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Department of Information Science and Media Studies

Logging and Visualizing Affect to Facilitate Communication in a Therapeutic Context

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1 Introduction

In recent years there has been an increasing focus on monitoring health and wellbeing with the intent to prevent and manage different illnesses. Advancements in mobile and wearable technology are making data logging easier and more reliable than ever before. An area that has benefited from this development is the area of mental health informatics. One emerging trend aims to provide users with enough data to self-manage their illness, without the involvement of a health care professional. A wide array of different systems meant to prevent or manage mental health issues is now available to the general public. Advanced systems are being researched and developed with the intent to automatically register emotions and moods. The area of affective interaction disagrees with this way of trying to formalize emotional states. They view emotions, or *affect*, as something more complex than physiological responses.

This thesis discusses the challenges of logging and visualizing data about affect. Here, affect refers to the internal dynamics of a person's emotions, moods, and cognition (Passer & Smith, 2011; Picard, 1995). A common way to collect data about affect is having users self-report their affective state in mobile or web applications, by prompting user at different times during the day. Such systems are often specific and focused on specific challenges, like logging and managing depression or anxiety. Although a common method, there are some areas that could benefit from a different approach. These include the context of use and specificity of the data. Many systems target a specific user group or condition which may not suit the user's needs. Another issue is the threshold for registering data, which can affect the frequency of data registration and the accuracy of the data. Furthermore, registering data can be an onerous task, and postponing registrations leads to decreased memory recall. Lastly, there are some issues related to privacy, such as keeping sensitive data on a mobile phone.

In this thesis I present a platform, currently under development by Bryggen Research, under the assumed name *Clutch*. The Clutch platform is intended as a tool to support the therapeutic dialogue and used for registering and visualizing data about any affective state. The platform differs from many other tools for data registration as the main interface is a small, stone-like object embedded with sensors that responds to pressure. Squeezing the stone will register data about the intensity and duration of an experienced affective state. The act of using a squeeze action to collect data creates a lower threshold for data registration. The data is stored in the stone and later transferred to an iPad to be used in a therapy setting.

The Clutch platform is defined as an affective interaction system which influence the way affect is regarded, and as a results, how the data is represented. To design for such a system, a literature review examined how affect is represented in different systems. A series of prototypes were then developed and evaluated in an iterative design process. The high-fidelity prototype of the data visualizations were subject to user testing in the last phase of this development.

This thesis contributes to the scientific discourse on affective interaction by providing two things: a literature review on how visualizations are used to represent affect, and a design-proposal for data visualizations generated through design-oriented research. My personal ambition is to generate more interest in the field of visualization data about affect.

1.1 Background

In November 2014, my thesis advisor introduced me to the Bryggen Research team. They were in the process of developing the Clutch platform, consisting of a stone-like object that responds to and stores squeezes and an application for visualizing these data. For more information see chapter 2 - The Clutch Platform. The tool was meant to be used in a therapeutic context and Bryggen Research wanted to collaborate on creating a graphical representation of the data collected by the stone. They would contribute with their expertise and programming skills, and cooperate on the design choices. My part would be to do research, come up with design proposals, collaborate on design choices, and carry out user testing and analysis.

1.2 Research Questions and Thesis Aim

This thesis seeks to facilitate the dialogue between the patient and the therapist by introducing a data visualization tool. This thesis also aims to lay a theoretical foundation which can be used when further developing of the Clutch platform.

The research questions are as follows:

RQ1: How are visualizations used to represent affect?

RQ2: How can the data stored in the stone be visualized to support dialogue between patient and therapist?

To begin answering the research questions, a literature review exploring areas such as human-computer interaction, affective interaction, and data visualization was conducted. Relevant research was gathered on an ongoing basis throughout the development of the system. A wide range of different visualizations to be used in a therapeutic setting were prototyped. These prototypes were developed in iterations based on previous designs and feedback from different evaluations, consistent with design-oriented research. The final prototype did not seek to answer the question whether or not the dialogue was supported, but provide a design solution that could be further developed.

1.3 Thesis Outline

- Chapter 1 covers this thesis ***introduction***, its ***background*** and its ***research questions***
- Chapter 2 introduces ***the Clutch platform***
- Chapter 3 covers ***simple concepts***, and ***related research***
- Chapter 4 covers the different ***methods*** and ***methodology*** used in this thesis
- Chapter 5 covers the ***design, evaluation*** and ***results*** from the first pilot to the final iteration
- Chapter 6 covers the ***discussions*** part of the thesis
- Chapter 7 ***concludes*** the thesis and discusses possible ***future works***

2 The Clutch Platform

The Clutch platform consists of a portable stone-like object and an iPad application. The Clutch stone registers squeezes via internal pressure sensors; these data are then stored and later transferred to an iPad for graphical presentation. Together, they are meant to be used in a therapy context to facilitate communication between the patient and the therapist, as well as help the patient get involved in their own therapy. The Clutch platform is currently under development by Bryggen Research.

2.1 Overview of the Platform

The Clutch stone is a portable, stone-like object small enough to be held in the palm of the patient's hand. The stone-format is a conscious design choice. Firstly, by providing the patient with a tool that is small and inconspicuous the stone can be carried around at all times. This makes data registration easier and the patients are able to register data more consistently. Secondly, as a familiar hand-held object, the act of squeezing it is a natural reaction and a low-threshold way of logging data. Lastly, the stone can function as a transitional object, representing the relationship between the patient and the therapist. The stone can serve as a reminder of a shared goal or a shared bond.

The stone is hollow to support the internal hardware (i.e. pressure sensors, memory, central processing unit, etc.). It responds to pressure, which is stored in the stone's internal memory as numbers with a corresponding time stamp. To view the data, it must be transferred to an iPad application. No other data about the patient is stored in the stone's memory. If the stone is lost, the data cannot be interpreted or tracked back to the patient, thus protecting their privacy.

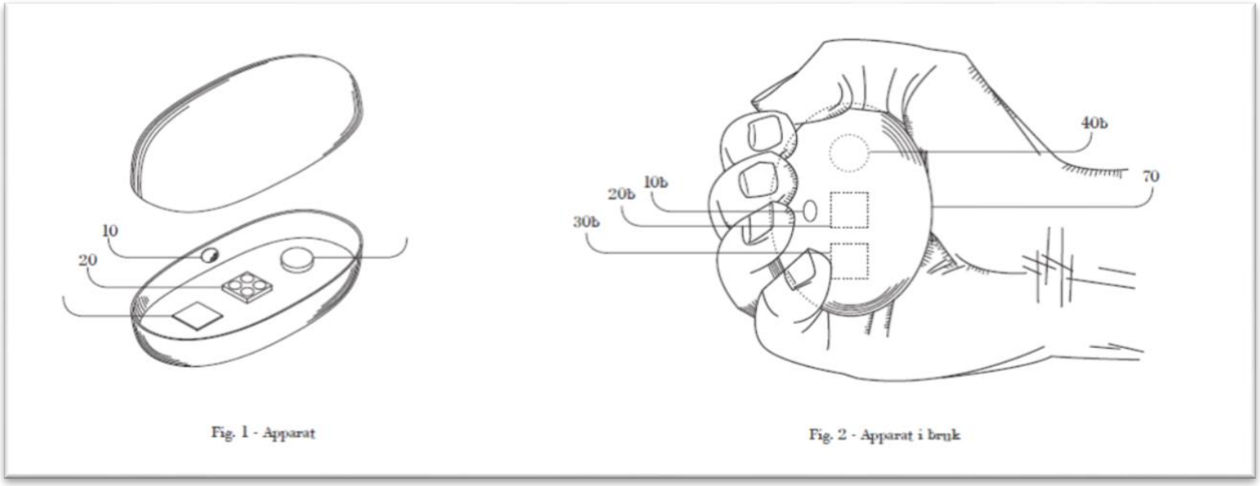

Figure 1 – A technical drawing of the Clutch stone

The Clutch data visualizations display graphical representations of the data registered by the stone. The visualizations will be used in a therapy setting and its intention is to support the dialogue between the patient and the therapist.

The users are divided into two groups; the therapists and the patients.

- A *therapist* is defined as any user helping the patient in a therapeutic setting. A therapist need not necessarily be a health care professional.
- A *patient* is defined as the user of the stone and whose life the data revolves around.

2.2 Background

Bryggen Research has been in contact with various therapists and health care professionals which all had their own take on the possible utilization of the Clutch platform. For instance, one therapist who works with patients in drug rehabilitation wanted to use the stone to help his patients get a sense of time back. According to him, drug addicts in rehabilitation typically have issues with time, like duration and chronology. Other proposed therapy cases include e.g.:

- Anorexia and other eating disorders
- Depression, anxiety and other mental disorders
- Anger management therapy and other cognitive behavioral treatments
- Keeping track of changes related to medication use and symptoms

As a result of Bryggen Research extensive inquiries it was decided that the Clutch platform could function as a general, multi-purpose tool. The platform could adapt to the users individual needs, as opposed to systems targeted at specific patient-groups, like adolescents, or conditions, like depression or anxiety.

2.3 Objectives

The Clutch platform has multiple objectives which will be described below. The main objectives of the stone are:

- To function as an extended memory
- To function as a transitional object

The stone works as an extension of a patient's memory by storing data about his/hers affective events. The patient doesn't have to clearly remember the events as the stone will store the events for him/her. A study into patients suffering from depression indicates that memory impairment is quite common (Shelton & Kirwan, 2013). The stone can also function as a transitional object for the patient, like a security blanket or teddy bear (Arthern & Madill, 1999). It then represent an embodiment of the therapeutic relationship, providing the patient with something physical that represents a refuge (Arthern & Madill, 1999, p. 9).

The main objectives of the data visualizations were outlined at the first brainstorming session with the stakeholders. They are:

- To provide the therapist and the patient with a quick overview of the patient's affect over a period of time
- To provide the therapist and the patient with information about the patient's development

When the patient's data is presented in a suitable manner, it will quickly provide the therapist and the patient with a representation of the event which can help as an aid for exploration. Furthermore, by providing the patients with information about their affective states and development they can take an active role in their therapy. Studies indicate that patient engagement is vital for the success of the therapy (Breen et al., 2008).

2.3.1 Use Case Example

Following is a proposed use case on the Clutch platform[1] (Gjøsæter, Guribye, & Fjøsne, 2014).

> *In collaboration with a therapist a client is given a Helpstone to chart mental states. The therapist explains to the client that the stone stores how hard and how long it is squeezed. Together they agree that this week they will try to chart when the client feels anxiety so they can get a grasp of when and for how long these feelings occur. When anxiety appears; a light squeeze, stronger anxiety - hard squeeze, when it is overwhelming - harder still.*
>
> *When the client shows up for a therapy session the next week, these episodes appear as an understandable visualization on an iPad. This information provides the basis for discussing this week.*

Figure 2 – Use Case Example

2.4 The Challenge

As the Clutch platform is meant to be used by various patient-groups with a wide range of backgrounds, the data visualizations would need to support this. This meant that certain visualizations would be unsuitable as some conditions or users would be excluded. An examination on how affect was viewed and represented was necessary. In addition, Bryggen Research proposed some general requirements on the design to support accessibility and to suit the context of use.

- Avoid unnecessary text or numbers: To improve accessibility the design should avoid unnecessary use text or numbers in the applications interface. It would be better to find a solution that utilizes icons, colors or other elements that are easier to interpret.

[1] During the initial development of the system the platform was called the Helpstone as seen in the use case example above.

- Element size: Careful considerations should also be made when proposing sizes of the various elements making sure the elements are legible, as well as finding a balance between whitespace and screen real estate.
- Orientation: To suit the context of use, the design should not have a specific orientation. The screen should be readable for both users.

These requirements would help make the design more inclusive, not excluding user groups like children or people with cognitive impairments. The requirements would also function as a reminder to design with accessibility in mind.

2.5 Chapter Summary

This chapter described the Clutch platform which consists of a small, stone-like object that stores squeezes which are represented on an iPad. The platform's objectives and a use case example are also provided. Lastly, the challenges related to designing data visualizations for this tool is examined and the general requirements from Bryggen Research are defined. The next chapter will cover aspects from the areas of human-computer interaction, affective interaction, data registration methods and other concepts related to this thesis.

3 Background and Related Work

This section will outline relevant concepts and studies related to this thesis. It begins by providing an overview of human-computer interaction, data visualization, affective interaction and other relevant research areas. An examination on different methods of visualizing affect based on the reviewed literature is also presented here.

3.1 Human-Computer Interaction

Human-computer interaction (HCI) is a large multi-disciplinary field of study that focus on how humans interact with and are affected by digital technologies (Finlay, Dix, Abowd, & Beale, 2004, pp. 3–4). Since its emergence in the 1980's, HCI has expanded and effectively changed the way we view and interact with computer systems. In early HCI history the computer was a tool workers used to do their tasks more efficiently. Workers interacted with computers by means of keyboard, mouse and graphical interfaces. As hardware kept getting smaller, faster and cheaper, the computer was introduced into other areas of a people's life. The change from workplace to a more private sphere expanded the use of computers from work to include fun and play. Bødker (2006) dubbed this expansion as the *third wave of HCI*. As opposed to the *second wave*, technology in the workplace and the desktop computer, the third wave focuses more on enhancing areas in the private sphere (Bødker, 2006). Technological advances made it possible to create portable computers, which in recent years have developed into wearable and embedded technologies. Digital technologies are seemingly disappearing into our natural environment creating more natural interfaces and seamless interactive experiences. This technological development is resulting in artefacts previously unimaginable. By embedding data into ordinary items new ways of interacting with digital technologies are emerging as well. In recent years, gesture, touch and speech have expanded the interaction paradigm, whereas previously interaction was limited to a mouse and keyboard setting.

Technological advances are making technology, in particular smart phones, embedded technologies, and wearables, increasingly available to researchers and to the general public. Nowadays, wearing or using advanced digital technology to monitor and self-manage health and wellness is quite common. A research area that has greatly profited from this development is *health informatics*. Health informatics encompasses areas related to technology, health, and wellness*,* and greatly encourages patient self-management systems because of its effect on hospital admissions and its cost-effectiveness (Diederich & Song, 2014; Gillard et al., 2012). The terms *health* and *wellness* are diffuse and have been found to vary in different studies (Meyer et al., 2012). Meyer et al. (2012) separate these terms by being *proactive* or *reactive*. As a general rule, w*ellness applications* focuses on the promotion or maintenance of health, *health applications* focuses on managing or treating illnesses. Within health informatics, mental health has been an important research area due to the prevalence of mental illness in today's society and the social and financial challenges connected to this (Diederich & Song, 2014, p. 1). *Mental health informatics* is a subfield of health informatics that in later years are very concerned with automatic assessments of mental health issues as this helps to alleviate challenges in the health care system related to cost and availability (Diederich & Song, 2014). Automatic assessments by means of monitoring biosignals, image analysis, and speech recognition are increasingly being used to interpret a patient's physiological and psychological responses (Diederich & Song, 2014, pp. 3–7). Health and wellness applications for mental health are quite common. Some studies using biosignals and image analysis are presented in a later section. The area of mental health informatics is connected to the areas of affective computing and affective interaction. Both areas will be discussed in later section.

Based on the aforementioned definition the Clutch platform is a health application first and foremost, but depending on the patient can also be used as a wellness application. As such, studies including both the wellness and the health term will be covered in later sections. The main focus however will be on mental health, as opposed to physical health.

The motivation behind the HCI studies into health and wellness is quite varied. Some focuses on supporting emotional awareness and self-regulation (De Choudhury, Gamon, Hoff, & Roseway, 2013; Morris et al., 2010; Ståhl, Höök, Svensson, Taylor, & Combetto, 2008), creating personalized health care (Ananthanarayan, Lapinski, Siek, & Eisenberg, 2014), communicating emotions (Balaam, Fitzpatrick, Good, & Luckin, 2010; De Choudhury et al., 2013; Lin, Gau, Lai, Chu, & Chen, 2009; Morris et al., 2010) or promoting wellness (Anderson et al., 2007; Mattila et al., 2008; McCullagh, Beattie, & Nugent, 2010). The Clutch platform can touch upon all of these areas to some extent, depending on the patient.

In the studies reviewed the most used tool is a mobile phone. Only a few studies reviewed used a novel interface as its main device. These studies will be discussed in later sections.

3.2 Affective Interaction

Affective interaction is a research field and a concept within HCI that focuses on affect. Researchers like Höök, Boehner, Depaula, and Sengers (2005) have been vital in developing the field. Affective interaction originated as a counterpart to affective *computing*. Both affective interaction and affective computing use passive and active data gathering tools, the difference lies in the way the affect, or emotions, is regarded. As mentioned earlier, affect refers to the internal dynamics of a person's emotions, moods, and cognition (Passer & Smith, 2011; Picard, 1995). So affect is used to describe a state, which is viewed as a combination of temperament, moods, and emotions. Temperament is usually associated with personality or disposition, moods are longer-lasting states, and emotions are typically of a shorter duration (Lottridge, Chignell, & Jovicic, 2011, pp. 200–202). Figure 3 illustrates the differences between temperament, mood and emotion in a concise way. In affective interaction, affect is also viewed as a means for social communication. The social and cultural setting influence the way we display emotions and the way we understand them (Boehner et al., 2005).

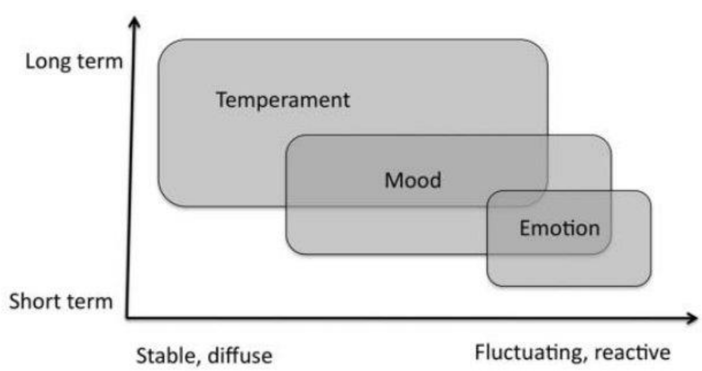

Figure 3 – Timing and responsiveness of temperament, mood, and emotion. Affect is used as a general state descriptor; for example, a person's affective state is the compound of his or her temperament, current mood, and current emotion. By D. Lottridge, M. Chignell, and A. Jovicic. 2011, *Reviews of Human Factors and Ergonomics.* Copyright 2011 by the authors. Reprinted with permission

Boehner et al. (2005) argues that in affective computing emotions are seen as information to be measured, isolated and interpreted (see also Höök, Ståhl, Sundström, & Laaksolaahti, 2008). Affective interaction however, views emotions as a constructs of the interaction and Höök et al. (2008) states that formalizing emotions is not desirable and argues that systems should support understanding and reflection of emotions, not focus on the *correct* interpretation of an emotion.

Boehner et al. proposed a set of design principles for designing for *affect as interaction* (2005, pp. 65–66):

- The design should recognize affect as a product of social and cultural interactions; emotions are understood in context with both internal and external processes
- The design should depend on and support flexible interpretation; meaning should stem from the user, not the designer
- The design should support an expanded range of communications; coding specific emotional displays to a set system (like color, emoticons, labels) is viewed as a hindrance for communicating emotions
- The design should focus on people using systems to experience and understand emotion; users express themselves through the system, becoming more aware of their emotions through this expression

A trend in affective interaction is to collect and display emotions in novel ways. The Affective Diary (Ståhl et al., 2008) is an example of the affective interaction approach. The Affective Diary (AD) is a self-reporting system that implements *bodily memorabilia* and *mobile media.* They had participants wear armbands that recorded pulse, steps and galvanic skin response. The participants added text from their own scribbles or SMS, as well as supplementing with photos and figures. One goal of AD was to offer their users a different way to re-experience their past. They also wanted to see how bodily representations could help user re-experience their past and if it could provide new ways of recollection (Ståhl et al., 2008). The participants in the AD study developed their own ways of interpreting their data, but not all the participants were able to make sense of all the parts of the system. Ståhl et al. states that "measurements read from the body are not necessarily linked to subjective experiences in straightforward ways" (2008, p. 376) and argues that sometimes the AD would capture behaviors or patterns the participants were not equipped to deal with or interpret.

Boehner et al. argues that designing for affective interaction has certain challenges. They state that design strategies become more complex when introducing flexibility. Furthermore, rich contexts are necessary to be able to interpret the communication. Lastly, they argue that it's necessary to explore new evaluation strategies as existing models are based on the affective computing informational way of viewing emotions (2005, pp. 66–67). As an affective interaction tool, the Clutch platform experienced some of these challenges during development. By allowing the Clutch stone data registration to include all types of affects via a single squeeze pattern, the graphic representation became much more challenging to display. One issue was the creation of a graphical representation to support communication, without locking the visualization to a specific use case or context.

3.3 Data Visualization

Data visualization is the graphical representation of generated data (Ware, 2004, p. 2). By presenting a dataset in different ways, patterns and stories starts to emerge from the set. Ware states that "[v]isualization provides an ability to comprehend huge amounts of data", "allows the perception of emergent properties" to become apparent and "facilitates hypothesis formation" (Ware, 2004, pp. 3–4). In simpler terms, a suitable graphical representation can help a user interpret large amounts of data they otherwise would not be able to, see patterns and stories in these data, and form opinions and conclusions about them. However, a user might also see patterns that are not really there, which supports the intention of exploring the data from the Clutch platform with a therapist.

The area of graphic representation of health data in a therapeutic setting are largely graphs, tables and charts. Previously, the area of interpreting health data used to be the researchers or health professionals' area (Wilcox, Morris, Tan, & Gatewood, 2010). In recent years the area of healthcare informatics has changed towards a more patient-centric view and patients are becoming more evolved in their own therapy (Breen et al., 2008; Diederich & Song, 2014). This has meant a change in the way health-related data is viewed and used, by involving the patient more in their own therapy in the various stages of it (Breen et al., 2008). In addition, the third wave's entry into the private sphere has made it easier for users to monitor and gather data about their mental and physical state without the involvement of health care specialists. This has meant a development towards visualizing data on smaller screens. The most used tool for displaying data visualizations are desktop computers or handheld devices like smart phones or smart pads. For the intent and purpose of this thesis, the visualizations selected as examples are limited to the scope of *affective* state datasets, meaning data that relates to moods and/or emotions. Additionally, some novel ways of gathering and displaying data related to the Clutch platform will be briefly explained. This was decided as the Clutch platform is still under development and might benefit from this input.

The Emotion Caster (Lin et al., 2009) is a small penguin-like puppet with a LED-display that broadcasts a user's mood. The puppet changes facial expressions when the user shakes it. The Cherry Blossom visualization (Ananthanarayan et al., 2014) illustrates how much time the wearer has spent outside via a blossoming picture of flowers, intending to motivate users to spend more time outdoors. The Activity Sculptures (Stusak, Tabard, Sauka, Khot, & Butz, 2014) represent a wearer's runs by means of physical sculptures. The physical representation of data is an interesting field of research and might lower the threshold for users, like children or patients suffering from cognitive impairments, to interact with their data in ways more meaningful for them.

Morris et al. (2010) developed a mobile application for self-reflection and coping. The system focuses on providing the participants with cognitive behavioral therapy by providing the participants with questions and mood registrations that were meant to promote reflection. Participants were prompted to report their mood three times a day using a Mood Map. The Mood Map allowed two types of registrations. The participants could register their mood on a horizontal axis marked "Negative-Positive", and a vertical axis marked "Low energy-High energy", a modification on the popular circumplex model of affect (Posner, Russell, & Peterson, 2005). They could also record single registrations of specific emotions, e.g. anger, happiness, anxiety, ranging from 0 (not at all) to 10 (extremely). The visualization uses a graph view, providing some dates along the x-axis and the intensity of the emotion along the y-axis. The colors are mainly black and blue, with a red vertical line to illustrate the middle of the study. This type of *medical-looking* visualization is quite common in the reviewed literature when the focus is on data gathering as opposed to end-user visualizations. It is not clear from the study whether the participants viewed their data as shown in figure 3. The focus seemed to be on providing data registration and behavioral therapy, rather than data exploration. In figure 4 the visualization of two emotions, anger and anxiety, for a participant throughout the study are shown. The granularity of three data points in a single day made this visualization unsuitable for the Clutch platform, which must support data streams.

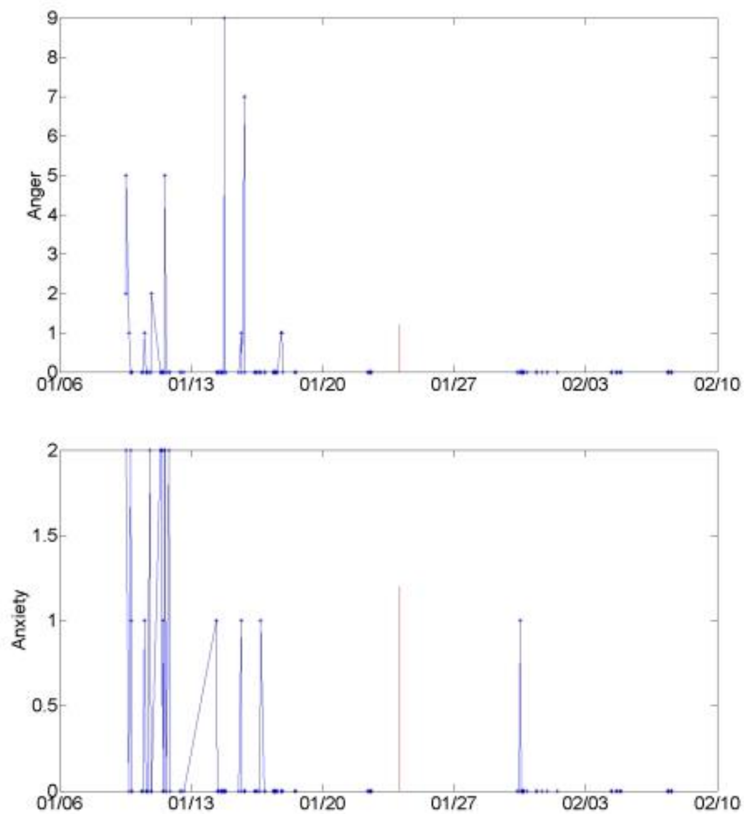

Figure 4 – Anger and anxiety mood ratings change for Tobias. Adapted from "Mobile therapy: case study evaluations of a cell phone application for emotional self-awareness." By ME. Morris, Q. Kathawala, TK. Leen, EE. Gorenstein, F. Guilak, M. Labhard and W. Deleeuw. 2010, *Journal of Medical Internet Research*, 12. Copyright 2010 by the authors. Reprinted with permission

A similar study that shows the visualization of moods come from the Mobile Mood Diary (MMD) (Matthews & Doherty, 2011). The MMD is a tool meant to increase engagement in and adherence to therapy amongst adolescent patients suffering from mental illnesses. The participants in the study registered their mood on a scale ranging from Very low (0) to Very happy (10). Additionally, they could add sleep data, journal entries, and add emoticons to the registrations. The Mood Diary uses both a mobile application and a web portal to display data. The participants could view a time period or filter for a specific mood in their Mood Diary interface. In the online version a time period is shown as a graph displaying two lines: a teal colored energy line and a yellow mood line. The x-axis displays the date, the y-axis displays the mood scale from Very low (0) to Very happy (10). A bold horizontal line divides the top and bottom. In the mobile version called History each day is presented by an emoticon, followed by the date and a text excerpt. The MMD supported multiple affective states and was used in a therapy setting, which makes it very relevant for the Clutch platform. However, it breaches the requirement from Bryggen Research about too much text and although an emoticon is an easy way to represent emotions, I question the use of a single emoticon to indicate the affective state of an entire day.

Another example is found in the MONARCA 2.0 study (Frost, Doryab, Faurholt-Jepsen, Kessing, & Bardram, 2013). MONARCA 2.0 was developed for patients suffering from bipolar disorder and tries to move beyond the visualization and provide *insight* into the connection between behaviors and health. MONARCA 2.0 collects self-assessed data, like mood and sleep. It also automatically saves accelerometer data and phone usage data The mood registration ranges from Severe mania (3) to Neutral (0) and Severe Depression (-3). The mania spectrum uses red colors, the neutral zones greens, and the depressed spectrum uses blue colors. MONARCA 2.0 uses both a mobile application and a web portal to display data. The mobile screen uses a graph visualization with color and a black line to describe the mood on a given day. The x-axis shows the weekdays and the y-axis indicates the mood level from 3 to -3. This application is also distinctive as it aimed to present a five day *Mood Forecast*. Mood Forecasting would show the patient's a five day forecast based on current behaviors, which was meant to provide reflection that could motivate behavior change (Frost et al., 2013). Different colored speech bubbles with text and their percentage of magnitude showed the impact factors like sleep, alcohol and physical activity would have on the user's mood. Although the system had good intentions the developers removed the Mood Forecast from the patient view. The reasoning was that if the system provided a negative forecast, it could negatively affect the patient and become a self-fulfilling prophecy (Frost et al., 2013). This study provides a very important insight into visualizing sensitive data, although the intention is good, the outcome might be different than what was originally expected.

A different take on data visualizing affective state is the Affective Health Project (Vaara, Silvăşan, Ståhl, & Höök, 2010). The Affective Health Project is an application that translates biodata into an interactive interface on a mobile. It shows the data in real time to provide the users with indicators about their lifestyle and stress level. It uses a spiral with different colors to visualize the data, the spiral center shows real time data. The visualization can display one-minute, one-hour or one-day data sets, but was deemed unsuitable for the Clutch platform as it focuses on real-time display and was difficult to understand.

Lastly, a study into emotion-aware interfaces (Lee, Kim, Kim, & Kang, 2014) represented an emotional state by means color and animation of a tree. The registration is limited to two parameters, valence (happy, neutral, unhappy) and arousal (high, neutral, low). Higher valence will result in a yellowing of the screen, whereas high arousal will result in the faster animations. This is the only study using speed to indicate emotional state.

3.3.1 Visualizing Affective States

During the literature review certain methods for visualizing affective states were used more frequently than others. The last two studies mentioned, Affective Health Project and Emotion-Aware Interface, are some of the few that examine and justify the choices for their proposed data visualizations. It was decided that an analysis of the user interfaces would be conducted to make obvious the most common ways of visualizing affect. Graphical elements with the intent to convey meaning was registered, like the use of colors in MONARCA 2.0 to indicate mania (red) or depression (blue) (Frost et al., 2013) or emoticons to indicate mood (LiKamWa, Liu, Lane, & Zhong, 2013; Sánchez, Kirschning, Palacio, & Ostróvskaya, 2005). However, since the design choices remain unknown certain meaningful elements may have gone unnoticed. The analysis is not meant to provide an extensive overview, but rather demonstrate an excerpt of a wide range of use cases, types of visualizations, and different views on emotion (affective computing versus affective interaction). Some studies were selected as they fulfilled the criteria of either i) presenting a new way of designing for affect, like Affective Diary (Ståhl et al., 2008), ii) present different ways of displaying or registering affect, like Rüüg (Thompson, Friedland, & Cargiuolo, 2005), or iii) have similar characteristics to the Clutch platform, like the Subtle Stone (Balaam et al., 2010). Studies that did cover the area of affect, but did not provide a graphical representation or sufficient explanation of the interface were excluded. Lastly, studies that focused on solely on biometrics where excluded as the visualizations were largely unsuitable for the domain of affect. Additionally, it proved difficult to provide a clear separation on studies that view affect like affective computing or affective interaction. Most studies use different terms or seemingly don't differentiate between the two views. In table 1, the Focus column illustrates my attempts to categorize the undefined studies as either affective computing or affective interaction. This analysis would likely provide more information on how affect is displayed, and if there was an apparent difference or similarity between the two views. Systems that used a fixed system for representing affect, like a labeled mood scale or labeled color system, these were categorized as affective computing systems, shortened to AC. Systems that let the users define the system or express themselves freely were categorized as affective interactive systems, shortened to AI. Table 1 provides an overview of the different studies reviewed with a short description of the data visualizations, the type of visualization used, the study's use case, and my interpretation (or the researchers own) of the study's focus.

Table 1 – An overview of the reviewed studies with focus on the data visualization elements

Study	Short Description	Vis. Type	Study Use Case	Focus
ADA Lamp (Angelini, Caon, Lalanne, Abou khaled, & Mugellini, 2015)	A lamp displaying colored smiley faces and collecting data through tangible gestures	Color, emoticons (smiley faces)	Communicate moods to the immediate environment	AC
Affective Diary (Ståhl et al., 2008)	A diary with SMS, text, colored blobs and pictures that lets the users express themselves	Color, pictures, animations	An advanced diary tool for bodily memorabilia and mobile data	AI

Affective Health (Vaara et al., 2010)	Shows affective states in real-time via color	Color, graph (spiral)	Indicate stress level and support reflection on lifestyle	AI
Emotion Caster (Lin et al., 2009)	A small robot with a LED display	Emoticons (smiley faces)	Communicate moods to the immediate environment and friends	AC
Emotion-Aware Interface (Lee et al., 2014)	A tree with falling leaves. The rate of falling tree leaves indicate arousal. The yellow-filter indicate valence	Picture, colors, speed, animation	Proof-of-concept for emotional awareness in user interfaces	AC
eMoto (Sundström, Ståhl, & Höök, 2005)	Sending emotional mobile messages using colors, gestures, shapes	Colors, shapes, animation	Emotional mobile messages	AI
Empath (Dickerson, Gorlin, & Stankovic, 2011)	An overview of different metrics like sleep, weight, speech, and movement was shown with different colored bars	Colors, emoticons, graphs (bars)	Real-time depression monitoring system for the home	AC
EventScapes (Adams, Phung, & Venkatesh, 2011)	A two-dimensional mapping of color to emotion	Colors	Information retrieval	AC
Mobile Mood Diary (Matthews & Doherty, 2011)	Graphs and emoticons showing user's mood	Graphs, emoticons	Increase treatment adherence amongst adolescents	AC
MobiMood (Church, Hoggan, & Oliver, 2010)	Proof-of-concept social mobile application enabling mood sharing between groups	Colors	Proof-of-concept for emotion sharing on mobile	AI
MONARCA 2.0 (Frost et al., 2013)	Shows bipolar moods via colors and graphs	Color, graphs, icons	Supporting disease insight and management amongst bipolar patients	AC
Mood Board	Mood boards with pictures	Pictures,	Play a role in design	N/A

(Lucero, 2012)		colors	processes	
Mood Map (Morris et al., 2010)	Graphs showing user's mood	Graphs	Display moods	AC
Mood Squeezer (Gallacher et al., 2015)	Digital floor display shows different colors	Colors	Redesigning the workplace	AI
Mood-oriented Interfaces (Sánchez et al., 2005)	Using emoticons in synchronous textual communication (chat)	Emoticons	Display moods and emotions in a chat	AC
MoodScope (LiKamWa et al., 2013)	Colored smiley faces that indicate mood in a journal	Emoticons, colors	Mood journaling	AC
MoodSource (Robb, Padilla, Kalkreuter, & Chantler, 2015)	Pictures used to mood source a crowd	Pictures	Mood sourcing a crowd	AI
Moon Phrases (De Choudhury et al., 2013)	Moon phases indicate emotions based on Twitter data	Icons	Reflection and wellness, social media trends	AC
Photographic Affect Meter (Pollak, Adams, & Gay, 2011)	Measures affect by having users select a photo that suits their mood	Pictures	Frequently measure affect via EMA	AI
Rüüg (Thompson et al., 2005)	Plush rug embedded with different sensors	Colors	Personal communication between two Rüüg-sisters	AI
The Roomba Mood Ring (Rea, Young, & Irani, 2012)	Ambient display with different colored lights	Colors	Mood sourcing a crowd	AI
The Subtle Stone (Balaam et al., 2010)	A small stone that displays different colors	Colors	Display affective states in a classroom setting	AC
You're Happy, I'm	Colored Twitter data	Colors,	Diffusing mood	AC

Happy (De Choudhury, 2014)	distributed on a graph	graphs	expression on Twitter	

From the general analysis, affective states are typically represented via colors, icons/emoticons, graphs, pictures or other methods. Table 2 demonstrates that the most used elements in affective computing and affective interaction of the reviewed systems and as defined in this thesis. In affective computing the most used elements are colors, emoticons/icons, and graphs. Colors were most often used, typically showing clear, bright colors to indicate a high arousal and darker colors to indicate low arousal. Emoticons (or variations of smiley faces) were also a popular choice, possibly due to the widespread availability of emoticons on mobile phone. These findings correspond well to the idea labeling emotions in defined systems, as mentioned previously. In affective interaction systems the most used elements are colors and pictures, which also correspond well to the idea of expression and undefined systems. Pictures with colored motives of different objects or settings were also common. Animation, speed, and shapes were the least used methods. Haptics or sounds were not used in any of the studies reviewed here.

Table 2 – Elements used in affective computing and affective interaction

Element	Aff. Computing	Aff. Interaction
Color	8	7
Emoticons/icons	8	0
Graphs	5	1
Pictures	1	3
Animations	1	2
Speed	1	0
Shapes	0	1

3.4 Data Registration

Data registration can be divided into two main approaches, passive and active approaches. Kalnikaite et al. (2010) describes the passive approach as automatically logging data without user involvement, whereas active approaches requires a user to intentionally log data. Another separation is related to the time of registration, divided into asynchronous or synchronous registration. Asynchronous registration occurs after the event has taken place, as opposed to synchronous registration where registration occurs while the event is ongoing.

3.4.1 Passive Approaches

A passive approach focused on capturing a person's daily life is called *lifelogging.* Lifelogging usually focus on capturing audio, pictures or videos from a person's surroundings to aid memory and reflection (Kalnikaite et al., 2010). Often the data interaction is after registration has occurred, when modifying the log or adding more information to the log manually. Kalnikaite et al. states that automatic logging "eliminates the burdens of users having to decide whether a particular incident is worth capturing, as well as the need to manually prepare and operate a capture device. The advantages are obvious – no important moment gets missed, and users aren't taken "out of the moment"." (2010, p. 2045). It answers the questions of where, when and with whom. The disadvantages can be the sheer size of the logs, storing copious amounts of data that might not be relevant and may prove difficult to sort through. An example of a lifelogging application is Emosnaps (Niforatos & Karapanos, 2014). Emosnaps is a mobile application that automatically captures pictures of the user's face with the mobile's front-facing camera. Users are later asked to recall how they felt and report this in the application with a scale ranging from Very Bad to Very Good (Niforatos & Karapanos, 2014). Another trend is the use of data from sources like mobile usage. The MoodScope application (LiKamWa et al., 2013) is a mood sensing application that analyses the smart phone usage (like e-mails, phone calls, and text messages) to infer the user's mood (LiKamWa et al., 2013).

Another passive approach, called *biofeedback* in affective computing, focuses on the registration of biological signals. Devices utilizing biosensors can measure body temperature, blood pressure, heart rate, galvanic skin response and much more. Biosensors combined with mobile phones make it possible for data interaction to occur in real time (Kanjo & Chamberlain, 2015). Biosensors were previously mainly used in research, but in later year's biosensors are becoming increasingly more common on the general market due to the popularity of wearables and fitness trackers. An example of a biofeedback applications is the MoodWings system (MacLean, Roseway, & Czerwinski, 2013). It's a small butterfly meant to be worn on the wrist. The wings of the butterfly show the wearer's stress-level in real time through wing actuations (MacLean et al., 2013).

Both lifelogging and biofeedback are generally synchronous, registering the data when the event it taking place. Another similarity for the passive approaches reviewed is the issue of privacy. Lifelogging devices can capture and store data about situations or people that can be quite sensitive. If a camera is lost, the data stored on the can be used to identify the wearer or his/hers surroundings. Biofeedback devices store data about a person's biological states that can be used to identify them. Real-time visualizations of a person's state or obvious mood-regulating devices can also present uncomfortable situations. The review of the MoodWings system indicated that most users were uncomfortable with exposing their stress state (MacLean et al., 2013). To increase perceived privacy Matthews and Doherty (2011) renamed the Mood Diary application to MD, so that user would not feel stigmatized or embarrassed by having it on their phone.

3.4.2 Active Approaches

Self-reporting is a method for manually registering data about symptoms, experiences or behaviors. Registering while experiencing the symptoms, experiences or behaviors is called *synchronous* logging, logging after the fact, is called *retrospective logging* or asynchronous logging. Common methods include journal keeping or answering questions related to the specific challenges. People report data in a qualitative way, by providing e.g. text or pictures, or they report the data in a quantitative way, e.g. on a labeled scale ranging from 0 to 10. Smart phones have made self-reporting easier than ever before by letting the user register data anywhere and at any time. A widely used approach is the *experience sampling method* (ESM), also called *ecological momentary assessment*. ESM which can be divided into three categories that varies the time of data registration. These are interval-contingent, event-contingent and signal-contingent sampling. The data collection occurs after a set time interval, after specific event occurs, or when prompted by a random signal (Scollon, Prieto, & Diener, 2009, p. 159). An advantage of this method is the possibility of seeing patterns around certain emotions, like situations or time of day (Scollon et al., 2009, p. 157). The drawbacks to self-reporting, especially retrospective logging, are largely related to memory. A person may choose to report at a later time than prompted, or may not remember exactly what they felt or did when asked to report it. There is also the possibility of the person falsifying the data to appear either better or worse for personal reasons. Privacy is also an issue in self-reporting, if lost, the data can be used to identify the person.

3.4.2.1 Intentional Data Registration

The Clutch platform is an active self-reporting method for intentionally registering data about an affective state (Gjøsæter et al., 2014). The stone is meant to be used *while* experiencing the affective state, and can be seen as an extension of the synchronous registration, as it provides information about variations on intensity and the length of affected state. Data registration is low-threshold; a simple squeeze of the stone will register data. Furthermore, the scale by which they register and interpret the data is their own. Each user will have a different signature, based on their strength, hand mobility and so on. As mentioned earlier the stone might also have a calming effect on the user, if functioning as a transitional object. Lastly, privacy is protected as the stone only stores numbers (the squeeze intensity) and corresponding a time stamp. If lost, data interpretation would be difficult in its current state, as the context of use is known only to each user and their therapist.

3.5 Tangible Interaction

Tangible *interaction* is an umbrella term of a research field under HCI and evolved from the area of tangible *interfaces.* Tangible interfaces developed as a response to the way graphical user interfaces was believed to disconnected the user from the data (Ishii, 2008). As Ishii stated, graphical user interfaces were “utterly divorced from the way interaction takes place in the physical world” (2008, p. xv). As technological advances made it easier to create new systems and thus new interfaces, the tangible interface term was replaced by the wider term tangible interaction. Tangible interaction focuses on user interfaces and interactions that emphasizes (Hornecker & Buur, 2006, pp. 437–438):

- tangibility and materiality,
- physical embodiment of data,
- embodied interaction and bodily movement as an essential part of interaction,
- embeddedness in real space

The main focus of tangible interaction is the interaction with and through a system that is physical and embedded with data or meaning (Fernaeus, Tholander, & Jonsson, 2008; Hornecker & Buur, 2006). Familiar things are being embedded to facilitate interactions in new ways. Dourish argues that the physical properties of an artefact can suggest its possible use (Dourish, 2001, p. 52). As Holone and Herstad (2012) states:

The use of everyday things, like pillows, carpets, and paper, is characterized by our familiarity with the things and what we can do with them. By focusing on familiarity, we build on users' pre-existing involvement, understanding and relationship of the "everyday" world. (2012, p. 266).

To hold a smooth stone in the palm of the hand and squeeze it is a natural interaction that does not require special training or skills. The physicality of a stone invites the user to touch and interact with it. Fernaeus, Tolander and Jonnson (2008, p. 225) argued that tangible interaction was experiencing a conceptual shift towards a more action-centric view, where physical artefacts was not only input/output devices, but had a deeper meaning attached to them in a social and personal sense. The Clutch platform is meant to represent more than an input/output device, by also functioning as a transitional object. The following systems were selected as I believe they represent the ideas of physical affordances and social/personal meaning in a good way.

The Rüüg system focuses on providing a shared experience for two users that are separated by long distances. (Thompson et al., 2005). Two rugs can communicate emotions to each other via pressure, color and text. The Rüüg is a rug embedded with sensors that respond to pressure, like walking or lying on the rug. It also has a heat-sensitive dye that allows it to change color. The Rüüg system is similar to the Clutch platform in its intent to communicate affective states between two people and might function as a transitional object. It is also a private communication as the rug can only communicate to another specific rug. Other than these similarities the two systems are quite different in where they are used (home vs. everywhere) and the purpose of use (communication vs. therapy).

A tool similar to the Clutch platform called the Subtle Stone (Alsmeyer, Luckin, & Good, 2008; Balaam et al., 2010) was created to help show students emotional response during class to their teacher. The Subtle Stone use light to indicate various moods by means of what the developers call *colour:emotion language.* Users individually map their emotion to one of seven colors, and by squeezing the stone the light is activated. The difference between the Clutch platform and the Subtle Stone are many. Both are used to communicate affects, but in different contexts (school vs. everywhere) and for different reasons (education vs. therapy). The Subtle Stone also registers more emotions, which is suitable for the context of use. The Clutch stone can be used to register any affective state, but focus on registering one at a time. Lastly, pressure intensity was not registered in the Subtle Stone.

Lastly, a very promising tool also based on direct squeeze interaction is the Skweezee system (Vanderloock, Vanden Abeele, Suykens, & Geurts, 2013). The Skweezee is a soft object, filled with conductive padding, which can be squeezed or bent according to the user's wish. As a result of multiple electrodes, the Skweezee can detect a wide range or deformations – such as stretching, cutting, punching or crumpling up the Skweezee. It was created as a tool for creativity and self-expressions. Although the study focused on the underlying technology the use cases for such a system can be quite similar to that of the Clutch platform. For instance, a conductive teddy bear that registers and stores affects via different interactions can be a valuable addition to the therapeutic setting for e.g. smaller children.

3.6 Chapter Summary

In this chapter a backdrop was provided to frame where the Clutch platform and the data visualizations belong. A review into systems similar to the platform in this thesis shows a range of common design solutions for visualizing affect divided into the affective computing and affective interaction way of viewing affect. The Clutch platform is viewed as an affective interactive system which stores and represents data about affective states. A set of design guidelines suggested by Boehner et al. (2005) describe the challenges and objectives when designing such systems. Furthermore, an examination into data registration methods reveals that the stone, as a tangible object, expands upon the active synchronous method of logging data. This intentional logging provides information about affect which includes intensity over a period of time determined by the patient. Lastly, as a tangible and familiar object the threshold for data registration is very low compared to other reviewed systems. In a later chapter a comprehensive discussion on the differences of the Clutch platform and reviewed systems is provided. The next chapter will present the methodology and methods used during the progression of this thesis.

4 Methodology and Methods

In this chapter the methodology and methods used during the development of the Clutch system is presented. The focus is on what was done, how it was done and the justification behind the decisions. During the design process a number of different tools were used. For a complete overview of these, see appendix A – Tools Overview.

4.1 Design-oriented Research

This thesis aims to present a visualization of affective data in a way that supports a dialogue between patient and therapist. The visualization of intentionally registered affective data is a largely unexplored area and more research is required. *Design-oriented research* is about contributing with new knowledge through design. Design-oriented research is well-suited for this thesis as the main goal is to generate new knowledge and share it for future use. Through the process of bringing the artefact into being, knowledge is generated. The design is a means to an end, not a goal in itself (Fallman, 2003). By providing and presenting different solutions at different stages in the development I create a road map that explains the design development.

Researching through design is an iterative process, consisting of three basic phases: *problem identification*, *solution design* (called *prototyping* in this thesis), and *evaluation*. The phases themselves might contain one or more activities, depending on the method chosen (Offermann, Levina, Schönherr, & Bub, 2009). By providing design solutions to a problem and learning from its evaluations, new insights from the design become apparent and are implemented in the next iteration. Following are a description of the three basic phases: problem identification, prototyping and evaluation, and the activities they contained.

4.1.1 Problem Identification Phase

To find a problem setting and gather requirements two brainstorming sessions with the stakeholders from Bryggen Research was held. In the brainstorming sessions everyone was encouraged to share their design ideas, their feedback on suggested ideas, and sketch new ideas. Sketching is seen as an ideal way of communicating ideas and concepts with other as it is quick and reduces ambiguity (Fallman, 2003). By involving the stakeholders in the different phases it was easier to set a clear direction for the development of the system. The Bryggen

Research team has a diverse background including team members focusing on art, user experience design, computer engineering, and programming, which meant they all had valuable input into the development. By having two sessions it was easier to ensure that the design developed in a satisfactory manner.

The feedback from the first brainstorming session was implemented in different design prototypes and evaluated in the second meeting. Furthermore, *proto-personas* and *scenarios* were created after the first meeting. I used these during the development to help keep the focus on affective states, and prevent the design from developing to suit a specific age or user group. They were also vital in creating requirements for the system. The feedback from the second brainstorming session was implemented in the next prototype and evaluated with a psychologist. By including an expert into the evaluation round valuable input into the therapy setting was discussed and revealed, and included in the updated design.

4.1.2 Prototyping Phase

According to Sharp, Preece & Rogers (2011, p. 390) users have a tendency to be vague about what they want, but when presented with a solution, they can be quite clear on what they don't want or like. Prototyping is a way to test a design to see what the users want and don't want. Prototypes are manifestations of a design meant to explore alternatives, communicate ideas, and answer questions (Sharp et al., 2011, p. 390). According to Warfel (2009, p. 22) prototypes reduce misinterpretations, saves time and effort, and creates a rapid feedback loop. Prototypes can vary from low-fidelity types, composed of a few paper sketches, to high-fidelity, a functional app. For this system both low- and high-fidelity prototypes were developed to communicate ideas, generate insights and gather feedback. The low-fidelity method chosen, paper prototyping, was used as it takes no coding skills, and it can easily be refined at any time (Snyder, 2004). It's also a nice way to communicate to others that input is welcome since the design is not *done*. Lastly, it makes it possible to change the design proposals with ease, which is very useful when sharing design proposals with a group. The high-fidelity version was made in a vector-based program.

The main objective of this thesis is to provide the Bryggen Research team with options, insights and knowledge they can further utilize when developing the system. Two systems were developed separately by me and Bryggen Research. I developed a calendar system both in low- and high-fidelity version. The low-fidelity paper prototype was developed through various sketches. The first and second iteration was evaluated with the Bryggen Research team, and the third iteration was evaluated with a psychologist. The fourth and final iteration was a high-fidelity version that underwent usability testing with five users. Creating both low- and high-fidelity prototypes was valuable. There are different things to consider when sketching on paper versus drawing in pixels. Paper is excellent for generating ideas quickly and for collaboration, but has issues with accuracy, color choice and producing the same view multiple times. Vector-based drawings are more time-consuming to create, but provide much better accuracy, elements can be copied and edited and allows for a more *real* experience during user testing.

Bryggen Research worked on programming a high-fidelity, interactive version, not feasible for paper prototyping due to the highly interactive components. The two prototypes were meant to be tested up against each other in the usability tests. Due to the complexity of the problem and programming, Bryggen's app was not ready in time for the usability rounds.

4.1.3 Evaluation Phase

Evaluation is a necessity when creating a system, but even more so when aspects of the system is a novelty. Evaluation is necessary to ensure that we are creating something relevant and suitable for the problem we are trying to solve (Sharp et al., 2011, p. 441). At the time of writing few resources were found that described research relevant to the problem we were trying to solve, thus the evaluations became a knowledge-generating activity. The system underwent various evaluations to ensure that different design options, whether approved or discarded, were documented.

4.1.3.1 Expert Evaluation

Formative internal evaluations were conducted twice with the Bryggen Research team. The main goal was to ensure that the system was developing in a way that would generate knowledge the team could use at a later date. The team members contributed with knowledge in their field vital to the systems development which meant looking at the system in different ways. The feedback gathered from these meetings were implemented in iterations two and three respectively.

An external evaluation was conducted with a psychologist. The objective was to ensure that the system would be usable in a therapy context. The evaluation comprised of a small usability test of the system, where she was asked to explain and comment on certain aspects of the system, and a semi-structured interview. As a possible user of the system, and with her background as a psychologist, her insights into the context of use were invaluable when going forward with the development of the last iteration.

4.1.3.2 Usability Testing

To test how usable and suitable the design was it underwent usability testing with five participants. Five participants were chosen to limit the time cost of the testing with regards to data saturation, this is in line with recommendations from various sources (Jacob Nielsen, 2000; Jakob Nielsen & Landauer, 1993; Sharp et al., 2011).

Before the actual usability testing a pilot was conducted to check for unexpected issues and test that the mobile testing system would work with regards to audio and video feed. For the actual usability tests all participants signed a consent form and was told explicitly that the test would be filmed. Only the iPad screen and the participant's hands were on taped. The Clutch platform was then described to the participants and the data was presented as the moderator's data. The participants were given one assignment at a time and asked to solve them in the prototype. Each assignment was given verbally and the participant was told when they had finished an assignment. The first assignment was a low-threshold assignment meant to build their confidence. The last assignment was a free run of the system, where they could comment freely on anything they wanted. To see the entire test set up, see appendix B – User Testing Guide and Assignments and appendix C – Consent Form.

The main goal of the usability tests was to gather feedback with regards to the data visualizations and overall system. Results from the test and limitations on the tests are described in later sections.

4.1.3.3 System Usability Scale

The System Usability Scale (SUS) is a survey consisting of ten questions that seeks to measure the overall impression of a system. To answer the participant must choose one of five possibilities on a Lickert scale (Affairs, 2013). Travis (2015) recommends using a SUS survey to complement usability testing. Figure 5 shows a question taken from the survey.

Figure 5 – Question three from the system usability scale

The survey was implemented to produce quantitative data, which can be easier to interpret for the novice than qualitative data. To lessen possible biases, like participants not wanting to offend the moderator or seem negative, the survey answers were decided to be registered anonymously. All participants received a link to their personal e-mail after all the usability tests were concluded. This ensured that their answers were truly anonymous. SurveyMonkey (2015) was used to collect the data and the answers were handled after all participants had completed the survey. The results and the limitations of the SUS survey will be described later. To view the complete survey, see appendix D – System Usability Scale.

4.2 Methods for Establishing Requirements

To get to know the potential users and gather requirements for the system, two methods were utilized; *proto-personas* and *scenarios*. These requirements would supplement the ones Bryggen Research had already projected at the first meeting.

4.2.1 Proto-personas

The *proto-persona* method is typically used when you don't have firsthand knowledge about your users and are a modification on traditional personas. Personas are used to incite emphatic thinking when developing a system, to help the developers and designers get involved in the people they are creating the system for. This is utilized to prevent the team from viewing themselves as the intended users, and to help guide them create a system suitable for their intended users or user groups (Buley, 2013, pp. 132–135; L. Nielsen, 2013). Traditional personas are typically based on extensive research into a product or systems existing user groups, however the Clutch platform does not have any such groups since it is a novel and untested system. Buley recommends using proto-personas when “you have an unclear picture of your target user” and “you find that you (…) talk about users and their motivations in generic and non-specific terms” (2013). As the proposed user groups range from patients in drug rehabilitation to children being bullied, proto personas not only make the creation of personas easier, but faster as well. It was therefore decided that proto-personas would be utilized. Four such personas were made in line with guidelines recommended by Nielsen (2013) and Travis (2015). The selected personas were created to provide a range of different ages and users. In table 3 the different personas are described in text. Their issues, which type of user they are, and how they use the system is provided. A small justification on the choice of user is also provided. This would help in making sure the system didn’t become too focused on a certain age or user group. The proto-personas were part of the process of gathering requirements, along with the scenarios.

Table 3 – A textual overview of the proto-personas

Persona	Issue	User Type	System Use	Justification
Christel	Depression	Patient, self-helper Young adult	The stone, the mobile app (journaling)	Depression is quite common and some user groups would like to help themselves
Ramtin	Anger Management	Patient, but not by choice Teenager	The stone	Reluctance to use the system might be an issue
Helle	-	Therapist Adult	The Clutch app	A psychologist is a must
Martine	Anxiety	Patient Child	The stone	It’s a taboo that small children suffer from mental health issues
Martine’s Mom	-	Parent Adult	The Clutch app	Not all users need a certified therapist

4.2.2 Scenarios

A *scenario* is a means of telling a story involving the users of a system and the system itself. The focus is meant to be on the human interaction and thus focus on the goals of the user and their needs, as well as the requirements of the system (Sharp et al., 2011, p. 374). Scenarios differ from when in the development phase there are being utilized. As such, the following scenarios emphasize usability and the tasks performed by the users. The scenarios were used to gather data to form requirements for the system. For all the proto-personas and their scenarios, see appendix E – Proto-Personas and Scenarios.

4.3 Chapter Summary

This chapter described why research-oriented design was used to develop the system and how it generates knowledge which can be utilized at a later date. The chapter also described the different methods for creating prototypes, proto-personas and scenarios. The prototypes underwent different evaluations before it resulted in a high-fidelity prototype that underwent usability testing and a survey. The next chapter will describe the designs and their evaluations with the intent to provide the reader with a roadmap of the entire development and the result from each phase.

5 Design and Evaluation

When designing through research, all parts of the process provide various inputs that can be valuable at a later stage. This section describes the different iterations, what changes were made to the system, and the justifications for the alterations. It provides a roadmap of the design and evaluation process from beginning to end, including the results from the various stages.

5.1 First Iteration

The first iteration consisted of a brainstorming session with the stakeholders from Bryggen Research. The ideas and information from the session was used when creating the first paper prototypes.

5.1.1 Brainstorming with Bryggen Research

The brainstorming session helped to generate different ideas and approaches to the design. The group defined the goals of the visualization and its users, defined the areas of interest, discussed requirements for the design, and allocated areas of responsibility.

The users were defined as being both the therapist and the patient. Further investigation was required to answer questions with regards to actual usage, as the Clutch platform had not yet been in use. Thus, there were no data available and all data in the prototypes would are conjectures. The goal of the design was to support a dialogue between the therapist and the patient, where the data visualizations would play a supporting role. The data visualizations were not intended to be used by the patient alone. Synchronization of the data would occur when the patient was with their therapist and together they would explore and explain the data.

What was unclear at the start was how to best visualize the data. The top priority was to get a sense of the data in some way by providing an overview. One issue that made the data visualizations especially challenging was that the Clutch platform was not a single-purpose item. Its potential use was defined by the therapist and the patient. Therefore, a single visualization might prove fruitful in one area, but be sub-optimal in another. Additionally, the system should not target specific emotions or moods, such as anger, sadness or anxiety, but function for people experiencing eating disorders, undergoing phobia treatment or drug rehabilitation. Lastly, due to the small screen size a one-to-one mapping, one pixel per one second, of the data was not the optimal approach, as the data would be unreadable.

Figure 6 shows an overview of some of the suggested visualizations that were suggested during the meeting, ranging from a traditional calendar to more novel approaches like spiral and cloud-like view. The spiral data visualization was discarded as it was deemed difficult to interpret. Bryggen Research suggested an interactive timeline visualization based on the timeline and cloud-like visualizations. The calendar approach would go into paper prototyping.

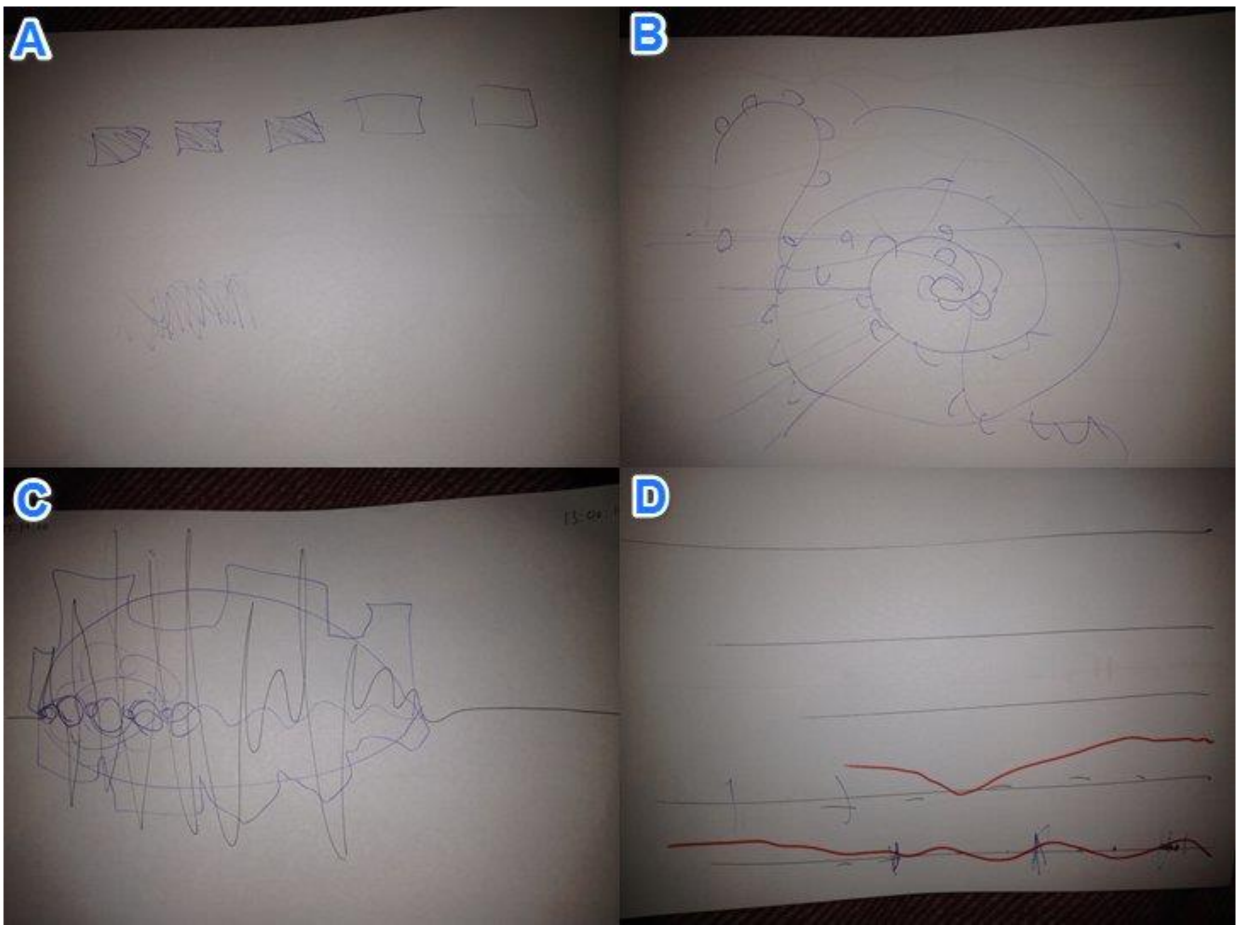

Figure 6 – Suggested designs from the first brainstorming session. A) shows a calendar approach with colored boxes to indicate active days, B) shows an interactive spiral, C) shows a cloud collection of evens and D) shows a timeline with weather overlay.

5.1.2 Proto-Persona and Scenario Pilots

After the first brainstorming sessions work began on sketching out the proto-personas and creating some scenarios. They were put on display in my personal workspace used when developing the prototypes.

5.2 Second Iteration

The second iteration consisted of researching possible designs via a literature review and creating paper prototypes that would be evaluated in a new brainstorming session with Bryggen Research. The feedback from the session was used when developing the second prototype. This prototype would be evaluated in the third iteration.

5.2.1 The First Prototypes

After the first brainstorming session with Bryggen Research, low-fidelity sketches were developed to examine possible design solutions and design issues. The main goal of the visualization was to create an overview of the data, a Month view, to help the users to find the most interesting days quickly. Furthermore, a Day view with a more accurate mapping would be provided to single out specific events interesting for the therapy session.

The first paper prototypes did not consider color choices, granularity or screen real estate. It was based on principles of familiarity of the design. The first version was a traditional calendar approach, something considered familiar to many users thus requiring little or no translation or explanation, to be decoded by the users. To prevent the introduction of unnecessary text or numbers in the interface, as required from the Bryggen Research team, dots and columns were selected to display the data. Both dots (size/area) and columns (length/width) have been proven to be suitable visual encodings for qualitative data, with length being preferable over area (Cleveland & McGill, 1984; Siirtola, 2014). The time-line is horizontal and the data is vertical as this is considered familiar and easy to read to users from western cultures (Meirelles, 2013).

Figure 7 below is an excerpt of the first prototype is shown, the Day view. The horizontal line depicts the selected time span and the pink vertical bars represent the intensity of the squeezes. There is also a date, a search box and a menu button. The orange line to the far right represents the current time of the day, as not data will be shown after that time.

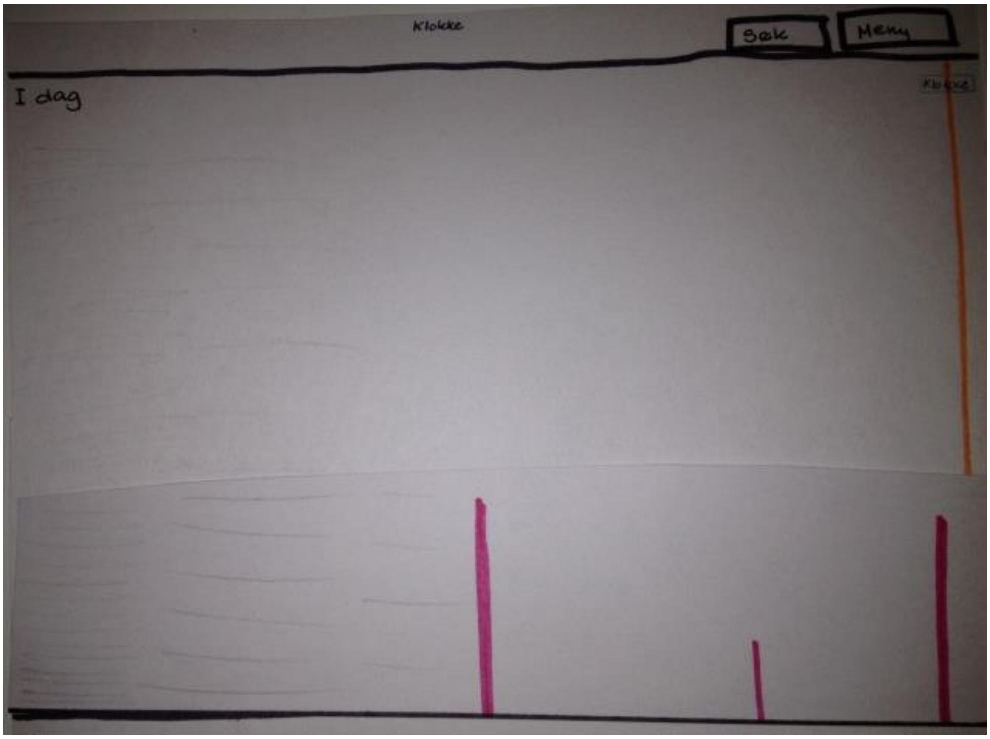

Figure 7 – The first Day view

Figure 8 shows a selection of possible month visualizations in the calendar view. The boxes represented days, the notation within the boxes the number of squeezes and/or the intensity. With the even dots, a dot represents a single event, with no regards to intensity. The uneven dots represent the intensity of the squeeze as well as the event. The vertical split view shows more of the day by splitting the screen and events displayed like bars. The height of the bar represents the intensity. The horizontal split works on the same principles as the vertical version, with the length of the bars representing the intensity.

Figure 8 – A selection of possible month visualizations. A) Shows even dots, B) shows uneven dots, C) shows a vertical split of the screen with bars, and D) shows a horizontal split with bars

During the design phase issues with regards to the two proposed views arose. The suggested Day view had issues with regards to granularity, screen real estate, scrolling and navigation. Granularity is important as each event (or squeeze) can be quite small in size. This would be difficult to solve on paper and needed to be worked out in higher fidelity at a later stage. Also with the Day version, most of the screen was whitespace creating an unbalanced look to the interface and wasting space. By using so little of the screen to show data, scrolling through the data would likely be extremely cumbersome. With regards to navigation there was no way of easily and effectively navigate to surrounding days.

The first Month view was also flawed. The dots removed the time of day from the overview, making it impossible to see when something had occurred. Both views had some issues with granularity, if a user has more events than the available allotted space, this would occur in either loss of data accuracy or introduce more text or numbers into the interface. Both were considered unacceptable.

5.2.2 Design Meeting with Bryggen Research

A new brainstorming meeting was held to go through the first prototype designs. The meeting was labeled a *design meeting* to keep the main focus on the visualizations. The first prototype designs were discussed and some were discarded. The issues regarding wasted screen space and navigation in the Day view was addressed. A new version called *Overview+Detail* (Cockburn, Karlson, & Bederson, 2008) was presented and was considered appropriate for the updated Day view. In figure 9, a sketch of the new Day view is shown. It simplified navigation by adding an overview over the week in the bottom of the screen, whilst keeping the current day in the upper half of the screen. The detail view would make it easier to view specific data entries; the overview would provide easy access to previous weeks.

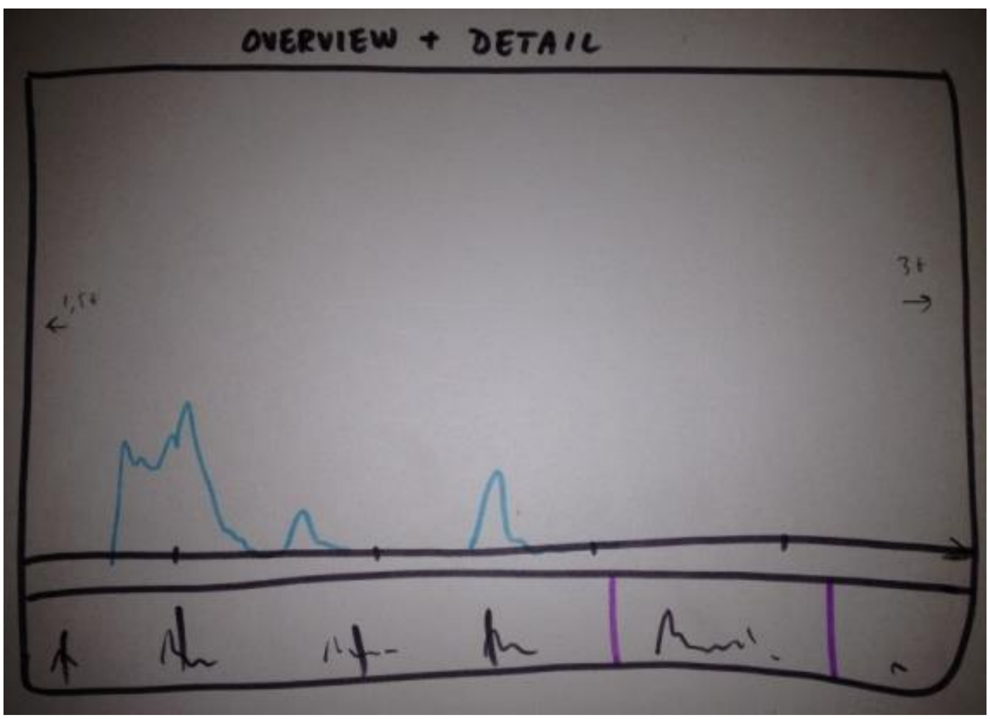

Figure 9 – A sketch of the Overview + Detail version

The issue with time of day in the Month view was also discussed. Time periods could be indicated by adding color shading or different colors to the dots in the month view. In figure 10 the different green colors represent the time of day. The idea was that the colors would match the environment around the users. A dark green color would represent night or evening, whereas lighter colors would indicate morning or daytime.

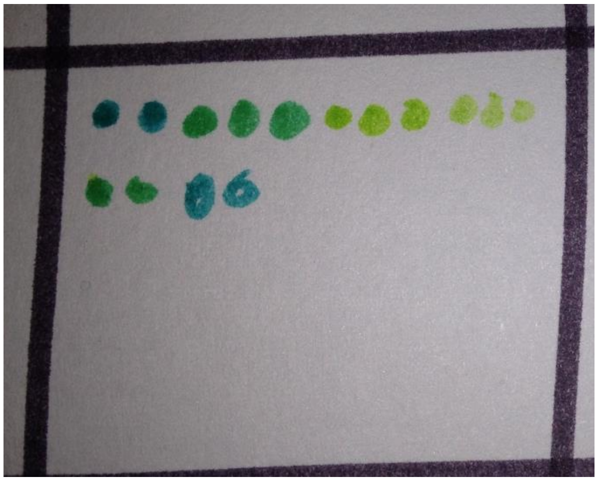

Figure 10 – Adding colors to the dots as a possible solution to discern time of day.

I suggested the possibility of tagging or annotating the data. This would mean raising the threshold of use for some users, but could provide more meaning to the data and allow for filtering of the data. Annotating the data could also mean that the user could use the system and explore their data by themselves, as seem to be the trend in health informatics. There were some concerns voiced on adding more features to the design as this was not our area of expertise. The orientation of the design was also a major topic of discussion. It was decided that annotating data and orientation would be addressed later during the evaluation with a psychologist.

Lastly, Bryggen Research decided to start developing the interactive timeline to function as a counterpart to the calendar design. Their interactive design would allow the user to zoom in and out on a timeline in the hopes of enhancing the user's natural ability for pattern recognition. Figure 11 is an illustration of the time-line view. Section a shows five different data clusters, the cluster with a red ring is selected by the user for examination. When the user zooms into this cluster it breaks apart revealing the containing data points at a higher resolution, section b. When the user continues to zoom the exact data registrations appear, in section c. As this was a graphic representation highly dependent on its interactivity to make sense, making it unsuitable for paper prototyping, it was decided that Bryggen Research would program this version and I would do the user testing.

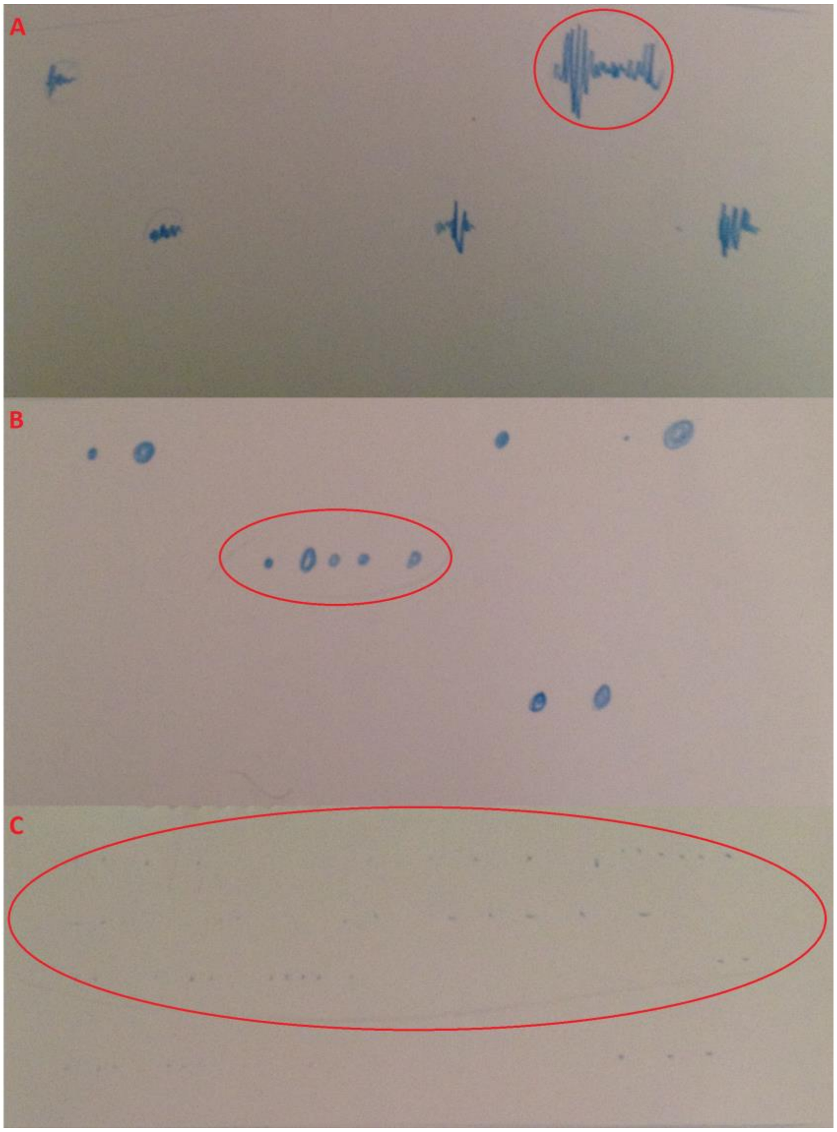

Figure 11 – A) A section of data is selected for examination. B) User zooms in and the view changes to show more data. C) All the data entries from B are shown in more detail.

5.2.3 Proto-Personas and Scenarios

After the last brainstorming session, five proto-personas and the scenarios were established. They were used when developing the prototypes and the functional requirements for the system. The next subsection includes a proto-persona and her scenario. The remainders of the proto-personas and their scenarios can be found in appendix E – Proto-Personas and Scenarios.

5.2.3.1 Example of a Proto-Persona and Scenario

Christel

«When the going gets tough, the tough get going.»

Background
- 19 years old
- Female
- Student at the faculty of law
- Lives alone in Bergen

Lifestyle
- Christel enjoys student politics and working out
- She spends hours in the lecture halls

IT skill level
- Medium. She uses apps like RunKeeper and Lifesum.

Tasks
- Synchronizing the stone
- Journaling
- Interpreting the data

Frustrations
- Slow apps and apps that hide data
- Ugly, android interfaces

Figure 12 – The Christel Persona

Christel's Scenario

Christel was recently admitted to the faculty of Law in Bergen, a lifelong dream for her. She moved away from her family and friends in Aalesund to study. She's always been a very social student, engaged in out-of-school activities and used to getting good grades. Since she started at the university some months ago she's been feeling alone and homesick. She spends most days at the lecture halls or studying in her dormitory, but lately she's started to sleep in instead of going to classes and she's falling behind. Following her mom's advice, Christel seeks out the SiB counseling, a low-threshold initiative for students experiencing difficulties. At the counseling session, Christel describes her symptoms of homesickness, the sleep changes and the general feeling of feeling blue. The SiB councilor asks is Christel would be willing to try a new method for a while. She is asked to squeeze the stone if she feels lonely or homesick, and also to jot down in the app what she did that day, and with whom.

Christel is conscientiously journaling every day, keeping track of when she feels best and worst. She brings the stone with her as a reminder, but rarely feels the need to squeeze it. She compares her notes to see if she's progressing, adding a scoring system of the overall day.

Figure 13 – Christel's Scenario

5.2.4 Requirements

To ensure that the design was on track, requirements describing the system and its content needed to be determined. Non-functional requirements are considered outside of the scope of this thesis and will not be included. The functional requirements are made based on feedback gathered at the brainstorming sessions, the proto-personas, and scenarios. Bryggen Research's initial requirements are repeated here as well.

5.2.4.1 Functional Requirements

The system should provide the therapist and patient with:

- a quick way to see relevant days or event
- a simple way to view a day / an entire week / entire month
- a journaling tool
- a way to compare different time periods to examine changes in event registration
- multiple ways to compare different time periods to examine changes in event registration
- a search function to help them locate journal data
- a way to differentiate time of day
- icons that are easy to understand
- an interface free of needless text or numbers
- a simple way to synchronize the stone's data

5.3 Third Iteration

The third iteration consisted of further development of the paper prototypes, literature searches, and an evaluation by a psychologist.

5.3.1 The Second Prototypes

After the design meeting a number of new proposals were examined for the Month and Day view. The Day view was updated to include a new visualization, the Poplar visualization, and Overview+Detail. The Poplar visualization, as seen in the bottom of figure 14, is shown as small poplar trees, where the stem of the tree represents an event, the size of the crown represents the intensity of the event and the color represents time of day. In the upper right corner a small color explanation is shown. The intention of the Poplar visualization was that this would bridge the Day view to the Month view, where the dots (or crown) from the Poplars would be similar in both views. Small timestamps are also shown under each event to indicate time and the length of the event. The purple box around Sept 27th indicates the selected day.

Figure 14 – Day view from prototype round 2

As seen in figure 15, the Month view now included colored dots, in various sizes and formations. It was decided these versions would be tested in the evaluation with the psychologist. There are four versions of the dots visualization. The first version displays all even dots, only sorted on time. The second version displays all even dots, sorted into four time rows that indicate time of day. The third version shows uneven dots that display intensity of the event, sorted into four time rows that indicate time of day. The fourth version displays uneven dots, only sorted on time. The second prototypes were brought to the evaluation with the psychologist to get her opinion on the set up, the visualization choices and orientation.

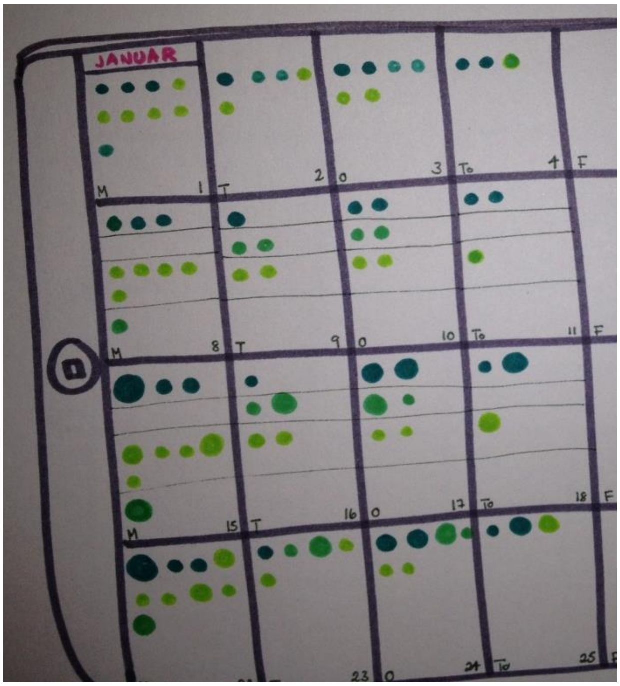

Figure 15 – The Month views from prototype round two

5.3.2 Expert Evaluation

To gather more information about the context of use and gather data on the suggested visualizations, a psychologist agreed to evaluate the prototype and partake in an interview. She was shown the paper prototypes, asked to comment freely and add her own ideas. She liked the week overview on the bottom of the Day view, but disliked the choice of color coding. She would have like the colors to be intensity, not time of day. She would also prefer some sort of graph visualization, and did not like the poplars. Also, she stated that for patients with cognitive impairments and young children it would be useful to have a very clear indication on time of day, for instance via natural icons like the sun and the moon to display day or night time. Another option could be to add emoticons to the visualization to oversimplify the meaning.

In the semi-structured interview she answered questions with regards to orientation and journaling. With regards to orientation, she stated that in a therapy setting she would hold the iPad so that it was the right way for her patients, or sit almost side by side. She mentioned that in a therapy setting, the preferred way was at a slight angle from each other. Therapists have different preferences, but for her, orientation was not considered an issue. With regards to keeping a journal, she said that the trend moves more and more into people helping themselves and she thought that keeping a journal could be very helpful for some patients.

For the full set up and consent form used see appendix F – Expert User Consent Form and G - Expert Evaluation with a Psychologist.

5.4 Last Iteration

The last iteration underwent some significant changes from the previously examined designs. This was greatly due to the feedback gathered from the evaluation with the psychologist, as well as changing the format from paper to pixels. The final prototype is a high-fidelity version and was tested on an iPad mini. Lastly, a SUS survey was carried out.

5.4.1 From Paper to Pixels

The transfer from paper into a high-fidelity version created some unexpected issues with regards to the data visualizations. Paper prototypes are more forgiving with regards to fidelity, accuracy, and granularity. Additionally, the feedback from the psychologist indicated that other designs should be considered. This resulted in some new designs that were first tried out on paper, but with pixels in mind.

The original Dots view could only hold a certain amount of data before becoming unsuitable for an overview and difficult for a comparison. If the user had a really bad day, the number of events would exceed the allotted space. Four other kinds, and variations thereof, were tried out:

- The Slope Graph
- The Star Glyph
- The Nav Glyph
- The Bars View

The Slope Graph provides a simplified overview of the entire day via a single line. A benefit of the Slope Graph is that it’s easy to read. Disadvantages include difficult to compare, reduces the entire day to a single overall experience and loss of information about time.

The 4-Slope Graph is a modified version of the Slope Graph that tries to solve the time issue. It was deemed too complicated for comparison.

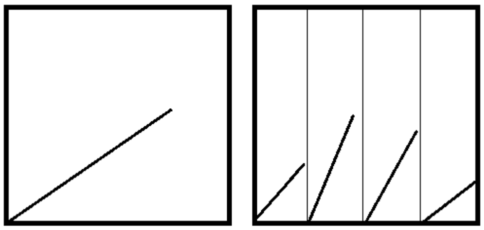

Figure 16 – The Slope and 4-Slope Graph

The Star Glyph is a glyph visualization. This version divided the day into four parts and the size of the part indicated the overall number of events and intensity within the selected time frame. A benefit here is the time frames. A disadvantage of legibility becomes obvious when trying to compare a glyph to other glyphs.

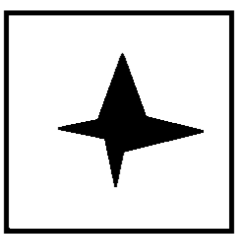

Figure 17 – The Star Glyph

The Nav Glyph is based on the Star glyph to help with the comparability. Both color and size are used to indicate overall number of events and intensity within a selected time frame. Although it helped when trying to compare different types, it was still difficult. Another disadvantage is deciding which dots represent which time frame.

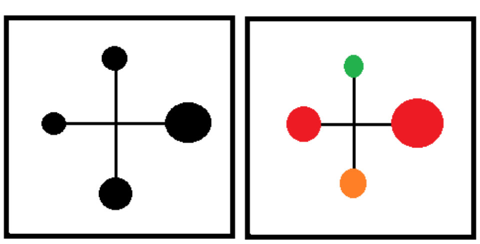

Figure 18 – The Nav Glyph

The Bars View is a standard bar visualization. This version is divided into three and four parts, black and colored (red, yellow[2], green). The color and height are meant to indicate the overall number of events and intensity within a selected time frame. The benefits from this visualization are the time frames, comparability, and legibility. Downsides are the color choices, which may be an issue for people with color deficiencies. Different shades of blue may be an option here since heights indicates the zone as well as the color.

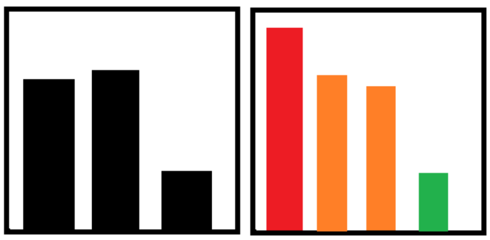

Figure 19 – The Black and Color Bars View

The Bars visualization was selected for the last prototype as it proved the most easy to compare of the earlier designs. Length is also viewed as more accurate for assessing qualitative value than e.g. slope, area or color (Cleveland & McGill, 1984; Siirtola, 2014).

5.4.2 The High-Fidelity Prototype

As mentioned earlier the last prototype has different graphical elements than previously proposed. A complete overview and justifications for the modifications will be presented here. The major changes in the Day view were:

- dividing the screen to view twelve hours (as opposed to six)
- adding icons and background colors to display time of day
- the poplars were replaced by four bars that indicate time of day
- the four bars indicate intensity via height and colors: red, yellow and green

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[2] Yellow were replaced with orange in the example above as it's more visible on both paper and screen

These changes are made to use more of the screen space available and thus reducing the amount of scrolling needed to explore the data. By adding icons and corresponding background color the intention is to show which time period the user is viewing. The icons are intended to represent the time of day. The night icon is a moon with small stars, the morning icon shows a small sun rising up from behind the clouds, the day icon is a sun, and lastly the evening icon is a moon and some stars behind a cloud. The background color in the Day view is divided into dark blue, to indicate evening or night time, or light blue, to indicate morning or day. This grading of the background color attempts to reinforce the information in the graph, as suggested by Kosslyn (1989, p. 187). In the overview section colored bars now indicate the overall intensity and frequency of a 6-hour time period. Six hours are chosen as this divided the day into four time slots that is believed to correspond well with the general idea of “night”, “morning”, “day” and “evening” respectively. Red, yellow and green are used to indicate high, medium and low levels of activation. The idea is that this will signal to the users which parts of the day were most activated, which might be of interest in a therapy setting. Figure 20 shows the last prototype for the Day view.

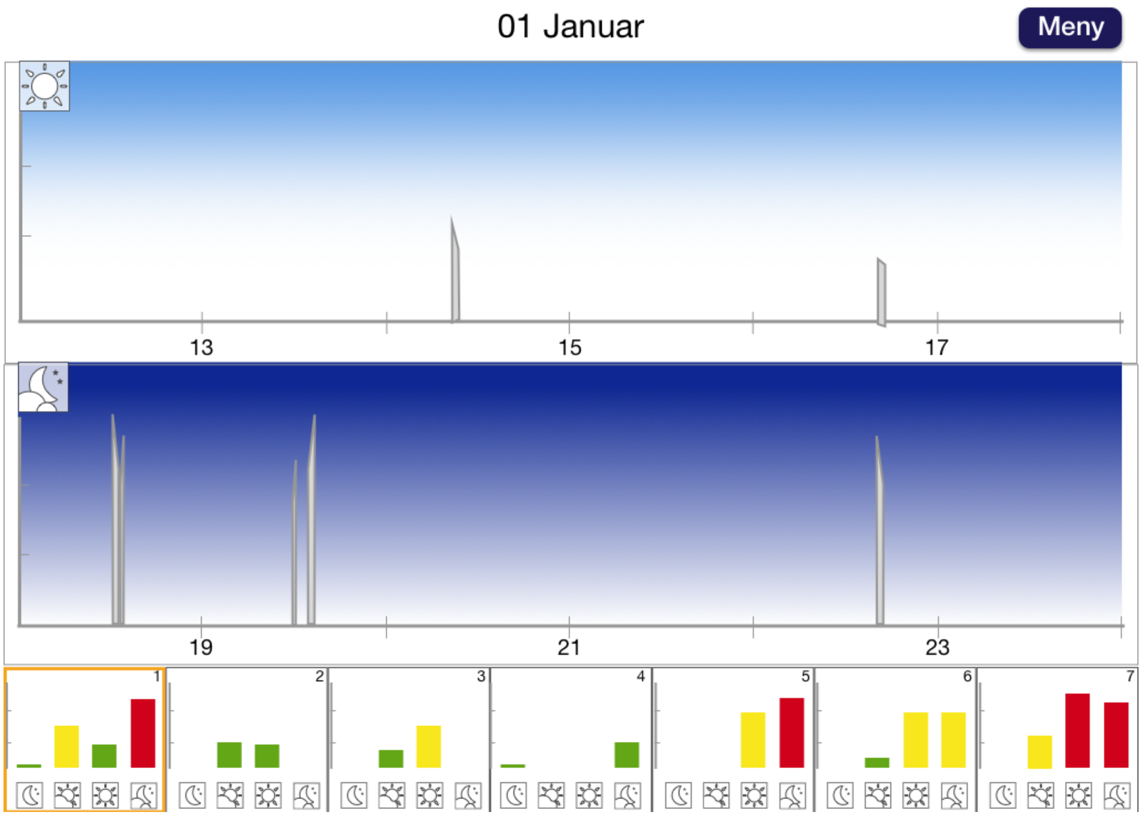

Figure 20 – The Day view in the last prototype

The Month view used the same bars elements as seen in the Day view in the previous figure. This was done with the intention to describe the relationship between the different views.

5.4.2.1 New Visualizations for Comparing Data Entries

Two additional visualizations were made to compare the data from two, or two or more months – the Dots compare and the Bars compare. The comparisons are meant to be used as a tool to compare different months and visualize the patient's development. The Dots view, as seen in figure 21, compares two or more months by displaying three colored dots – a red, yellow and green one. The dots are a pool of the number of red, yellow and green registration in a month.

Figure 21 – The Dots compare showing three months – April, May and June

The Bars version, as seen in figure 22, is best suited for two months, as more months would make it less legible. The Bars are divided into three heights, by white divider lines, meant to illustrate the red, yellow and green zones from other parts of the system. This was done as using red, yellow or green here would make it difficult to discern the different months. In the upper left corner the months are categorized with a color. The horizontal axis display the date, 1st through 10th of January and February respectively.

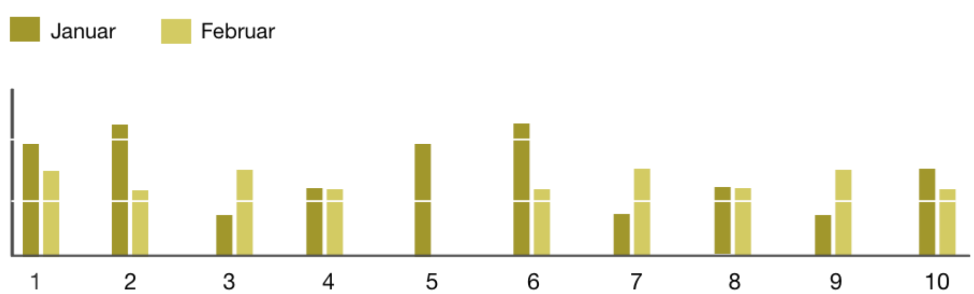

Figure 22 – The Bars compare showing ten days of January and February

For more screen shots from the last prototype, see appendix H – The Last Prototype.

5.4.3 Usability Testing Pilot

Before the actual usability testing a pilot was conducted to check for obvious problems related to the prototype, the test equipment, and general set up. The pilot revealed that the prototype behaved erratically in the Safari browser, which resulted in an unsure and annoyed participant. The prototype was therefore moved from a browser set up to an app designed for running prototypes. No other apparent issues with set up were registered.

5.4.4 Usability Testing

A usability testing was conducted to examine the last prototype. The sample consisted of N=5 of participants (4 female and 1 male), age ranging from 25 – 57, with an average of 26,4 years. The participants were introduced to a high-fidelity prototype of the system and asked to perform six different tasks. All users were asked to volunteer for the user testing by means of personal communication or via Facebook. All users were familiar to the moderator. Out of the five participants, all users signed a consent form and no user chose to withdraw from the study. One test was not videotaped due to a human error, but field notes were sufficient to cover results from the test. The participant agreed that I could use these notes as my results.

The user testing were formative in nature, meaning that gathering statistical data was not the objective. Testing how fast a user managed to do an assignment was not as important as whether they understood the different parts of the system. Thus, the goal of the test was to ensure the development of the system was on track and gathering data on the users' views of the system.

For the user testing an iPad mini with the ProtoSee (2015) application was used. Running the prototype this way allowed the users to interact with the prototype as if Clutch was a real application. The test lab was mobile and set up in a quiet room where the participant and moderator could be undisturbed. The users were asked to complete six tasks in the prototype whilst thinking aloud. Before each test, the moderator illustrated thinking aloud and practiced this with the participant. For the entire test set up, see appendix B – User Testing Guide and Assignments.

5.4.4.1 Usability Test Results

The usability tests results presented here focus on the data visualizations and use, as this is the main concern for this thesis. Issues with navigation, font size and other things related to Apples iOS guidelines are not presented here as the application would undergo a redesign before being released. When direct quotes are used, the participant number will be presented in parentheses like this (P1), indicating participant 1. The results are divided into the different views; Month, Day, Bars, Dots, and general feedback.

5.4.4.1.1 Month View

As part of assignment one, participants were encouraged to share their views and interpretations on the different graphical elements. In the Month view, two participants had trouble understanding the icons used and what they were meant to convey. One participant thought it might weather icons and could not see why that would be necessary. One participant was very dissatisfied with the general interface design, and commented that the entire interface should be redesigned with regards to different color choices, repeating elements and the main color theme.

Four out of five participants understood that the colors meant different intensity levels, but none were sure what the information *behind* was. All participants were able to quickly determine which days were the worst in the Month view. The worst days were the highest red days or the days with more red bars. The best days were interpreted as both the low green days and the days with no data registration. When prompted for this the reasoning differed, but all participants interpreted having no or a low data registration to be a good thing.

Finding more information about the icon sets and colors was part of assignment 2. Three out of five participants had some trouble finding the information icon in the upper left corner and commented on the small size of the icon. Figure 23 shows the small pop-up with explanations on the icon set, time of day and color intensity. When presented with this all user understood the icon set and colors, but one user commented that the night and evening icons were too similar.

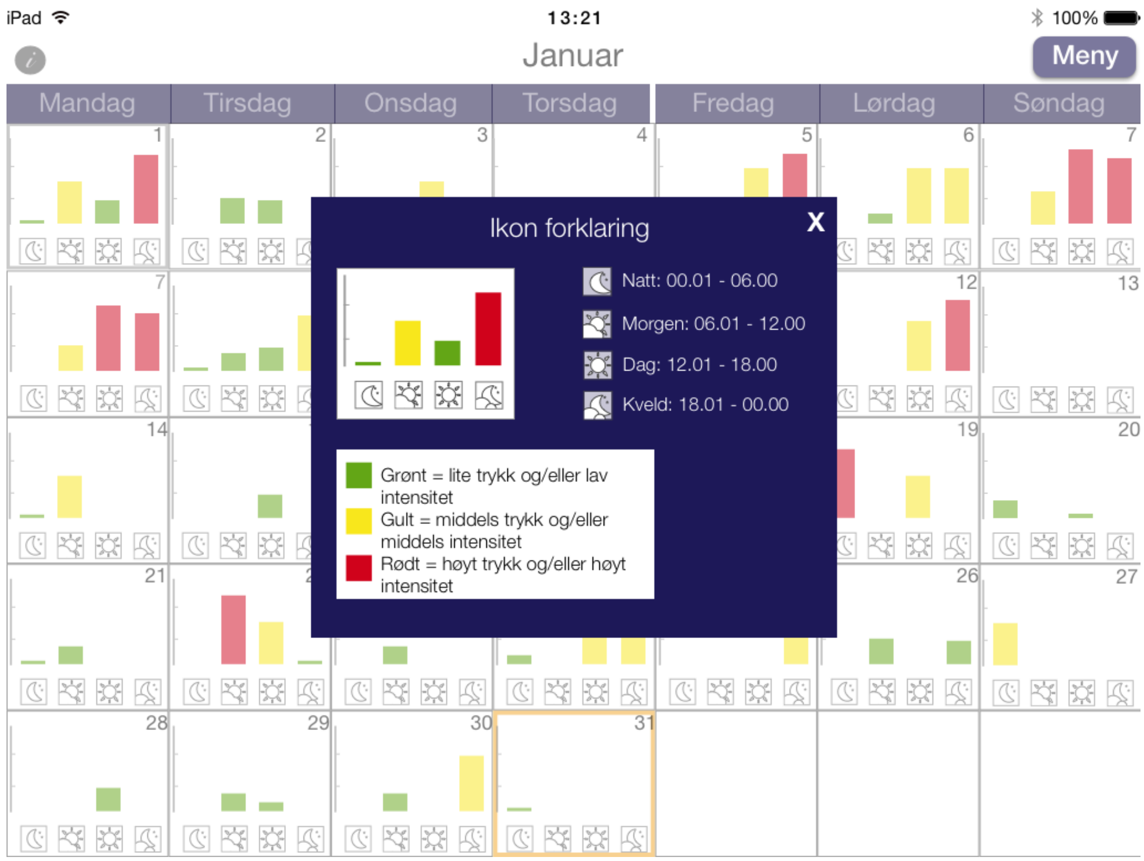

Figure 23 – Icon and color explanation pop up over the month view

The comments from the participants indicate that a redesign of the icon set would be preferable. The colors combined with height presumably helped the user in their interpretation of the data. Using color to indicate intensity is common practice, as seen earlier in the reviewed studies, but a color version for users with common color deficiencies should be provided.

5.4.4.1.2 Day View

In the Day view participants were asked to give their opinion on the design. Three participants commented that the use of background color to indicate time of day was a good idea. Two participants struggled to understand why the grey event indicators sloped upwards or downwards. When I explained that it was related to the varying intensity of a squeeze, they said they understood the sloping. One participant said that the events "reminds me of needles" (P4). Three participants commented on the choice of numbering on the x-axis and lack of numbers on the y-axis, and wanted all the hours represented on the x-axis.

Figure 24 illustrates the 1st of January; the first event on screen has a small note on it to show the users that a journal entry is registered. All participants were able to enter a journal data without trouble, no comments were made on the system. When prompted for opinions, all participants were satisfied with the small note to indicate a journal entry.

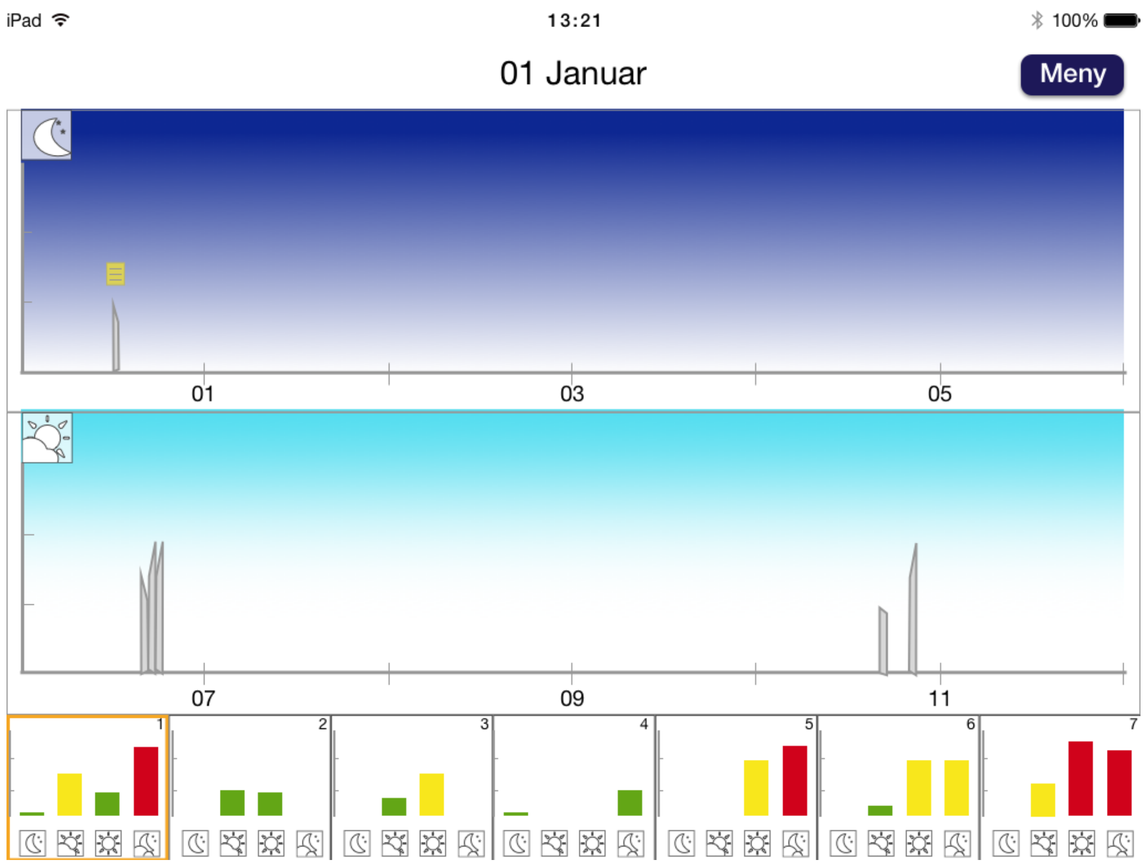

Figure 24 – Entering a note on an event that happened January 1st

5.4.4.1.3 Bars Compare

In the Bars compare all participants were dissatisfied with the color choices on the months. The color was selected as is suitable for people with the most common color-deficiencies, but the low level of contrast made it difficult to distinguish the months from each other. Furthermore, no participant could tell with certainty which month was best. Four participants guessed and one participant chose to count them all. This is a strong indication that the Bars compare does not work for comparing two months. One participant said that the Bars compare was good for looking at certain days or weeks and wanted to be able to filter the amount of information presented in this type of view. Also, in the Bars compare three participants requested an explanation on the white divider lines.

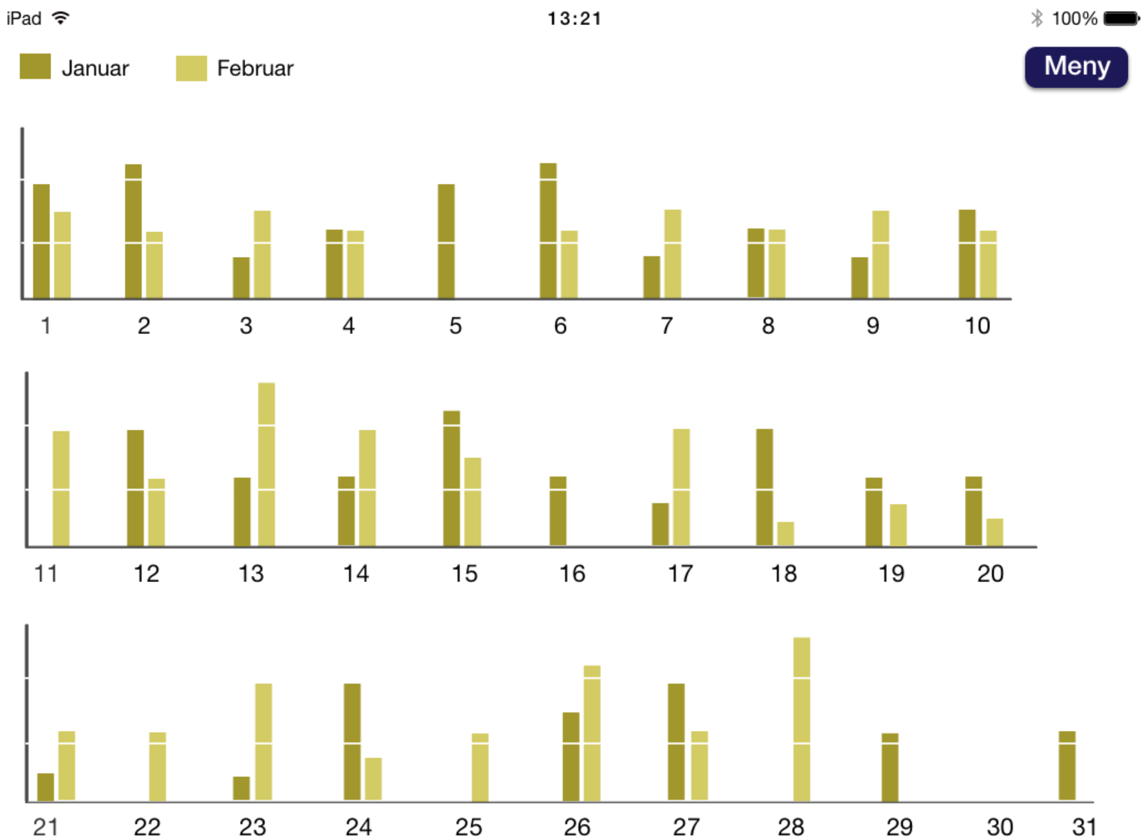

Figure 25 – The Bars view comparing January and February

5.4.4.1.4 Dots Compare

In the Dots compare all participants could tell which month was the best. Four participants could tell which months they thought was worst with greater certainty than in the Bars compare. Two participants said that it would be nice to have more data available underneath the dots, e.g. by pressing on the dots a number would be displayed, or some way of telling which dot was larger, e.g. by adding circles around to indicate size. Three participants wanted some way of filtering the data, e.g. showing only the “red data” (P5) or “the worst month in a year” (P5). One user thought the visualization was “very childish” (P4) and preferred the bars version, even though readability was poorer, as it looked better.

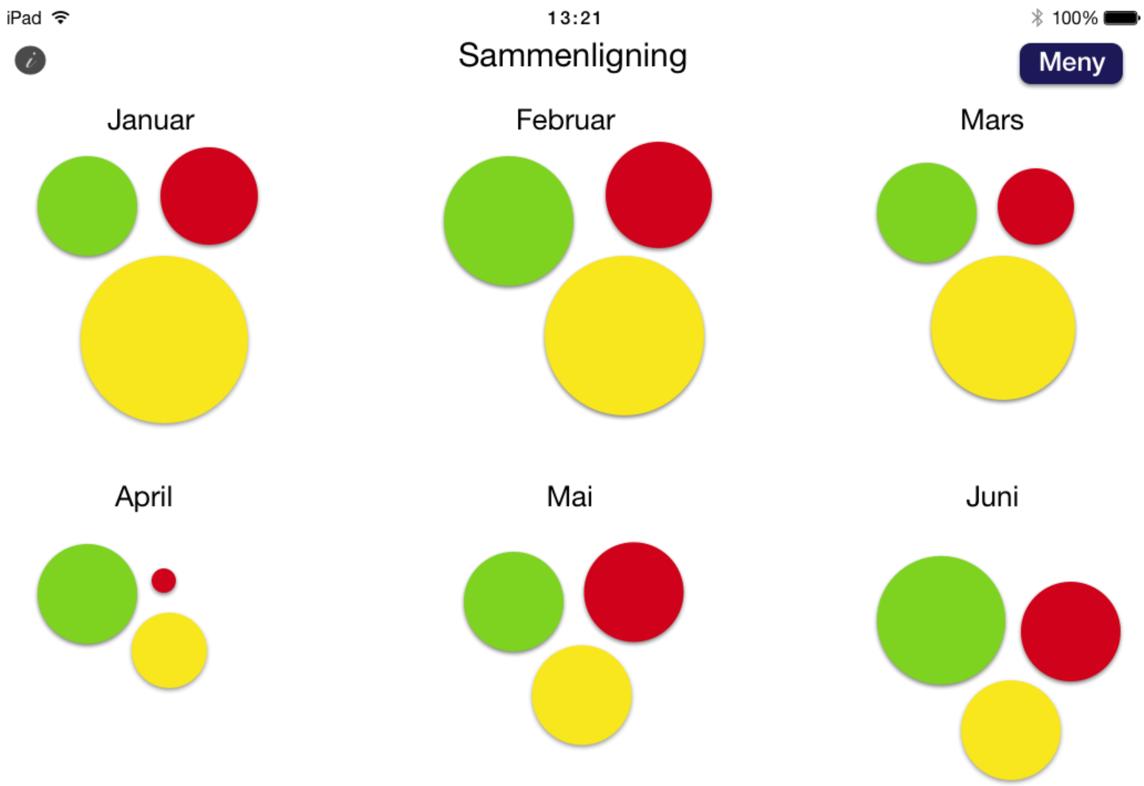

Figure 26 – The Dots view displaying six months for comparison

5.4.4.1.5 General User Feedback

When the participant had completed all the assignments they were encouraged to explore the system and comment freely. In general the users indicated that they were satisfied with the system and the visualizations, however one user was very dissatisfied with the graphical profile and color choices. Another had some trouble reading the screens which in part may be due to the fact that the participant forgot to bring their reading glasses. This may have affected the test with regards to navigation and general legibility, and thus might have affected the participant's general view of the system.

5.4.5 System Usability Scale

To provide more feedback about the prototype, a System Usability Scale (SUS) was carried out after the testing. When all participants had responded the overall score was calculated. The final value is used to grade the system. The grading system (A-F) is an easy way to communicate user satisfaction and any grade under C indicates that the system, or parts thereof, is not good enough (Bangor, Kortum, & Miller, 2008). Table 3 shows an overview of the SUS scores. The column header Sum shows the raw data from the tests, the Final Score shows the calculated scores, and finally Grade shows the grades of the system.

From the overview in table 4, respondents 1, 3 and 4 are very satisfied with the system, the score being equal to an A or B grade. Participant 3 and 5 are very dissatisfied, the score being equal to an F grade. Since the answers were anonymous there was no way of going back to interview them without revealing their identity.

Table 4 – An overview of the SUS scores

#	Sum	Final Score	Grade
1	35	87,5	B
2	19	47,5	F
3	37	92,5	A
4	34	85	B
5	10	25	F

When examining the results from the individual questions, the distribution of the answers are quite wide ranging, from Strongly Agree to Disagree or Strongly Disagree, as would be expected from the grades. All users agreed or strongly agreed that they would use the system frequently, which might indicate that the system's intent is considered useful, even if they didn't understand or approve of the prototype. On the question, whether the system was considered easy to use, three users agreed or strongly agreed, one user was neutral and one user strongly disagreed. This might be the result of the prototype, the assignments given or a combination of both.

One respondent disagreed strongly that the system was easy to use and one respondent agreed that he/she would need the support of a technical person to be able to use the system. Two respondents disagreed that most people would be able to use the system very quickly. Another two strongly disagreed or disagreed that that they felt confident when using the system. These results strongly indicate the need for a redesign, especially if a future version of the system is to be used by the patient alone.

5.4.6 Redesign and Research Suggestions

To improve the prototype some design and research suggestions are provided here based on the collected feedback.

- Follow Apple guidelines
- Focus on aesthetic design
- Focus on accessibility
- Research visualization types

A redesign with regards to Apples guidelines is necessary. The application is meant to be run on iPads and using the standards provided by Apple would presumably increase the user's confidence when using the application, e.g. with regards to navigation. By providing a more aesthetic design, with regards to color, font and form, some users are likely to be more positive towards the system (Chawda, Craft, & Cairns, 2005). Another design issue concerns itself with accessibility. From the user testing it was obvious that color contrast was not considered. Future design should focus more on accessibility, like color, size, and alternative means of navigation, to include more users.

For future research into visualization, different types of data visualizations should be tested with a wider range of users. The Bars compare didn't function as intended and might be replaced with a different type or include a filter as requested by some users.

Based on the overall scores and feedback it would be appropriate to redesign the system and test it with real data and real users. Feedback is valuable; however as long as the system has no real data it's conjectures.

5.5 Chapter Summary

This chapter described the process of developing visualizations with the intent of supporting the therapeutic dialogue between patient and therapist. The results from the different evaluations were assessed and implemented in the iterations on the design. A high-fidelity prototype underwent usability testing and a survey to provide feedback with regards to suitability and future works. Not all users were satisfied with the system and a redesign of the system is required. Furthermore, testing the system with real data and real users is needed. In the next chapter a discussion on how the research questions were answered is presented along with a discussion on the limitations of this thesis.

6 Discussion

This section will seek to examine how the research questions were answered. Lastly, a discussion on the different limitations with regards to this thesis and its design will be reviewed.

6.1 Visualizing Affective States

To answer the first research question, a literature review was conducted on areas related to data visualizing affective states. The first research question was as follows:

> ***RQ1: How are visualizations used to represent affect?***

The scope of the literature review was narrowed down to a few large areas; data visualization, affective interaction, and tangible interaction. The review shows that data registration is divided into two main approaches, a passive and an active approach. Passive registrations happen continuously without the need for a user's involvement, often logging large amounts of data. In some variants of passive logging, like the aforementioned lifelogging with pictures, the user would go back into the log and edit it manually. In other versions of passive registration, like biometrics, there's no cause to go back and edit the data entries. Active registrations are dependent on the user, and issues like their level of motivation and adherence to the registration system, will affect registration rates and accuracy. Active registration methods can be retrospective registrations, where the users register data after the fact, or snapshots throughout a day, like in the Mood Map (Morris et al., 2010) where users were prompted for data registration three times a day. The first method, retrospective logging, is prone to issues with memory, like memory recall or confirmation biases for patients suffering from severe depression (Shelton & Kirwan, 2013). The last method, synchronous data registration of affect is therefore preferable for data accuracy. The Clutch platform uses a form of intentional synchronous logging, where the data is registered via a tangible interface and lasts for as long as the patient squeezes the stone. The data is also highly personalized, the meaning of the data is known only to the patient and his/her therapist. This is in direct opposition to data registration methods that register either biometrics or affect in a set system, like the circumplex model of affect (Posner et al., 2005). The use of the circumplex model of affect and the visual analog scales (Ahearn, 1997) are considered valuable tools and is quite common for mood assessment.

As seen earlier most studies reviewed in this thesis utilize a set of registration methods that support both passive and active types of registration, with a focus on synchronous data registration.

The review also revealed that different areas of research viewed emotion in different ways, like the *information view* in affective computing versus the *emotion through interaction* in affective interaction. By viewing affect in different ways, the methods for registering and viewing the data is different. As a crude generalization we can say that affective computing utilize passive and active registrations of biosignals to determine affective states, whereas affective interaction utilize passive and active registrations to explore and reflect on affect. The truth is probably somewhere in between, as Picard and other researchers argue (Höök, 2014) over this separation of affective computing and affective interaction.

As seen in the reviewed studies, affective computing most often passively monitors and registers emotions from a range of different biometrics; amongst others these include heart rate, galvanic skin response, picture analysis, and speech patterns (Ahtinen et al., 2013; Diederich & Song, 2014; Niforatos & Karapanos, 2014). Different types of biometrics are combined to indicate affective states. The visualization for these types of system generally seeks to explain what a patient has felt or experienced at the time of registration. Affective interaction however sees affect as something both on the inside and a means of social communication (Boehner et al., 2005). This difference in the way affect is viewed influences the way data about affect is visualized, as is discussed below. New ways of displaying data through novel interfaces are also reviewed to introduce new ideas for future research.

In most of the reviewed studies the affective state is captured on a specific one- or two-dimensional scale for both passive and active data registration. For researchers, the registration is then visualized as a graph showing the data; like the date, time of registration, and the value in either on a one-dimensional or two-dimensional setting. For the end-users, the most used way to visualize affective data is by providing a user access to their own data via a mobile application or online portal. Most of the visualizations inclined to focus on communicating the data to the patient to facilitate self-management. Only one of the applications reviewed focused on communication between a therapist and patient (Frost et al., 2013). Additionally, many of the tools that aimed to research affective states either provided no information on how they did visualize the data, or had no specific strategy for how to visualize the data. The motivations for collecting data about affective states vary from promoting self-management and reflection (Frost & Smith, 2003), promoting wellness, managing illness (Matthews & Doherty, 2011; Morris et al., 2010), and for research purposes (Wang et al., 2014).

When reviewing studies related to the Clutch platform and affective state visualizations, it quickly became apparent that most studies had one focus area, one focus group, or a limited scope in some way. By doing so the visualization is easier to create and adapt for multiple reasons. They know more about their target groups, and thus the context of use. The researchers can focus their studies into smaller areas that remain unexplored or less understood. It will also make it easier to find related research on which to base their visualizations on. The literature review seems to reveal a gap in the research that needs to be examined more closely. How do you create suitable graphical representations of affect? What choices need to be made when visualizing affective states in this way? Which representations are more suitable? A decision to go through the different visualization was made, and the results from this analysis are shown in table 1 under section 3.3.1 – Data Visualization. As previously stated, data about emotions or moods are typically represented via colors, icons/emoticons, pictures, graphs, or by other means. Colors and pictures were by far the most common in affective interaction. Animation, shapes and speed were the least used methods.

6.2 The Clutch Platform in Context

As mentioned previously, the platform is a tool that supports intentionally and synchronous registration of data about affect *while* experiencing the affective state. It provides a low-threshold method of gathering data while simultaneously functioning as a transitional object. This data is then transferred to an iPad and used as a communications tool. With regards to the reviewed literature the system is viewed as belonging to the affective interaction domain. The stakeholders do not aim to explain or describe a patient's affect and leaves the interpretation up to the users. As such, the main difference between the Clutch platform and other reviewed system can be ordered into six categories described in the following sections.

6.2.1 Context of Use

The Clutch platform's main objective is to provide a tool that supports the therapeutic dialogue. This differs from the general trend observed in the literature concerning trends in mental health informatics. Here users are provided with the data and responsibility of interpreting the data to help alleviate the workload on the health care system. Another difference is that the Clutch platform is not as specific as other systems. Specialist systems like MONARCA 2.0 (Frost et al., 2013) are unsuitable for patients not suffering from bipolar disorder. With the Clutch platform however, the patient can use the tool in any context defined in collaboration with the therapist.

6.2.2 Type of Data

The type of data is also different as the data's meaning is agreed upon by the patient and the therapist. Other systems provide advanced registration of valence and intensity with regards to specific emotions, moods, or challenges. Only a few of the systems reviewed provided a more generic registration of feeling *something* on a scale from good to bad, or high energy to low energy. In the proposed system the meaning of the registrations are meant to be determined in collaboration between patient and therapist. They can include any affect context, from drug rehabilitation to bullying, and any affect, like pain or shame. They also focus on a specific issue, as opposed to monitoring multiple issues at ones. This distinct focus might be beneficial in a therapeutic context, where users need to work through single issues at a time.

6.2.3 Time of Registration

Time of registration is a key difference from the reviewed systems and the Clutch platform. As previously discussed, active methods for synchronous data registration in other systems provide a prompting at random or set times during the day, and users log a snapshot of their current affect. The advantage is that this can provide information about current context that provokes different emotional responses. The disadvantages to this are that the affect a patient is trying to monitor may not be what the user is experiencing in the moment registration occurs, and that no prompts for registration occur during the night. The Clutch platform lets a user register as much data as they need at *any time* whilst experiencing the affect. The data collected is also more focused an issue individual for the patient. Retroactively adding data to the stone makes little sense.

6.2.4 Threshold for Use

The low threshold for registering data is something unique to tangible interaction systems. Most reviewed systems used a mobile or web interface for registering and displaying the data. This creates a higher threshold for some potential users, with regards to cost and usage. User may not afford or know how to handle a mobile phone or computer. It's arguably more onerous to register data in a mobile or web interface than squeezing an object.

6.2.5 Frequency of Use

Because the time of registration and threshold for registering is different, this will likely affect the frequency of registrations and might generate more data on a single issue. The stone can be used whenever the patient feels the need to do so, in opposition to other systems that prompt for three or more snapshots.

6.2.6 Privacy Issues

Lastly, with regards to privacy, the stone is considered to protect a patient's privacy better than other reviewed systems. Most systems are applications kept on mobile phones and the data is accessed through the application. If the phone is lost, the data can be used to identify the patient and his/hers challenges. The stone stores timestamps and intensity, the application is needed to display the data. If the system in the future is developed to be used as other applications, this would lessen this claim, and additional work should be put into protecting patients' privacy.

6.3 The Clutch Visualizations

The literature review of visualizing affect and the previous explanation of the differences of the Clutch platform versus other system brings us to the second research question:

> ***RQ2: How can the data stored in the Clutch stone be visualized to support dialogue between patient and therapist?***

To answer this question a research-oriented design approach was applied and the result is the visualization for showing affect within a therapeutic setting, as seen in the section 5.4.2 – The High-Fidelity Prototype. A general overview of the system and the design justifications are described below.

6.3.1 A General Overview

This section provides a brief repetition of the data visualizations. The main objectives of the data visualizations are repeated here (directly underneath are the design solutions):

- To provide the therapist and the patient with a quick overview of the patient's affect over a period of time
    - This resulted in the Month version displayed as a calendar for a monthly overview
    - This resulted in the Day version for a daily overview
- To provide the therapist and the patient with information about the patient's development
    - This resulted in the Month view, the Bars compare, and the Dots compare

The data visualizations are examples of graphically presenting affective state data in a therapeutic setting. The visualizations is meant to be able to function for any valence, as well as any user group. It's based on an analysis of other similar systems, focusing on presenting the data by means of colors and different graphs. The system has two main views, Month view and Day view, with different use cases. The Month view shows an entire month in a calendar format and is meant to be used as an overview. Colors were used to indicate periods of high, medium or low activation. This overview can also help communicate patterns of behavior, e.g. see if a pattern changes as a result of therapy or medication use. The Day view shows the events for a specific day, if the patient wishes to discuss a single event that occurred, a visualization of the event will be provided. The Dots and Bars compare can also function as pattern communicators, using time periods that are as close or as far apart as the patient or therapist wants. By providing different representations of the data, it's more likely to find a way to increase communication between patient and therapist. In the next section I discuss the justifications for the designs.

6.3.2 Design Justifications

When creating data visualizations for affect, it's important to know how the system views affect. If affect is viewed as measurable units with a *correct* interpretation this will largely influence the way the visualization can be presented. The prototype presented in this thesis views affect as described in affective interaction, emotions are seen as constructs of the interaction with a social and cultural communicative element. This view influence the way affect should be presented. The proposed visualizations provides different representations of data about affect, the system does not seek to formalize or explain the experiences, only display them to the patient and therapist for exploration and reflection.

To create a visualization for a tool within the affective interactive domain, the four guidelines from Boehner et al. (2005, pp. 65–66) were used as a guide. They are repeated below for convenience.

1. The design should recognize affect as a product of social and cultural interactions – emotions are understood in context with both internal and external processes
2. The design should depend on and support flexible interpretation – meaning should stem from the user, not the designer
3. The design should support an expanded range of communications – coding specific emotional displays to a set system (like color, emoticons, labels) is viewed as a hindrance for communicating emotions
4. The design should focus on people using systems to experience and understand emotion – users express themselves through the system, becoming more aware of their emotions through this expression

The Clutch platform's design, the stone and the visualization, already follows the first guideline. One could argue that it is inherent in the stones design as a receiver of affect. This translates to the main objectives of the visualization – to see how the patient has felt, and to explore their development. The visualization seeks to keep the interpretation of the patient's data up to the therapist and patient in two ways (guideline 2). Firstly, by keeping the interface clear of indicators of which types of affect the system registers (guideline 3), and secondly, by providing the users with different types of visualizations to see the same data in different ways: Day, Month, Bars and Dots (guideline 4). The removal of specific systems (excluding the colors to represent intensity and icons to represent time of day) and not including emoticons create a less defined visualization. It was also decided that the system should provide different visualizations so that the users can use the one that makes sense to each of them for reflecting upon the patient's data.

6.3.2.1 The Month View

The Month view was decided to be a calendar as this is considered a well-known view. In line with Bryggen Research's guidelines, only numbers and/or text seen as vital for understanding and navigating the view were added to the prototype. This includes the weekday labels, dates numbering, and so on. Removing any of these elements would decrease both interpretation of the view and navigation. Language and cultural context may decrease the readability of the view – the language in the prototype is Norwegian and the text direction is based on left-to-right, top-to-bottom conventions. The set up for the Month screen is seven columns, each representing a weekday, and five rows, each representing a week. This was done to provide consistency when reading the data. Patterns occurring on a weekend would always be in the same place, on the right half of the screen. It was decided early on that days which had no data should not be removed, as no data registration can be seen as data in itself. An empty day can mean a really good day, or it could mean the user forgot the stone. A limitation to the Month view is the empty days in the last week, but it was deemed acceptable at the time as it would reduce scrolling. In future iterations this would quite likely change as none of the participants in the usability test gave any indication that scrolling in the Day view or other parts of the system was cumbersome.

Icons and colors were used to indicate time of day and intensity. The decision to separate the day into four parts was to provide the patient with a different view of a day than many other systems. I argue that representing an entire day as "one emotion" based on very few registrations can create a false sense of pattern. A study into people suffering from severe depression indicate that they have difficulty seeing smaller patterns of emotion and collect them all into their most used pattern, which usually is a negative one (Shelton & Kirwan, 2013). When dividing the day into four, as opposed to one whole day, the possibility of showing both the good and the bad times of a day increases. Using the RAG-system (red, amber, green) was decided after the evaluation with the psychologist. Different color-versions should be implemented for users suffering from color deficiencies to increase legibility. In the four bars that indicate the time of day, height and color illustrate intensity, but separating these two parameters to illustrate different interpretations is possible. For instance, height could indicate duration and color the intensity of the squeezes.

The Month view is considered to fulfill the objective of functioning as a quick overview of affect over time. All participants in the user testing were able to ascertain the best and worst days of the month.

6.3.2.2 The Day View

The Day view was chosen to be displayed as a time-line graph with small bars to indicate events. Time would be represented on the horizontal axis and the intensity of the squeeze on the vertical axis. This was considered a familiar format or easy to read as it's a common representation of time. Either way, the format can be interpreted by the therapist if the user is not able to read or interpret the representations.

The Day view is divided into four sections corresponding to the icons from the Month overview. Each day is separated over two screens, each screen displays twelve hours. Each twelve hour-period divided into two parts, as seen earlier in figure 24. The top part displays the hours between midnight and six o' clock. The hours are marked on the horizontal axis, however to reduce chartjunk as recommended by Tufte (2001), only every other hour is marked. Feedback from user testing indicate that most users wanted all hours marked. The Day view also has colored background to indicate time of day along with the larger corresponding icon. This colored background would help illustrate to the users which time period they were viewing without reading the hours. The first twelve hour period would have dark to light background, whereas the last twelve hours would have light to dark background. The addition of pictures or colors to a background to convey more meaning is a topic for discussion (Stephen M. Kosslyn, 1989), but feedback from the user testing was positive.

The Day view disregarded the general requirement of orientation from Bryggen Research, as the prototype has a right way up with regards to reading the different elements. This breach is intentional as evaluation with a psychologist revealed it to be less significant than initially assumed. Another breach of data visualization custom is the low visibility of the underlying data. For the events in the Day view it was decided to focus on events with regards to intensity and, to a lesser degree, duration. Precisely showing *when* something had happened was not regarded as important – in general, time is difficult to remember exactly, so an approximate indication was suggested. The prototype therefore shows *manipulated* data, where events may appear longer or at other times than they actually are. This was not commented upon during user testing, which could indicate that users are more concerned about the intensity or clusters of events, rather than specific data. This is an issue with regards to granularity and keeping the interface clean of unnecessary numbers, and it needs to be tested when real data has been gathered.

The Day view is considered to fulfill the objective of functioning as a quick overview of affect over a period of one day. Most users understood the visualization and were able to interpret the events; however some users needed an explanation of one or more of the elements suggesting a future redesign with emphasis on creating a more intuitive interface. Another possibility is to provide an onboarding for new users where they are presented with the different elements and an explanation on the interface.

6.3.2.3 The Compare Views

By allowing user multiple views of their data, it was considered that they would find a version that suited them best. To compare data from two or more data sets, it was decided that two different versions would be prototyped.

The Bars compare displays data from two separate months for comparison. The days are placed on a horizontal axis and the overall intensity is displayed on the vertical axis. The height of the bar represents all the data for the selected day. The Bars compare does not display any numbers for the y-axis as it was impossible to know without any real data. It was therefore decided that the y-axis should be divided into a green, yellow and red zone. A white divider line was implemented over the data to help illustrate where the day went over into the next zone. The prototype did not provide colored labels to indicate the zones, which is an apparent limitation on the design as the users would not be able to find information about what this divide means.

The bar graph in the Bars compare was selected for its presumed readability, Kosslyn (2006) recommends using bar graphs when comparing specific measurements. However, the Bars compare did not function as anticipated in the user testing. None of the participants in the user testing could tell which month was the best or worst. Another caveat was the color choice, which all users were dissatisfied with for a number of reasons (choice of colors, color disparity, etc.). When comparing smaller sections it proved easier to read, indicating that the colors or their disparity may not be the key issue. Different visualization or moderations on the Bars compare should be examined.

The Dots compare displays data from two or more months by three colored dots. This use case is similar to the Bars version, but the data is not as specific as the Bars compare. The colors are red, yellow and green corresponding to other parts of the system. The sizes of the dots are a representation of all the yellow, green, or red events in a month. The Dots compare used area as this is also considered suitable for showing qualitative data (Cleveland & McGill, 1984). During user testing this system was deemed easier for comparing months, but there were some issues regarding dots of similar sizes. Participants wanted some way of measuring the dots area.

Based on the feedback from the user testing the Dots compare was the best at providing information about a patient’s development. In the Bars compare participants were unable to tell which month was the best or worst. Both the Bars and Dots compare need a redesign. One possibility is adding filters to show data within a specific timeframe, e.g. showing only week 42, or display specific events, e.g. show only the red events. Allowing users to adapt the system more to their needs would likely be beneficial for appropriation. Creating another system that confides the users to a set system of visualizing affect is not consistent with the idea of affective interaction.

6.4 Limitations

The following are limitations on the research and design of the proposed system and the thesis. As the system was in an ideation phase and meant to provide new insight rather than a solution, the limitations were deemed acceptable at the time of development.

6.4.1 The Clutch Platform

There are some inherent limitations to the Clutch platform that will influence the data visualizations. These are as follows:

- Malingering: There is no way to hinder the user from manipulating the data. A user could misrepresent their emotional responses for a number of reasons. The system cannot differentiate between *real* and *fake* data.
- Misuse: If the patients registers data not related to the otherwise registered affect, the data is less valid.
- Misinterpretation of purpose: If the therapist and the patient have separate ideas for what the system is being used for, the data interpretation will be less reliable.

6.4.2 Empirical Limitations

At the time of writing the Clutch platform was not in operation and we had a limited number of options as to how we would solve the issue of data generation. Ideally, we wanted users to carry a stone around for some days, collecting data in a natural setting before interpreting the data. This was not possible as we only had one pilot stone and it was neither wireless nor stable. The second option was to let a user squeeze the pilot stone and then randomly generate more data from those data or collect data from external sources. This was also rejected as the data would be random and would not carry any meaning for the user. A middle way was to present the data to the user as the moderator's data in an attempt to lessen the confusion. By presenting them with data they are not expected to recognize, the user would hopefully feel less of an obligation of interpreting them *correctly* or experience an increase in test anxiety.

6.4.3 Programming the Timeline Visualization

Programming the interactive timeline visualization prototype took longer than expected and a user testing of the application was not feasible with the given time constraints. This resulted in one round of user testing of a single system, instead of a comparison of two separate systems, as originally intended.

6.4.4 The High-Fidelity Prototype

The prototype has some issues that need to be sorted out. Feedback from the user testing rounds indicates that the design would benefit from a redesign. Different types of visualizations or variations on the suggested version should be examined. With regards to granularity, as mentioned previously, real user data will help solve the issue of how specific an event should be represented.

6.4.5 User Testing

With regards to user testing a number of factors may have influenced the work in this thesis. The moderator was unexperienced and may have unintentionally biased the participants in either direction. Sampling was also an issue in this study. The user testing included individuals of quite similar characteristics – 4 out of 5 participants were females and/or in their twenties, all participants were familiar with iPads or similar products. Furthermore, the participants were all known to the moderator, creating a possible bias issue where users don't wish to appear negative or insult the moderator. To lessen this bias the participants were asked to answer the SUS survey anonymously to ensure that the participants' opinions were recorded. A wider range of samples with regards to gender, age and "device knowledge" would be preferable for a larger study into the visualization of this type of information. Lastly, the assignments in the user testing intended to test the visualizations, but as the data in the prototypes is conjectures this should be tested with real users and real data to provide more accurate results.

6.4.6 SUS Survey

The SUS survey only included five respondents which makes any statistical analysis unreliable. However, statistical analysis was not the main objective; it was meant to serve as a general indication on the system's success. Lastly, since the survey was anonymous it's not possible to track the data back to a specific user and cross-check with the video feed from the user testing to gather more data from there or further interview the user. Breaching the anonymity was not considered an option as some of the feedback might prove uncomfortable for the participants to explain.

6.5 Chapter Summary

This chapter discussed how visualizations are being used to represent affect. The literature review shows that affect is viewed in different ways which influence the way collected data is presented. This chapter also provided a discussion on how the Clutch platform differed with regards to context of use, type of data, time of registration, threshold for use, frequency of use, and privacy issues. Lastly, the high-fidelity prototype was presented with justifications on the design decisions made. The next chapter describes possible future directions and concludes this thesis.

7 Future Works and Conclusion

This section will suggest future directions of research for the system and provide a conclusion for this thesis.

7.1 Future Work

The Clutch platform is still under development and its potential uses seem endless. The Clutch platform obviously needs to undergo extensive testing with different user groups to research both potential beneficial and harmful effects. The data visualizations needs to be researched and evaluated further, particularly the interactive timeline version. In the future development and research into this system, here are some areas that I would like to see researched or developed.

7.1.1 Moving Beyond the Screen

In my opinion it would be interesting to expand the visualization possibilities for the stone beyond the iPad screen. Three areas that captured my attention during the literature search are the visualization of data via auditory signals, haptics or physical visualizations. It would be interesting to see how displaying the data in different ways, like texture, heat, pressure or vibrations, might affect the way the data is perceived and experienced.

7.1.2 Self-Regulation and Materiality

Furthermore, I found no research that described how such a platform might affect a user's ability to self-regulate their affective states with regards to materiality. Does the stone function as a transitional object or just a data registration device? Does a specific materials feel provide more or less calming effect? Are some materials more suitable than others? This could be an interesting area of research.

7.1.3 Targeted User Interface

In my opinion, the system could also benefit from an interface that is targeted at children or people suffering from cognitive impairments. It does not exist in a vacuum; the therapist can assist the patient in reading the data. However, I believe that it would support autonomy and a feeling of mastery if the patient could interpret the data themselves.

7.2 Conclusion

The objective of this thesis is twofold: it intends to begin answering how visualizations are used to represent affect, and propose data visualizations to be used in a therapeutic tool. The literature review uncovered that the visualization of affect in a therapeutic setting is a largely unexplored area. Furthermore, the way affect is viewed influences the way systems are designed with regards to data collecting and data registration. The area of affective interaction views affect as a product of emotions, moods, behaviors and cognition, which in turn is influenced by social and cultural interactions. Guidelines for designing systems within the affective interaction domain argue that the design should be support flexible interpretation and expression of affect, and support a range of communications. The review concludes that some elements are used more frequently when designing such systems, namely colors and pictures.

The Clutch platform is defined as an affective interaction system that allows registration of any affect as defined by the patient and the therapist. The platform expands the method of active data registration in two ways: firstly, it offers a lower threshold for data registration than many other reviewed systems, and secondly, it captures varying degrees of intensity over a duration determined by the patient.

To design visualizations that allow for all types of affect a wide range of prototypes were developed. The prototypes were a result of different types of evaluations with stakeholders and other users, proto-personas, guidelines from Bryggen Research and Boehner et al. (2005), and a design-oriented approach. This finally resulted in high-fidelity prototypes that underwent usability testing. The tests explored user responses on the graphical presentations. The overall feedback and score of the system was good, suggesting that this tool is worth exploring further, however feedback indicate that the system would benefit from a redesign. Examining other types of visualizations or modifications on the ones presented in this thesis should also be a priority. Lastly, the visualizations are only as good as the data, and testing the entire platform with real users and real data is a required.

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Appendix A – Tools Overview

Trello – (Trello, 2015) is a free, online tool for project management. It allows sorting cards into different categories like “To Do”, “In Progress”, “Finished” and “Maybe Baby”. It was used to keep track of the backlog.

FaceYourManga – (FaceYourManga, 2015) is an online tool for creating manga avatars. This tool was used to create a picture for the proto-personas.

SurveyMonkey – (SurveyMonkey, 2015) is an online tool for creating surveys. This tool was used to create the anonymous SUS survey for the users.

Paletton – (Paletton, 2002) was used to select the color scheme for the high-fidelity prototype. Paletton was chosen as it provides a view of the color schemes selected with the various color deficiencies. The colors selected as primary and secondary are shown below with the link to the color scheme. http://paletton.com/#uid=33U0u0kllllaFw0g0qFqFg0w0aF

Figure 27 – The Paletto Color Scheme – The marked colors are used in the Bars Compare view

Sketch 3 – (Bohemian Coding, n.d.) is a vector drawing application. Sketch 3 was used to create the high-fidelity sketches for the final iteration.

Axure RP 7 – (Axure, 2015) is a tool for creating interactive prototypes. Axure was used to create interactivity on the high-fidelity sketches created in Sketch 3. I’ve had some previous experience with Axure, and the tool is easy to use, but hard to master. For instance, I was not able to produce a proper slide function using dynamic panels in the prototype. I was forced to add an extra button in the interface called “This is a slide function,” to let the user “slide navigate” to the next screen.

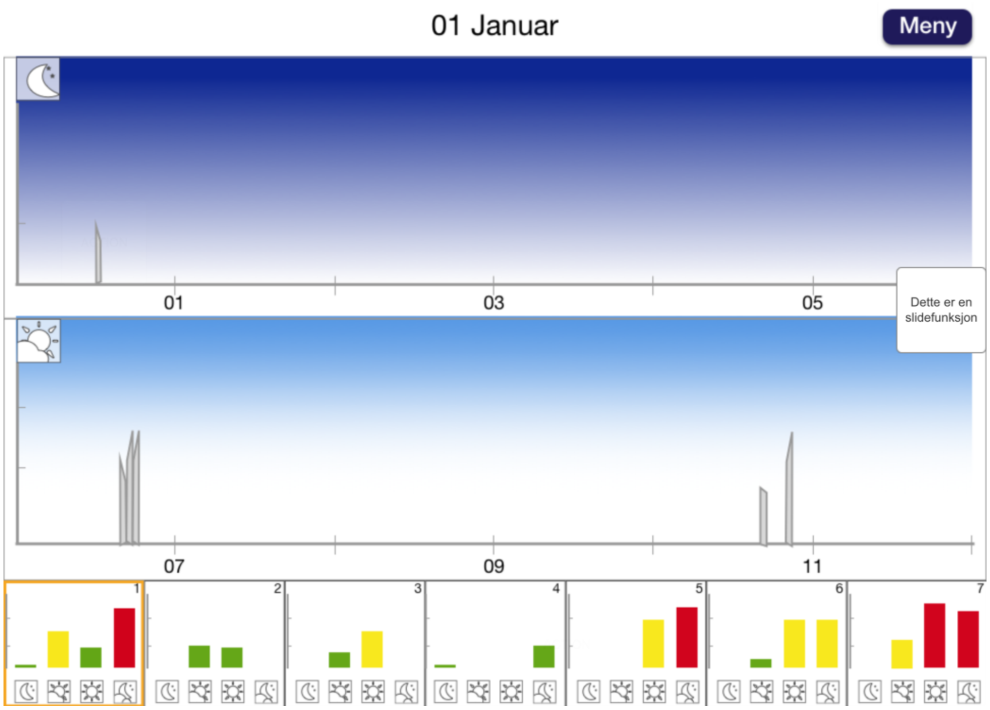

Figure 28 –"This is a slide function" button

ProtoSee – (ProtoSee, 2015) is an iOS app that runs Axure prototypes. ProtoSee was used in the user testing, as the Axure prototype behaved erratically in the browsers on the iPad mini.

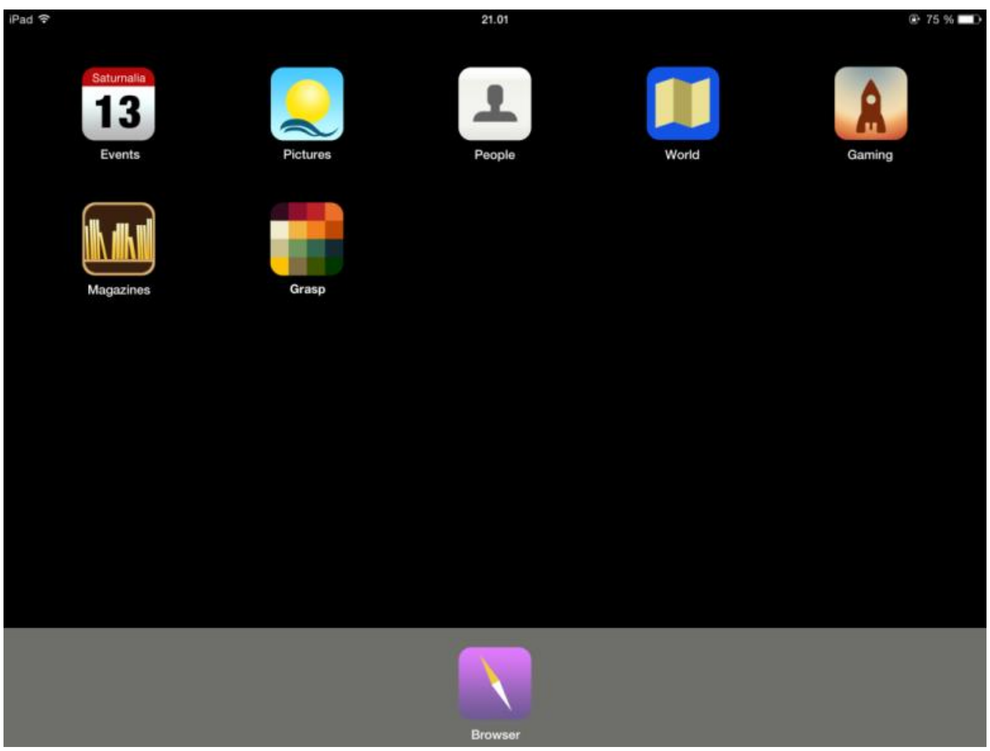

Figure 29 – The ProtoSee main screen. The app called Clutch starts the prototype.

Appendix B – User Testing Guide and Assignments

Oppsett av rommet

- Sjekke at rommet er klargjort og luftet
- Sjekke at kamera har batteri
- Be deltaker lese og signere samtykkeskjema
- Forklare steinen og bruken

Samtykkeskjema

Bruker får utlevert et samtykkeskjema som skal leses nøye og signeres. Bruker får også muntlig beskjed om at de kan trekke seg uten grunn når som helst og at all data da vil slettes, samt at de vil få tydelig beskjed når jeg slår på kameraet.

Forklare steinen og bruken

«Dette er Hjelpesteinen. Den leveres ut til en pasient som er under oppfølging hos en terapeut. Terapeut og pasient avklarer at når de føler eksempelvis angst, skal de presse på steinen. Hvor hardt de presser indikerer nivå av angst. Tiden de presser indikerer lengden på anfallet. Disse dataene, tid og press, lagres og neste gang pasienten er hos terapeuten overføres de til en app. *(Fikk du med deg dette?)*

Et av formålene med steinen er å hjelpe terapeut og pasient å kommunisere om følelser, en annen er å vise følelsene - hvor de oppstår og når som kan skape ny innsikt.

Dataene lagret viser hvordan pasienten *selv* føler at de har hatt det. Dette er noe pasienten selv styrer, ikke noe steinen avgjør. Disse dataene kan da vise om man har fremgang eller tilbakefall, eller om det er perioder eller miljøer som er mer utfordrende enn andre.

Min oppgave i dette er å lage visuelle fremstillinger av disse dataene slik at pasient og terapeut kan se hvordan pasienten har hatt det siden forrige time. Her har jeg fått noen føringer fra teamet bak Hjelpesteinen. Jeg ønsker å se hvor lett det er å lese disse eksemplene og se etter designfeil. Her trenger jeg din hjelp. (Er du klar til å begynne?)

Introduksjon

«Takk for at du stiller opp!
Jeg kommer til å lese opp fra et manus, dette er slik at jeg ikke glemmer noe og slik at alle får samme informasjon. Jeg jobber i samarbeid med Bryggen Research og vi vil gjerne ha din mening om appen vi holder på å utvikle. Hvis du mener at noe er vanskelig eller dårlig vil vi gjerne ordne det før det lanseres!
Det er også viktig at du vet at vi tester systemet, ikke deg!

Dette skal vi gjøre i dag:

Før vi starter skal vi skal øve oss på å tenke høyt sammen og deretter skal jeg slå på kameraet når vi begynner testen på ordentlig.
Under testen får du noen oppgaver som du skal gjøre i appen. Jeg vil at du skal fortelle meg om hva som fungerer og ikke fungerer i bildet.
Etter testen får du tilsendt en lenke til et spørreskjema som vi ønsker at du svarer på. Dette er helt anonymt.
Det hele vil ta cirka 30 minutter.»

Tenk-høyt
Jeg viser hvordan man tenker høyt ved å vise en tenk-høyt øvelse. Bruker øver seg deretter ved å legge inn et nummer i deres egen mobil og øver seg på å tenke høyt rundt dette.
«Har du noen spørsmål før vi begynner? Da starter jeg opptaket.»
** Jeg slår på kamera **

Testen starter
Noterer ned alder og kjønn.
Hvor godt kjenner du til iPad eller smartbrett?

Oppgave 1: Synkroniser steinen
«Jeg har brukt steinen i en måned og vil gå gjennom mine data med deg. Jeg vil at du skal hente ut dataene fra steinen min.»
** Bruker utfører oppgaven **
«Fortell meg hva du ser i dette bildet.»
«Er det noen av disse elementene du ikke forstår?»

Oppgave 2: Finn informasjon om ikonene
** Jeg påpeker ikonene dersom de ikke har nevnt de **
«Jeg vil at du skal finne mer informasjon om ikonene.»

Oppgave 3: Tolkning av dagsvisning
«Jeg vil at du skal gå til første mandagen i januar og fortelle meg hva du ser her.»
** Bruker utfører oppgaven **
«Gå til andre halvdel av 1.januar.»

Oppgave 4: Lag notat
«Som du ser var jeg våken rundt halv ett om natten. Legg inn et notat for meg på dette tidspunktet.»
** Bruker utfører oppgaven **

Oppgave 5: Sammenligne januar og februar
«Nå har jeg brukt systemet noen måneder og vil at du skal sammenligne de to første månedene mine. Sammenlign januar og februar for meg.»
** Bruker utfører oppgaven **

«Fortell meg hva du ser her.»
** Bruker utfører oppgaven **

Oppgave 6: Sammenligne 6 måneder
«Nå har jeg brukt systemet et år. Jeg vil at du skal sammenligne de første 6 månedene mine.»
** Bruker utfører oppgaven **
«Fortell meg hva du ser her.»

Oppfølging:
«Har du noen kommentarer til prototypen eller noen av elementene?»
«Da slår jeg av kameraet.»

Appendix C – Consent Form

Forespørsel om deltakelse i forskningsprosjektet: «Datavisualisering for å fremme kommunikasjon mellom pasient og terapeut»

Bakgrunn og formål

Formålet er å lage en prototype av en datavisualisering som skal brukes i terapi av ulike pasientgrupper. Jeg undersøker hvordan data som lagres i Hjelpesteinen kan brukes for å visualisere pasientens indre følelsesliv på en enkelt lesbar måte. Denne visualiseringen er ment å fremme kommunikasjon om vanskelige emner, samt å vise fremgang eller tilbakegang i behandlingen.

Dette er en masterstudie ved Universitetet i Bergen.

Utvalget i denne studien er kvinner og menn over 18 år, med varierende utdanningsnivå.

Hva innebærer deltakelse i studien?

For å delta i denne studien må deltaker se på en prototype av en app og gjøre noen oppgaver knyttet til denne. Oppgavene vil blant annet omhandle hvordan deltaker tolker de ulike visualiseringene, hvilke de foretrekker og om de har noen kommentarer til designet.

Selve observasjonen vil ta cirka 20-30 min og video blir tatt opp. Filmen er nødvendig for transkribering og registrering av kroppsspråk, den vil ikke vises til andre enn studenten som gjorde opptaket eller gjenbrukes på noen måte.

All deltakelse vil anonymiseres, kun alder og utdanningsnivå vil være tilgjengelig i oppgaven.

Hva skjer med informasjonen om deg?

Alle personopplysninger vil bli behandlet konfidensielt. Kun studenten vil ha full tilgang til dine data. Du vil ikke kunne gjenkjennes i en publikasjon.

All informasjon vil bli lagret på en kryptert minnepenn.

Prosjektet skal etter planen avsluttes 1.juni 2015. Etter at karakter er satt for oppgaven vil all data innsamlet i denne studien bli slettet, unntaket er det som skriftlig blir presentert i masteroppgaven.

Frivillig deltakelse

Det er frivillig å delta i studien, og du kan når som helst trekke ditt samtykke uten å oppgi noen grunn. Dersom du trekker deg, vil alle opplysninger om deg bli anonymisert.

Dersom du ønsker å delta eller har spørsmål til studien, ta kontakt med:

Erle Krøger på e-post erlekroeger@gmail.com eller 45 15 02 20 (student)
Frode Guribye på e-post frode.guribye@infomedia.uib.no eller på telefon 55 58 41 84 (veileder).

Studien er meldt til Personvernombudet for forskning, Norsk samfunnsvitenskapelig datatjeneste AS.

Samtykke til deltakelse i studien

Jeg har mottatt informasjon om studien, og er villig til å delta

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(Signert av prosjektdeltaker, dato)

Appendix D – System Usability Scale

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Appendix E – Proto-Personas and Scenarios

Figure 30 – The Martine Persona

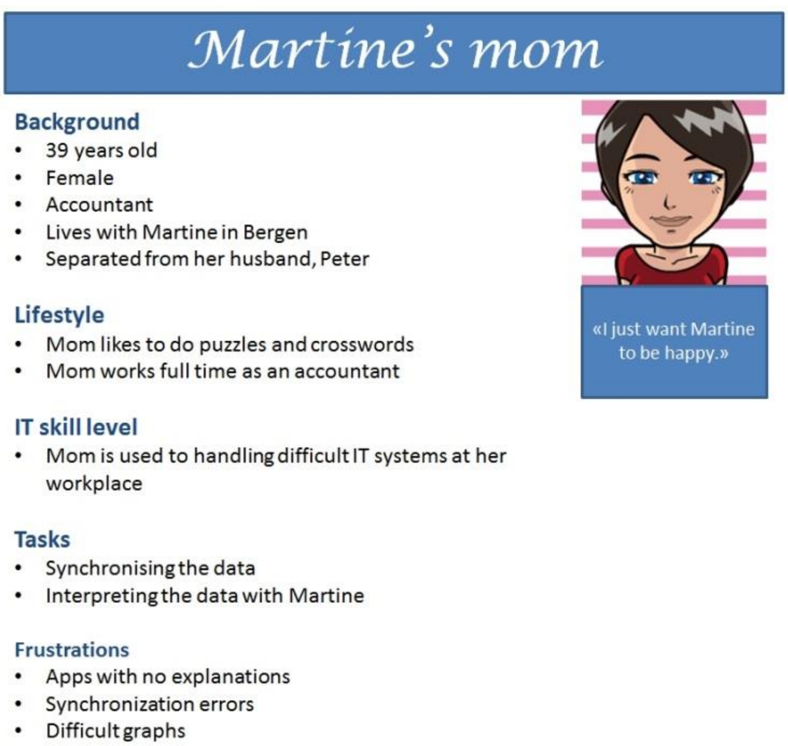

Figure 31 – Martine's Mom Persona

Martine and Mom's Scenario

Martine lives with her mom in Bergen. Three months ago mom and dad separated and Martine is having some issues dealing the separation. Recently Martine has been complaining of stomach aches and nausea, being sent home from school far more than usual. Mom takes Martine to the family GP, and is told that Martine is quite likely suffering from a mild form of anxiety. The family GP offers Martine and mom a small stone that Martine can carry with her. She's told to squeeze the stone when she's feeling sick. Mom is given a leaflet that illustrates how she synchronizes the data to an iPad, along with some tips on how to interpret them.

The first couple of day's mom synchronizes the data every day. After dinner they sit in the sofa with the iPad in mom's lap and point to certain parts of the day. Mom translates the time of day to Martine as "when you were at school" or "yesterday, just after supper". Martine mostly discusses what she can remember from that time, not focusing too much on the screen. After a while, mom does not need the data to have a talk with her daughter.

Figure 32 – Martine and Mom's Scenario

Ramtin

«I'm NOT a child!»

Background
- 15 years old
- Male
- Pupil
- Lives with his family in Sotra

Lifestyle
- Ramtin enjoys driving his motorcycle
- He spends most evenings in the garage fixing engines with his older brother

IT skill level
- Low. He has no interest in computers or technical stuff.

Tasks
- Squeeze the stone
- Keeping a journal
- Talking to his psychologist

Frustrations
- People treating him like a child, telling him what to do
- Not fitting in

Figure 33 – The Ramtin persona

Helle

«Everyone needs to be heard! It's a basic human need.»

Background
- 42 years old
- Female
- Psychologist
- Lives with her siamese cat, Prometheus

Lifestyle
- Helle enjoys reading books with a glass of red wine
- Helle is the head of a bridge club in Bergen

IT skill level
- Medium. She has experience from lots of different IT systems from work.

Tasks
- Synchronizing the stone
- Interpreting the data
- Communicating with the patient

Frustrations
- None!
- Well, maybe cat hairs in the wine glass

Figure 34 – The Helle persona

Ramtin and Helle's Scenario

Ramtin moved to Sotra six months ago from Syria, and is having some adjustment issues. He's already changed schools once due to aggressive behavior and Children's Services are following up on him and his family. Ramtin is not pleased to be treated like a child in Norway, when he was close to an adult man at home. His new psychologist, Helle, thinks he can benefit from having something to channel his anger into and proposes that he use the stone. This way "you can tell me when you're angry." Ramtin reluctantly agrees.

Two months later, Ramtin has shown some progress in adjusting his behavior. For the first couple of weeks, he had to be reminded to bring the Stone with him. But as time passed Ramtin saw one use of the stone, he could freely channel his aggression into it. He refuses to do the "diary" part as Helle suggested, as he thinks it's «too girly» for him. When Ramtin has sessions with Helle, she synchronizes the data from last week and briefly scans the data for clusters and peaks. She then places the iPad down on the table between them and let him choose what to talk about.

Figure 35 – Ramtin and Helle's Scenario

Appendix F – Expert Evaluation with a Psychologist

Hva vi skal i dag:

Brukertest: vi skal se på to forslag til visualisering - dag og måned. En versjon til, men den må testes i app.

Intervju: vi trenger hjelp

Vi tester visualiseringen, IKKE deg! Det finnes ingen feile svar!

Ekspertgjennomgang:

Dagsoversikt: Dagview + en tidslinje-stripe

- "Hvordan tolker du dette bildet?"
- "Hvordan tolker du disse dataene?"
- "Hvordan tolker du ulike elementene?"
- "Mtp å bruke dette i terapisammenheng, er det noe som er overflødig?"
- "Mtp å bruke dette i terapisammenheng, er det noe som mangler?"

***Månedsoversikt*:** Månedsoversikt + en fargekodelinje

- Vis rad 1: "Her er prikker, 4 farger, samme størrelse. Hvordan tolker du dette?
- Vis rad 1 og 2: "Nå har prikkene blitt satt i et system. Hvordan tolker du dette?"
- Snu og vis fargeskalaen.
- Rad 3 og 4: "Her er to versjoner - strukturer og ustrukturert, i tillegg er prikkene i tre ulike størrelser - liten, middels og stor. Hva tolker du av disse dataene?"
- "I en terapisetting, kan det være aktuelt å skifte mellom eksempelvis den strukturerte og ustrukturert versjonen?» Like prikker eller ulike prikker?
- "Mtp å bruke dette i terapisammenheng, er det noe som er overflødig?"
- "Mtp å bruke dette i terapisammenheng, er det noe som mangler?"

Intervju: (Obs: Ha tegninger og penner tilgjengelig!)

- I en terapisetting, hvordan sitter du med dine pasienter?
- Hvordan foregår en terapisetting for deg og dine pasienter?
- Som terapeut, hvilke data er nyttige for deg og din pasient?
- Hvem er hovedbrukeren og hvem skal benytte seg mest av disse dataene?
- Hvis du skulle brukt dette systemet. Hvordan ville du brukt det?
- Som terapeut, kan du se noen utfordringer med løsningen vi har valgt? Noe som mangler?
- Har du noe du vil tilføye?

Tusen takk for at du kom!

Appendix G – Expert User Consent Form

Forespørsel om deltakelse i forskningsprosjektet: «Datavisualisering for å fremme kommunikasjon mellom pasient og terapeut»

Om studien:

Denne studien er en del av en masteroppgave i informasjonsvitenskap ved det samfunnsvitenskapelige fakultet. Masteroppgaven skal etter planen leveres 01.06.2015. Alt datagrunnlag for masteroppgaven vil slettes etter at oppgaven er godkjent. Dersom du har spørsmål ved studien kan du kontakte:

- Erle Krøger (student) på e-post erlekroeger@gmail.com eller mobil 45 15 02 20
- Frode Guribye (veileder) på e-post frode.guribye@infomedia.uib.no.

Formålet med studien:

Formålet med denne studien er å se hvordan mennesker tolker den foreslåtte datavisualiseringen og applikasjonen. Din deltakelse i denne studien vil hjelpe Bryggen Research og undertegnede å lage en applikasjon som er enkel å lære og bruke. Du evaluerer systemet: vi evaluerer på ingen måte deg eller din ytelse. Dersom det er problemer ligger dette i systemet, ikke hos deg.

Dine rettigheter som deltaker:

Din deltakelse er helt **frivillig**!

- Du kan trekke deg fra studien når som helst og data om deg vil da slettes.
- Du kan ta en pause når du trenger det.
- Du kan stille spørsmål når du føler behov for det.
- Alle dine svar vil være konfidensielt.

Informasjon vi samler inn:

Vi vil spørre deg hvordan du oppfatter systemet og notere ned dine observasjoner, etterpå vil gjennomføre et kort intervju. Evalueringen vil bli tatt opp på video (med din tillatelse) og notater kan også tas utenom dette. All informasjon fra denne evalueringen vil bli brukt, sammen med lignende evalueringer, for å forbedre systemet. All informasjon som omhandler deg, som navn eller kommentarer, vil være fortrolig.

Tillatelse til å filme:

For å hjelpe oss i analysearbeidet ønsker vi din tillatelse til å filme evalueringen. Dette er hovedsakelig så fasilitator kan konsentrere på å samtale med deg fremfor å ta notater. Filmen kan også bli sett av Bryggen Researchs designteam i etterkant for å se hvordan du som bruker tolker systemet. Den vil ikke bli sett av noen andre og vil slettes etter at arbeidet med masteroppgaven er godkjent.

Ditt samtykke:

For å delta i denne studien må du signere på følgende skjema. Dette er ditt samtykke til at vi kan samle inn data og bruke de som beskrevet over.

Ditt navn: Dato:

Signatur:

Appendix H – The High-Fidelity Prototype

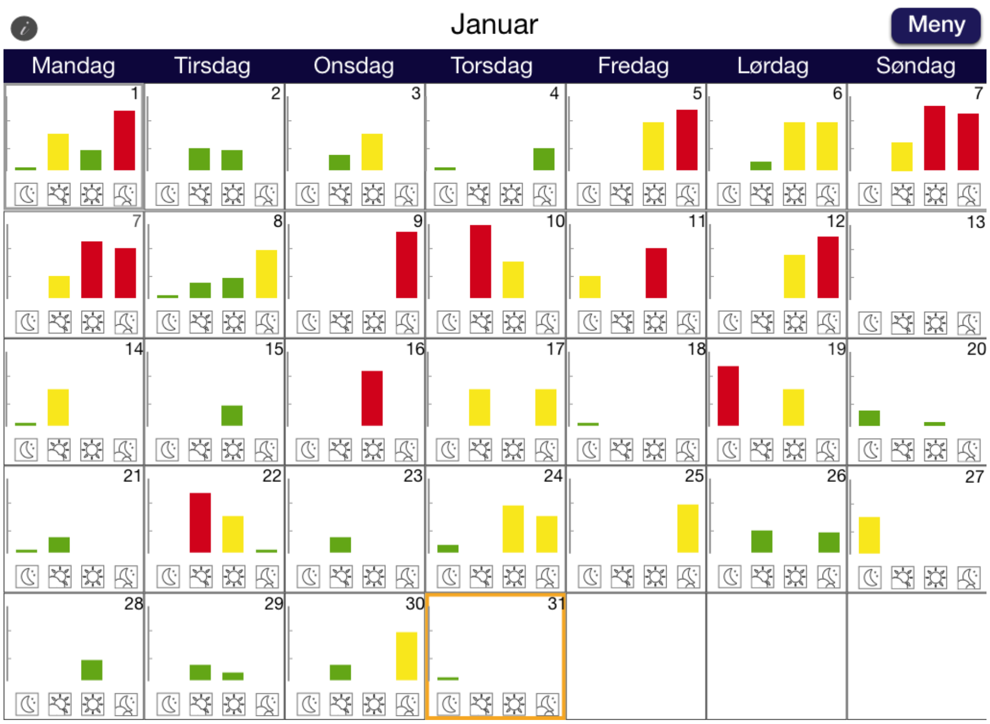

Figure 36 – The Month view