on sensing.		If this is showing when the intelligence is on. How do you see the heat event, this is the point where the heating is on.		
2515	Fit bit has a similar interface.	For me the little boxes are not sufficient to visualize events like heating. So one idea: if you click on the heating event it bring you to a different visualization. It maybe shows the heating going up and down... This is not just a state but it is something that varies.			
2730		I would see the representation on the calendar as an entry point for the interaction.			
2950		If it is in past copy will be disabled since it had already happened?	What is the difference between move and copy?		

				In google the default behavior is move. So if I have a meeting and the meeting got postponed, then I just move it. In a smart home it does not make sense to move things from the past but you want it to be consistent!	
3100		I like this better than google. I would not mind to have this on my personal calendar.		People expect a similar behavior to google. That is what HCI is about, to keep it similar.	
3230	When we change events of the home, we affect how the home works. The house learns. It is not the same with personal events.				
3300	Right now when you perform some changes, the home learns. Such calendar can help the home learn better: oh, this is what I always got it wrong.			I think that NEST learns automatically.	
		How does the calendar explicate in between rules?			
3657	What is remove from series?	I think that remove from series is very specific so I would rather just have a button to take me to the			

		event details.		
3840			There are scheduled events and there are sensor triggered event which will not be in the so called series. How would you generalize this to address both scheduled and sensor generated.	
4025		How about a change rule button? It will take you to some window where you can adjust the rules so that you prevent this event from happening.		
4140				If shades up takes only 10 sec. When you get to the calendar, the event will already be in the past.
4150	An undo btn will be awesome.			
4250			I was wondering what is the generality of this interaction to some other type of home actions? If you have a set of actions for each events, it gets very cluttered.	
4330		What you can also do is when you press the stop button it becomes and undo button if it is		

		possible to undo that action.		
4450			It will be generalizable if you will have something like stop and edit. Reverse and reschedule is kind of like a form of edit.	
4515		Once you have stopped it can't you use some normal interaction to move or change events?		
4640	Maybe this big red stop button needs to be looked at separately...	It is rather complicated to jump out of bed, get to the cal, find the current time and cancel. It does not seem like what the user wanted.		
4700	If you think of Casalendar as an app that scales to different interfaces you can have an overview of everything that is currently going on and then you can just swipe it or click. Or have stopping gestures. Some things can be reversible, maybe you can define standard reverse but otherwise you ll just have to use the edit button.			

5000	What did she say?		It would make sense to show on the calendar that the event was cancelled.		
5418			This is assuming a very manual approach.		
5700	Events should not belong to one calendar. Events should be associated with different labels (tags) that you can filter for. So that you can explore the dif rules that are setup. If you think about it you can track who created what. All events that mom created or all events that dad created.				
5800			I was also thinking that you can have a global rule that stops the heating when no one is in the house [by reading the personal calendars]		
5900	Someone also said that they will like to tell the Roomba to start only when no one is at home.				

Eidesstattliche Erklärung

Ich versichere hiermit, dass ich die vorliegende Arbeit mit dem Thema *„Smart Home Control through the Correction of Automation Effects"* selbständig verfasst und keine anderen Hilfsmittel als die angegebenen benutzt habe. Alle Stellen, die wörtlich oder sinngemäss aus veröffentlichten oder nicht veröffentlichten Schriften entnommen sind, habe ich in jedem einzelnen Falle durch Angabe der Quelle (auch der verwendeten Sekundärliteratur) als Entlehnung kenntlich gemacht. Die Arbeit hat in gleicher oder ähnlicher Form noch keiner anderen Prüfungsbehörde vorgelegen und wurde auch noch nicht veröffentlicht.

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