Effective and efficient business intelligence dashboard design
Gestalt theory in Dutch long-term and chronic healthcare

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ABSTRACT

This research focuses on the design process of an effective and efficient dashboard which displays management information for an Electronic Health Record (EHR) in Dutch long-term and chronic healthcare. It presents the actual design and realization of a management dashboard for the YBoard 2.0 system, which is a popular solution on the Dutch market. The design decisions in this investigation were based on human perception and computer interaction theory, in particular Gestalt theory. The empirical interviews with medical professionals supplemented valuable additional insights into what the users wanted to see most of all in a dashboard in their daily practices. This study successfully shows how effective and efficient dashboard design can benefit from theoretical insights related to human perception and computer interaction such as Gestalt theory, in combination with integrated end user requirements from daily practices.

INTRODUCTION: ELECTRONIC HEALTH RECORDS IN CONTEXT

This research focuses on designing an effective and efficient dashboard which displays management information for an Electronic Health Record (EHR) in long-term and chronic healthcare. Chronic healthcare includes the healthcare provided for people with a mental handicap. Long-term healthcare is the healthcare provided for (elderly) people in nursing homes. We report on a well-known healthcare information system in use within the Netherlands which has implemented our overhauled design such that we could evaluate its effectiveness in daily practice.

An electronic health record (EHR) can be viewed as an evolving concept defined as a systematic collection of electronic health information about individual patients or populations. It is a digital record with the information of patients of a particular group. By itself an EHR is just that, a record. It cannot do anything and a system is required to provide the functions that make the EHR useful. This combination is known as an electronic health record system (Moghaddasi, 2011). However, in daily practice, the term EHR is often used to refer to both the electronic health record as well as the system. Most of the EHRs are able to (1) capture health information in a coded format, (2) track clinical conditions and quality reporting, (3) support clinical decision-making and healthcare coordination, and (4) eventually improves performance of the healthcare institute. Spruit, Vroon and Batenburg (2014) notably perform an exploratory analYBoard on HER information in long-term care institutions within The Netherlands.

In 2008 about 98% of the healthcare professionals in the Netherlands already made use of some sort of EHR (Jha et al, 2008). For now, these systems are mostly standalone systems, or linked with just a couple of other systems. For example, an EHR of a local general practitioner can be linked with the EHR of the local pharmacy, but it is most likely not linked with the EHR of a pharmacy in a different city or state. Furthermore, according to a survey by Goldberg et al. (2012) in Virginia, USA, *'Physicians and staff also repeatedly described their EHR systems as complex, having too many functions to navigate, numerous steps needed to complete a transaction, and difficult to customize'.*

However, a recent survey shows that the Netherlands is a key player in adopting EHRs in ambulatory healthcare and hospital settings. The Dutch Ministry of Health aimed to establish a national infrastructure for data exchange between electronic patient records (EPRs). This way, healthcare providers which are connected will always have up-to-date information about a patient. The core of this infrastructure is the "national switch point" (LSP), an index with pointers to all registered EPRs of a patient (Tange, 2008). This project has now been taken over by the National IT Institute for Healthcare in the Netherlands. EHRs are a very hot topic in the Netherlands because of those relatively recent changes in the development of the national EHR.

Koopman et al (2011) show the benefits that dashboards can provide within an EHR in diabetes healthcare. Their survey shows that the mouse clicks needed to find particular information about patients is reduced by 95% and the time needed to find the information wanted reduced by about 25%. Although this survey was held for an EHR used in diabetes healthcare, it may be assumed that this is not only the case for the diabetes EHR but also for non-diabetes EHRs like the EHR used in long-term and chronic healthcare. Meulendijk *et al.* (2013) similarly report on the high demand from general practitioners for integrated and visual systems to optimize polypharmacy in the Dutch primary care sector. On a broader level than healthcare, more research has been performed regarding the use of dashboards. A 2009 survey showed that over 80% of dashboard users think that a dashboard has a positive impact on business results (Eckerson, 2011).

Finally, Wijaya *et al.* (2008) note that Web 2.0 technologies provide further opportunities to further enhance business values in online health systems.

BACKGROUND: DASHBOARD DESIGN

So, what exactly is a dashboard and how is it used? A dashboard is more than just a screen with some nice performance graphics in it. It is actually three applications in one, woven in a seamless fashion: (1) a monitoring application, (2) an analYBoard application, and (3) a management application. According to Eckerson (2011), the benefits of a dashboard appear to be endless; they can be used to communicate a company-wide strategy, refine and control that strategy and increase coordination and motivation throughout the company. With this taken into account, lots of companies decided to create or buy a dashboard systems tool.

Historically speaking, the first business intelligence dashboards where developed in the 1980s. Back then they were called Executive Information Systems (EIS). Those systems remained in offices of executives and there were only a few of them. The objectives of those EISs were to merely display key financial measures through a simple interface. Unfortunately, in most cases, the data used were not sufficiently complete to provide accurate information to the executives. Because of that, there were only a few dashboards available and no new dashboards where developed, until the required information became increasingly more available in the right quantities and qualities.

In the 1990s, technologies such as data warehousing, online analytical processing and business intelligence all tried to work together to group and analyse the sprawl of information and information systems within companies. It became more and more important to collect, correct, integrate and access the data as accurate and useful as possible. This created new approaches to management. Most notably, one new approach involved the identification and use of key performance indicators: the balanced scorecard (BSC; Kaplan & Norton, 1992).

One might argue that the big acknowledgement of dashboards came with the Enron scandal in 2001. This scandal put new pressure on corporations to closely monitor what was going on in their companies, thereby assuring shareholders they were in control of their companies. This increased accountability pressured Chief Information Officers to find new ways to help managers at all levels to monitor performance more easily and efficiently. The solution to this was to create or buy easy to understand dashboard systems. Most, if not all, of the Business Intelligence (BI) vendors nowadays offers some kind of dashboard solution. Some of them newly designed, some of them just adjustments or extensions to other systems.

Common mistakes

Overall, the fundamental challenge of dashboard design is the need to squeeze a great deal of information into a small space, resulting in a display that is easily and immediately understandable (Few, 2006). This can be done in several ways; one of them is to check for common mistakes in dashboard design. The thirteen most common mistakes in dashboard design that Few (2006) identifies are related to either data handling or screen development issues.

Data handling mistakes include **supplying inadequate context for the data.** Data needs a supporting cast to be successfully transferred. For example, a total quarterly sale presented without any reference to the previous quarter does not supply much information. This mistake is commonly made in financial and

qualitative dashboards. Also, **displaying excessive detail or precision.** Dashboards are normally used to gain a quick overview. Too much detail will only slow viewers down without providing them with any additional benefits. To provide the details needed in the dashboard, filters can be built in to the dashboard. In that way, details can be set on or off. Or, **choosing a deficient measure.** For data to be meaningful, it must be clear what is being measured and this must be expressed in the correct units. The measure is deficient when it is not the clearest and most efficient way to communicate that data. Although it can be accurate, it might not be the best choice for the message. Some information has to be communicated in exact numbers, and some in percentages to provide for a clear view of the information. Furthermore, **choosing inappropriate display media.** There are a lot of different ways to display data. It is very important to use the right display of data when showing information. This will be discussed in depth in the upcoming section 'Display of data'. Not to mention the issue of **introducing meaningless variety**. Some designers tend to think that using the same type of display medium multiple times will bore viewers. Therefore, they introduce different kinds of display medium, which will eventually just confuse the viewer. The means of display must be selected according to which display works best, even if that results in a dashboard filled with multiple instances of the same type of graph. The consistency in the display of data allows users to use the same perceptual strategy for interpreting the data, which saves time and energy. And what about **encoding quantitative data inaccurately**? Problems of this kind exist, for example, when the quantitative scale along the vertical axes for a bar graph does not start at 0. This gives a distorted view, so the start of the vertical axe should always be 0. The final data handling related problem in dashboard design is **highlighting important data ineffectively** or not at all. In a dashboard, attention should be drawn to information that is most relevant. This information has to be made visually attractive, in a way that it jumps out of the other, less useful, information.

Screen development issues include **exceeding the boundaries of a single screen.** Most information is picked up when the information is within eye span. Critical information can be lost when the user loses sight of some data by scrolling or switching screens. This is because people are able to hold just a little bit of information in their short-term memory. Therefore, people might not remember information that they no longer see. Also, **misusing or overusing colour.** When correctly used, colours can help viewers to understand the data in the dashboard. When incorrectly used however, colours can attract attention to the wrong parts of the dashboard. The use of colour will be discussed at a more detailed level in section 2.4. This is highly related to **using poorly designed display media.** A common mistake with poorly designed display media is using very bright colours, which creates overkill. Another mistake can be using too similar colours, making it difficult to distinguish between data sets. Apart from applying wrong colour schemes, there is also the problem of **arranging the data poorly.** Dashboards often need to present a large amount of information in a limited space. This data has to be organized well, or it will result in an unclear mess. The goal is not to simply make the dashboard look good, but to arrange the data in a manner that fits the way the dashboard is used. The most important data should be prominent on first sight. Data that requires immediate attention has to stand out. Data that should be compared has to be arranged and visually designed to encourage those comparisons. And another issue may be **cluttering the display with useless decoration.** Dashboards sometimes tend to be abundant with useless decoration. Attempts are made to make them look like a car dashboard or an electronic control panel. If this is not the main objective of the dashboard, it is just visual garbage that the viewer has to process before getting to the data. The final screen development related problem in dashboard design that Few (2006) discusses is **designing an unattractive visual display.** Some dashboards are just ugly. This can be a distraction when using the dashboard, so it should be avoided. When making the design of a dashboard, it must be kept simple, yet attractive.

In addition to the above mentioned thirteen common mistakes in dashboard design, there are three common early failures indicators. Those early failure symptoms were described by Eckerson (2011) and are leading factors within the design of dashboards. A developer designing a dashboard should always bear the following early failure symptoms in mind.

(1) **Too flat**. Dashboards can be considered too flat, when they do not provide enough data or analytical capabilities to let users explore the problems highlighted in the graphical indicators.
(2) **Too manual**. Some organizations tend to rely too heavily on manual methods to update dashboards with sizable amounts of information. In this way, people spend several days a week on collecting the data, instead of analysing it. Dashboards should provide methods for the automatic collection and delivery of information.
(3) **Too isolated**. Some dashboards do not show an enterprise a view of the whole system or organization. These dashboards only show management information on a small part of the organization, leading to confusion or tunnel vision with the managers.

Data visualization

According to Eckerson (2011), a dashboard should consist of three layers: monitoring, analysing and drilling down. This approach is called the MAD-framework. With this technique, each layer provides additional details, views and perspectives. This layered approach gives the users access to additional information and conforms to the natural sequence in which users want to handle that information.

The first layer is used for **monitoring**, and to provide a graphical view of performance metrics, usually in the form of graphics. This layer is essentially a visual report.

The middle layer has to be optimized for **analysing** the data perceived in the monitoring layer, and consists of dimensional data and lets the users the possibility to drill down to the information in the bottom layer.

The bottom layer is used to **drill down** to detail. In this last layer it is possible to drill down to single persons or actions.

Typically, with the MAD framework, the number of metrics and users increases when moving down in the layers. The first layer is primarily used by executives, the second layer by analysts and the third layer by day-to-day workers. In smaller companies and dashboard systems, the MAD framework also works but with a greater overlay between the different layers. In the case of smaller companies, the third layer will be used as well by workers as by executives and the difference between the layers is less clear-cut.

A key point is: for strategic dashboards the quality of the data is key, not the quantity. Simon *et al.* (2006) show that dashboards in healthcare organizations are mostly used for clinical quality, efficiency, and safety in the organization.

Visual perception

Vision is a very powerful human sense. Seeing and thinking are intimately connected. Vision dominates our sensory landscape, which is important to keep in mind when designing dashboards. The human visual system automatically looks for patterns. This quality can be translated into rules for displaying information. Following perception-based rules, we can present our data in such a way that the important and informative patterns stand out, which makes the overall dashboard much more comprehensible and useful.

Our eyes cannot register everything that is visible in the world around us, but only what is in their span of perception. The brain looks for tell-tale signs, and filters out the useful information. Only a portion of what our eyes sense becomes an object of focus. It is then transferred to the memory, which comes in three types (Few, 2006):

(1) iconic memory,
(2) short term memory, and
(3) long term memory.

In the iconic memory, the information is briefly kept until it can be processed to the short-term memory. In this research, the short-term memory is the most important memory type, as the short-term memory stores the information for processing. The short-term memory can only store three to nine *chunks* of visual information at a time. When the short-term memory is full, some of those chunks have to move to the long-term memory or they have to be removed from the memory altogether. This is the reason that information which belongs together should never be fragmented into multiple screens and scrolling should not be required to see this information. Once the information is no longer seen, it can easily be removed from the short-term memory. In that case, the information is no longer available for the brain to process. You have to switch back to the previous view to see that information again. This makes it very difficult to make good comparisons between information.

What a 'chunk' of information constitutes depends on the nature of the objects we are seeing, their design and our familiarity with the objects. Well-designed graphical patterns for instance, can be stored as one chunk. Individual numbers are also stored as one chunk. This is one of the great advantages of using graphics over text. There are some visual rules on which dashboards can be designed to use a natural flow in the dashboard, and chunk information optimal together for the most efficient understanding and perception of the data. Those rules are discussed below.

Gestalt psychology

It is important for a dashboard to work in a natural way. The design and display of information in a dashboard have a great share in this natural flow of information. Using a natural and clear flow in a dashboard facilitates an easier incorporation of knowledge than a dashboard that does not obey this natural way of working. Important work here has been done within the field of *Gestalt psychology*. The German word *Gestalt* simply means pattern in English. *Gestalt psychology* is a theory of mind and brain, started back in 1912, but it is still very useful today. The fundamental principle underlying *Gestalt*-perception is the Law of Prägnanz, which, in short, states that individuals tend to order things in their mind in a manner which is regular, orderly, symmetric, and simple. We discuss this with regard to the Law of Prägnanz and seven more laws in *Gestalt psychology* to help structure and organize the information in the mind below (Todorović, 2008; Gestalt psychology, 2016).
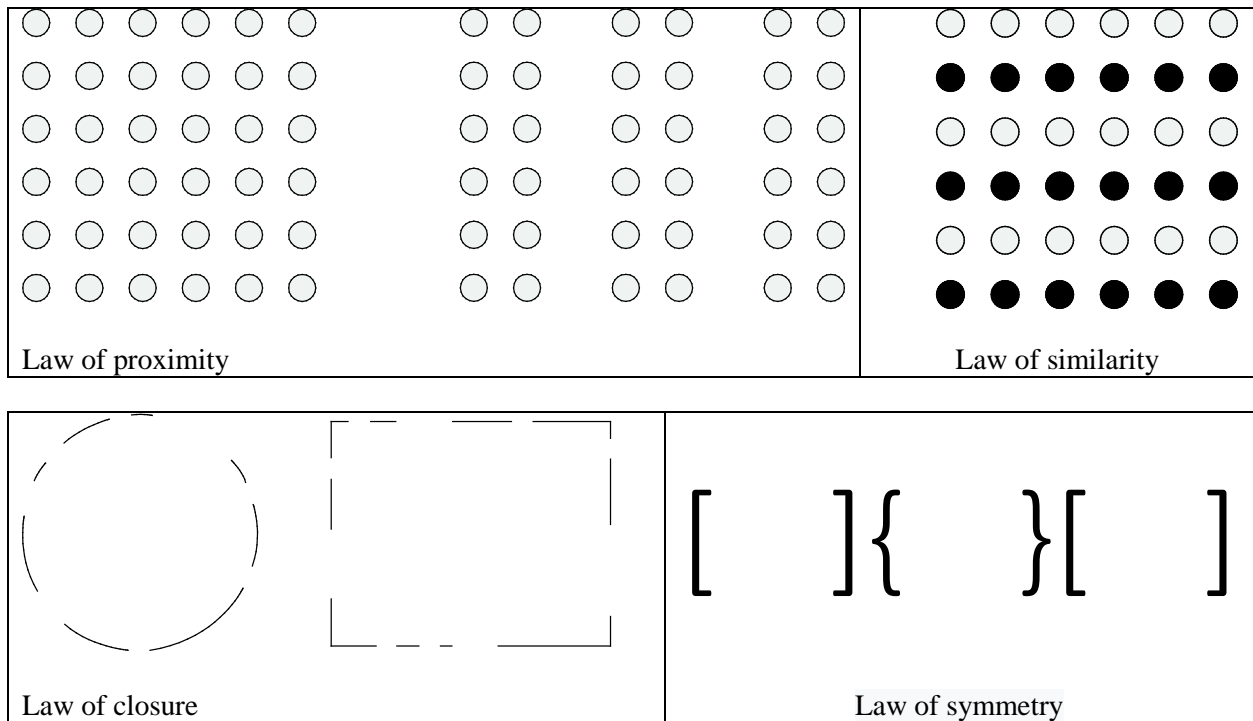
Figure 1: Gestalt principle examples (reprinted from Gestalt psychology, 2016).

Law of Proximity – According to the Law of Proximity, when a person sees multiple objects, the objects close to each other seem to form a group. According to this, several objects can be visually associated to form a group. Figure 1 (top-left) shows an example of the proximity law. In this image there are 72 circles, but instead of seeing those individual circles, the human mind perceives them as four separate groups of circles. Three separate groups of 12 circles on the right hand, and one big group of 36 on the left hand.

Law of Common Fate – According to the Law of Common Fate, objects that move together belong together. When from each group of circles in Figure 1 one circle starts to move, it will be perceived that it is a group, even though it is not a group according to the one of the other laws.

Law of Similarity – According to the Law of Similarity, multiple similar objects in a group of objects will be perceived as belonging together. This occurs whether or not this similarity really exists. The perceived similarity can occur on different levels, such as colour, form of shape, shading or other qualities. In the image at the top-right of Figure 1, there are 36 circles. For most people, the rows are grouped together consisting of coloured and not coloured circles, instead of seeing the circles apart.

Law of Closure – According to the Law of Closure, individuals perceive objects as being whole even if they are not complete. This can occur with all kinds of objects such as shapes, letters, pictures, and the like. When parts of a whole picture are missing, our perception fills in the visual gap. In Figure 1, bottom-left, there is an example of the law of closure. People perceive to see a circle and a rectangle, wheras in fact there are none.

Law of Past Experience – According to the Law of Past Experience, under some circumstances visual stimuli are categorized according to past experience of the mind. For example, if the mind has never seen

an image before, it is still able to figure out what is on that image by pointing out the different known images from the larger image.

Law of Symmetry – According to the Law of Symmetry, the mind perceives objects as being symmetrical and forming around one point. For the mind it is calmer to divide objects in to a number of symmetrical parts. The mind only has to remember one of those parts, to figure out what the counterpart is. When two symmetrical parts are unconnected, the mind perceived them to be connected to form a complete shape. Figure 1, bottom-right, shows six individual brackets, which are perceived to be three pairs of symmetrical brackets.

Law of Continuity – According to the Law of Continuity, lines are perceived as if they are following the smoothest path. This occurs when we see a trend and we decide to follow it at a particular up or downwards scope. We tend continue following that line when we perceive them to be heading in an implied direction. When two lines intersect, the continuation of each line is still apparent.

When designing a dashboard, the above laws should be kept in mind. When the dashboard is designed with respect to those laws, it is more likely that the user will perceive the natural flow when using the dashboard, which likely results in a higher usability of the dashboard design.

Configurable time spans

Data in a dashboard can be viewed in different time frames. Typical examples are: current year to date, current week to date, current quarter to date, yesterday, and this month. Those time frames can be selected by quick choices. In dashboards, it should also be possible to select custom data. This makes the dashboard as flexible in time selection as possible. In that way, the user of the dashboard can adjust the time frame to the range needed at that moment.

Data display

The layout of a dashboard is one of the major things contributing to its success. The basic structures for showing data are graphics, tables, and words. Often two or three of these devices should be combined (Tufte, 2007). Graphics, tables and words are different mechanisms with the same single purpose; the clear presentation of information. The best medium for displaying particular or specific data, however, will always be dependent on the nature of that data.

Graphics

An important thing to keep in mind is that graphics should only be used for richer, more complex, and more difficult statistical material. For less difficult statistical material, a table or textual overview is often better. According to Tufte and Roger (2007) graphical displays should at least always:

- Show the data,
- Induce the viewer to think about the content over form and methodology,
- Avoid distorting what the data has to say,
- Present many numbers in a small space,
- Make large datasets coherent,
- Encourage the eye to compare different pieces of data,
- Reveal the data at several levels of detail, from a broad overview to a finer structure,
- Serve a reasonable clear purpose: description, exploration, tabulation or decoration, and

- Be closely integrated with the statistical and verbal description of the dataset.

There are a few principles to enhance graphical integrity. The two most important principles for this research are (1) that the representation of the numbers, as shown on the surface of the graphics itself, should be directly proportional to the numerical quantities represented, and (2) clear, detailed, and thorough labelling should be used to defeat graphical distortion and ambiguity. Any important data should be supported by written explanations on the graph.

Data-ink is the ink on the graph that represents the data in that graph. There is also ink called non-data-ink, which is used for grid lines and other information lines. According to Tufte (2007), when a graph serves as a look-up table, the grid lines should be muted or completely suppressed so that its presence is only implicit. In this way, the non-data-ink does not compete with the data-ink. If the diagram does not serve as a look-up table, the grid can be removed completely to show the data as clearly as possible.

Another very important thing about graphs is that graphs must be instantly understandable: *'if you have to explain it, don't use it'*. Because of the user group of this particular medical system, it is very important to use easily understandable and clear graphics. Too much colour in a graph, for instance, often generates graphical puzzles. This is because the eye does not readily give a visual ordering to colours, except for red to reflect higher levels than other colours.

Color	Color name	RGB (1–255)	CMYK (%)	P	D
	Black	0, 0, 0	0, 0, 0, 100		
	Orange	230, 159, 0	0, 50, 100, 0		
	Sky blue	86, 180, 233	80, 0, 0, 0		
	Bluish green	0, 158, 115	97, 0, 75, 0		
	Yellow	240, 228, 66	10, 5, 90, 0		
	Blue	0, 114, 178	100, 50, 0, 0		
	Vermillion	213, 94, 0	0, 80, 100, 0		
	Reddish purple	204, 121, 167	10, 70, 0, 0		

Figure 2: Colors optimized for color-blind individuals.

There are also some guidelines to create user-friendly data graphs. One of those guidelines deserves special attention and is about choosing colours which can be understood by people with a colour-deficiency or who suffer from colour-blindness. Colour-blindness affects a substantial portion of the human population. In individuals of Northern European ancestry, as many as 8% of men and 0.5% of women experience the common form of red-green colour blindness (Albrecht, 2010). For this reason, the colours picked for the graph used in the model should be suitable for colour-blind readers. The palette of eight colours shown in Figure 2 has good overall variability in colours and can be differentiated by individuals with red-green colour blindness. The P and D indicate simulated colours as seen by individuals with protanopia (P) and deuteranopia (D), respectively.

Shapes and proportions

It is recommended to make the shape of the graphic more wide than tall. Wider-than-tall shapes usually make it easier for the eye to follow from left to right (Tukey, 1977). This is also in line with our normal sight. Our eye has evolved to detect deviations from the horizon, which is also more wide than tall. Graphics design should use this natural advantage. Furthermore, it is easier to write and read words from left to right. When the x-axis is wider than the y-axis, there is more space to write down the labels on the axis. The last point is that normally the causal influence is plotted on the horizontal axis. With a wider x-axis, there is more space to show the causal variable in more detail.

On a related note, a fifth century rule about the proportion of the axes is called the Golden Section. This rule states that the length of the horizontal axis should be approximately 1.618 times longer than the vertical axis. Most of the time, however, it should be taken into consideration how much the nature of the data suggests the shape of the diagram. This suggestion must be followed in designing the graphic (Livio, 2002).

Tables and numbers

Tables are clearly the best way to show exact numerical values. In small datasets, this notation is preferable to graphics. According to Tufte (2007) and other designers, tables are nearly always better than the pie chart. Tables are known for their organized, sequential details, are easily readable and therefore tables also work well when the data requires many localized comparisons. The table is a good and straightforward method of showing data in the dashboard described in this paper.

Sentences and words

In all dashboards, no matter how visually oriented, there is some information in the form of writing. However, the conventional sentence is considered a poor way to show more than two numbers because it prevents comparisons of data. The linearly organized flow of words, folded over at arbitrary points, offers only one effective dimension for organizing the data. For the reasons stated above, in this model should be made more use of tables and graphics and less use of sentences to describe the data.

Display type

An important thing to take into consideration while designing an electronic dashboard, is on which kind of display it will be presented. The dashboard described in this research will be designed to be shown on a computer screen, rather than a tablet computer or mobile (smart) phone. This distinction is important because the screen resolution differs between systems. The most widely used screen resolution for computer screens in 2012 was 1024*768, and in 2016 is 1366*768, and higher (W3Schools, 2012). This made us design the system of our case study to be at most 1000 pixels in width, in order to prevent scrolling bars from appearing on the horizontal side of the computer screen. More key design considerations regarding BI implementations are provided in Verkooij & Spruit (2013).

SINGLE CASE STUDY RESEARCH

We performed a single case study at the Dutch SME **CareSoft**. Their product **YBoard** implements a dashboard which displays management information for an Electronic Health Record (EHR) in long-term and chronic healthcare. At the time of this research, their version 1.x series of YBoard has become a popular solution within the chronic and long-term care domain. However, due to various reasons, together with CareSoft we set out to completely redesign the EHR management solution to realize a more effective and usable 2.x series of the product.

Data collection

To uncover how a more effective and sustainable management dashboard for YBoard should be designed, we first interviewed five of the end-users of the current system for their input in the functions and design of the management screens. This was done because different studies show that it is highly recommended that (potential) end-users are involved in the early design and creation of the dashboard. It is advisable because of the experience they have in their own organizations and the systems they use. With the help of end-users in the design of a dashboard, suggestions of functionalities and design questions can be incorporated which the designer would not normally think about.

End-users are typically great at articulating issues and problems with current systems, and identifying which features should be developed first and which are of lower priority. By interviewing end-users and using their suggestions there is a potentially high acceptance of the final product, because the users feel respected in their needs. A downside to this strategy is that users are usually not great in offering solutions, but they are great at identifying problems and needs. For most cases, problems are easily identifiable but solutions are harder to find.

Interviewing method

For this research, two rounds of interviews were held with five current users of the YBoard system. Those users are handpicked by CareSoft. These five current users are representative for the end users of the management screens which need to be developed for the YBoard system. The first round of exploratory interviews was held in week 49 of 2012 and was intended to discover some key features of the system. The second round of evaluation interviews was held in week 10 of 2013 and was intended to discuss the designed prototype with the end-users, and to find improvements in this first design. The results of the exploratory interviews are described in this chapter under three different sub-headings. These are: General remarks, Selections and information and Comparisons. This subdivision follows the course of the interviews.

Users of YBoard were interviewed from the following five companies:

Name	Location	Kind of care	Total clients	# of locations
1PergaCare	Echt	Chronic	1400	36
2OsiraCare	Amsterdam	Long-term	3100	23
3ZuidoostCare	Drachten	Long-term	1500	14
4FlorenceCare	Rijswijk	Long-term	2200	45
5NoorderCare	Leeuwarden	Long-term	1400	15

Table 1: Interviewed YBoard customer organizations

The first and second interview in the first round progressed relatively unstructured. This approach was chosen in order to be certain that the interviewee was not pushed in a certain direction, and so to see what the interviewee would come up with. After the first two interviews, it appeared that this was not an ideal method because the interviewees asked for data in the management screen that was not (yet) available in YBoard. This probably occurred because they were confused with other systems in the organization. The last three interviews in the first round where held according to a more structured approach, with a list of managerial questions the interviewee was asked to prioritize. It appeared that this was a better approach to get the desired workable results. All the interviews started with a short introduction to explain the reason for the interview. Some interviews were held with just one person, the responsible manager and in others

other people were present, such as a controller or another YBoard user. In the next paragraph, there is no distinction in the interviews with a single interviewee, and those where more people were involved.

Results of exploratory interviews

In all five interviews it was pointed out that a dashboard is a welcome and much needed addition to the current functionalities of the system. According to the interviewed professionals, a dashboard will save time in performing management and patient healthcare tasks.

Quotes on general requirements
1PergaCare: "We look for a better way to control and monitor specialized healthcare personnel, a management system will give me the information needed for this."

2OsiraCare: *"Even though we are still implementing YBoard and I am not yet working with it, a dashboard for overall management information is for me a key point to use YBoard. I am not that much interested in client information, but more in the whole picture. How is my team doing?"*

3ZuidoostCare: *"Accumulated information would be great, but when I have a more overall overview it would already help a lot. It is important that it is possible to classify user between different user groups."*

4FlorenceCare: "There is a need for more information about the registered Diagnostic Treatment Combination (DBC) information. This information is already available at the client level in YBoard, but not yet available as management information. The information has to be real-time and up to date. An export of all the information in YBoard would be great for starters. In that way, our controllers can do their own calculations on the numbers."

5NoorderCare: "We are very interested in such screens, especially for DBC information at the client level. Currently time is tracked by the healthcare providers in Excel and sent to the backoffice, which enters it in Excel. This is a very time consuming way of processing the information. If this could be done is YBoard and YBoard would give meaningful reports, it would save a lot of time."

Quotes on selections and information
1PergaCare: "Selection criteria can be age, or nature of disease. It is important to classify the different groups clearly. "

2OsiraCare: "Interesting information would be specific information about some key figures of the different locations. For example the number of CPR-certificates filled in. Currently there is no automation available for acquiring this information. "

3ZuidoostCare: "It is important that there is a possibility to differentiate between different locations, because there are many differences between different (sub) locations. It is also important to classify users in different user groups. "

4FlorenceCare: "Interesting selection criteria would be ICPC codes and number of reports per employee. In that way, we can see if our employees do report their work and we can subdivide the different groups of clients."

5NoorderCare: *"Most interestingly are the reports about DBC information. An example is information about the mean treatment duration. Selections can be on diagnosis, or on age of gender. It would be good to add a number of different selections methods."*

Quotes on comparisons
1PergaCare: "The treatment groups vary in our chronic healthcare centres, so it is difficult to make comparisons between those groups. It would be interesting to make comparisons in between groups between different locations or wards."

2OsiraCare: "It should be possible to make comparisons between different target groups on different locations. To compare, for example, the personnel from a certain discipline on the one location in comparison to the personnel from that same discipline on another location."

3ZuidoostCare: "With the selection made to differentiate the clients in different groups, it is important that it is possible to compare those groups with each other. In that way, we can find discrepancies between different groups or locations."

4FlorenceCare: "For the DBC information, comparisons are not very important in the beginning. It is important however, it is more important that the system can export data for our own use."

5NoorderCare: "Comparisons between different locations would be very useful, but there must be a possibility to select which clients or employees to compare."

Conclusions based on exploratory interviews
The first round of interviews confirmed that there was indeed a need for a management dashboard in YBoard. The interviews also gave some valuable insight into which kind of information is considered important for managers and controllers.

Some of the interviewed managers and controllers asked for a database export of the information of a selected user group, or all users. This suggests that those users or their subordinates have a thorough knowledge of Excel or another statistical program, and so they can perform their own queries on this export. With such an export, people can get all the possible information they want from the system.

Another insight is that there is a strong need for implementing the management screens, at least for DBC information. Because of an amendment of the law in the Netherlands, since January 1, 2013, healthcare providers only get paid for the medical rehabilitation healthcare they really provide and can prove. Therefore, all the medical professionals have to keep track of their hours in regard to rehabilitation healthcare to make it possible for the finance department to send the final bill to the health insurance of the specific clients. Even though it is already possible to track time in YBoard for DBC clients, it is also important to have a managerial overview of that information.

The interviews also showed that the choice of comparing different (sub) locations with each other received wide consensus. It should also be noted that the interviewees asked for a great range of selection criteria on the different (sub) locations, so that they can subdivide the big client or employee group of the different (sub) locations into smaller groups. With those smaller groups it is more useful and helpful to make comparisons.

The interviews also helped to prioritize the managerial questions, prepared by the CareSoft staff. With this prioritization, the implementation of the dashboard can be performed step-by-step. In this way, any (design) errors can be detected in an early stage before too much potential work is lost.

The last insight the interviews provided was that, for the managers, DBC is a very important group of clients. A DBC client is not just *a* client, but a 'special' client. When the DBC option is enabled in YBoard, these clients are given a different status and more / different options than other clients. For DBC clients, it is mandatory for employees to register time. It may be concluded from this information there are actually three groups of persons in YBoard; employees, clients and DBC-clients.

All in all, from the interviews conducted in this research, key data appeared to be having a good and clear selection process of the target group. With that selected target group, it must be possible to create a view of what kind of healthcare is provided to different selections of groups, and to compare this selection between locations and branches within the same organization.

THE BI DASHBOARD FOR YBOARD 2.0

YBoard is a major EHR system in long-term and chronic healthcare. According to CareSoft, other available systems are mostly just modules added to current accounting systems of healthcare institutes and these modules are not optimized for use as EHRs. The decision to use extension modules is often based on the idea of having just one supplier for all, or most, of the systems used.

YBoard is especially designed for use as an EHR in long-term and chronic healthcare, and therefore provides some specific functions which are not covered in the extension modules of other systems. YBoard is developed and tested by dozens of doctors, psychologists and paramedics in nursing homes and institutions for the mentally disabled. Because of this development in association with people who are actually using it, YBoard is specifically attuned to the needs of those users. YBoard is an EHR in the cloud, so all of the users automatically make use of the newest version available (*e.g.* Abdat, Spruit, & Bos, 2011). This is an advantage because there is no possibility of using an older, possibly more insecure and unstable, version of the system.

In the current version 1.0 of YBoard, decision making, healthcare coordination and improvement of performance are not yet used to its full potential. The information of the patients is available, but only on patient level. For managers, it is important to have an option to create an overview of the company as a whole. Therefore, the new version of YBoard needs a dashboard to display the medical information in a more efficient way.

User group

The user group of YBoard consists of doctors and managers in the long-term and chronic healthcare branch of Medicare. Most of the medical professionals are used to working with computers and information systems (Lupiáñez-Villanueva *et al.*, 2010). For the YBoard users, information systems knowledge is even more explicit because they already have experience in working with YBoard. Some of the users already have experience with other, in-house developed management screens. Therefore, it can be assumed that knowledge of computers and information systems is sufficient within this user group.

Notable constraints of this user group are that they mostly have a busy schedule, and do not have much time to learn a completely new system. Therefore, the management screens should be easily accessible, and clear within an instant of usage.

Dashboard design

In dashboard design, the guiding principle should always be simplicity: the data must be displayed as simply and clearly as possible, and unnecessary and distracting decoration must be avoided. Because of this, dashboards have to be well organized, concise, customized to the user and they must communicate the data as clearly and directly as possible. The best way of condensing lots of information is via summarization. The most commonly used summarizations on a dashboard are summing and averaging.

Another important point in the design is to address the information in the vocabulary of the audience. The users of this particular dashboard are medical professionals, therefore, the terms used in the dashboard should match the language used in their profession and in the rest of this EHR.

For this dashboard, a step-by-step approach is used. In the first part, a selection is made of the data which is sought. In the second part, the data is shown. In practice, presumably the steps will be used interchangeably when the dashboard is online. This does not affect the working of the dashboard.

The starting point of this research project was to do research in order to develop a dashboard for the EHR of CareSoft. In the sections above, the background information about EHRs and creating and designing of dashboards was given. This chapter will describe the final design of the dashboard, and the live version as added to the actual online product YBoard 2.0.

In this dashboard there are three main variables, which have to be presented. The first variable is the selected *population*; this can either be Clients, Employees or DBC-clients. The second variable is the *location*. From which location(s) does the dashboard need to show the data? This can be up to two different locations, which are visually displayed by the line in the diagram. According to the interviewed end-users, comparing two locations was enough to start with. With two locations, it is most effective to make a clear comparison. Technically, when feedback shows that there is a need to, it is possible to add more locations to compare at a later moment. The third variable can differ, is easily expandable and is displayed on the X-axis. For example *time*; to what timescale does the data refer? The time is set to one month as standard, but can be adjusted to day, year, or any manually selected period. It can also be the (average) record time in the specific location; what is the average record time in the home for the elderly? This variable can be extended with other variables when suited.

The first sketch

The first sketch of the design was made with Microsoft Visio, and is displayed in Figure 3. This sketch was based on the YBoard layout, and was made before any interviews were held. It was primarily based on literature and exploratory discussions with CareSoft. With the presentation of this first design, it quickly appeared that it was not clear for users within the first moment of sight. Because of this, it was decided to start again completely with creating a new design.
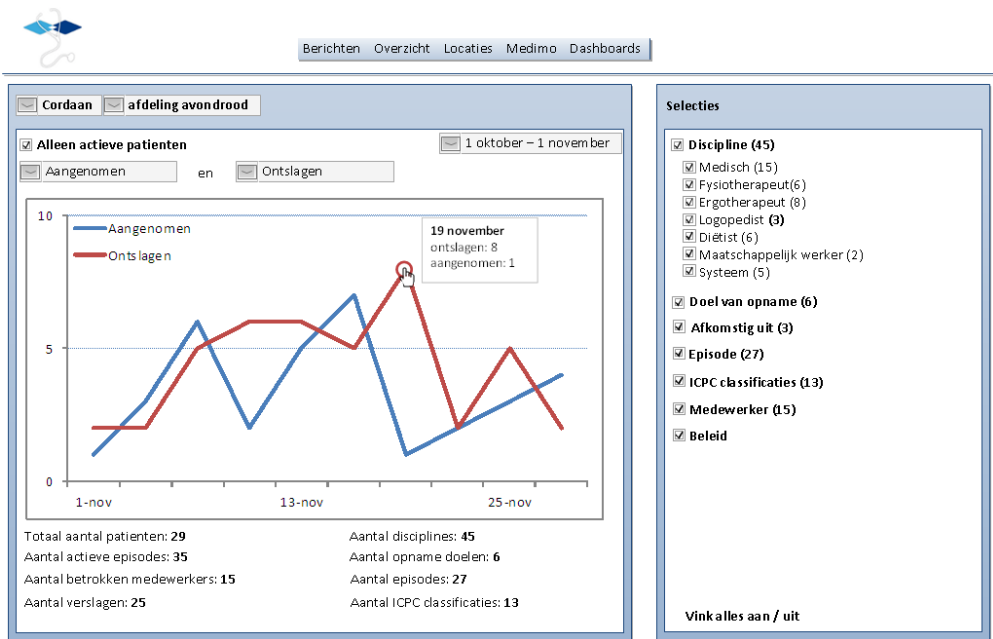
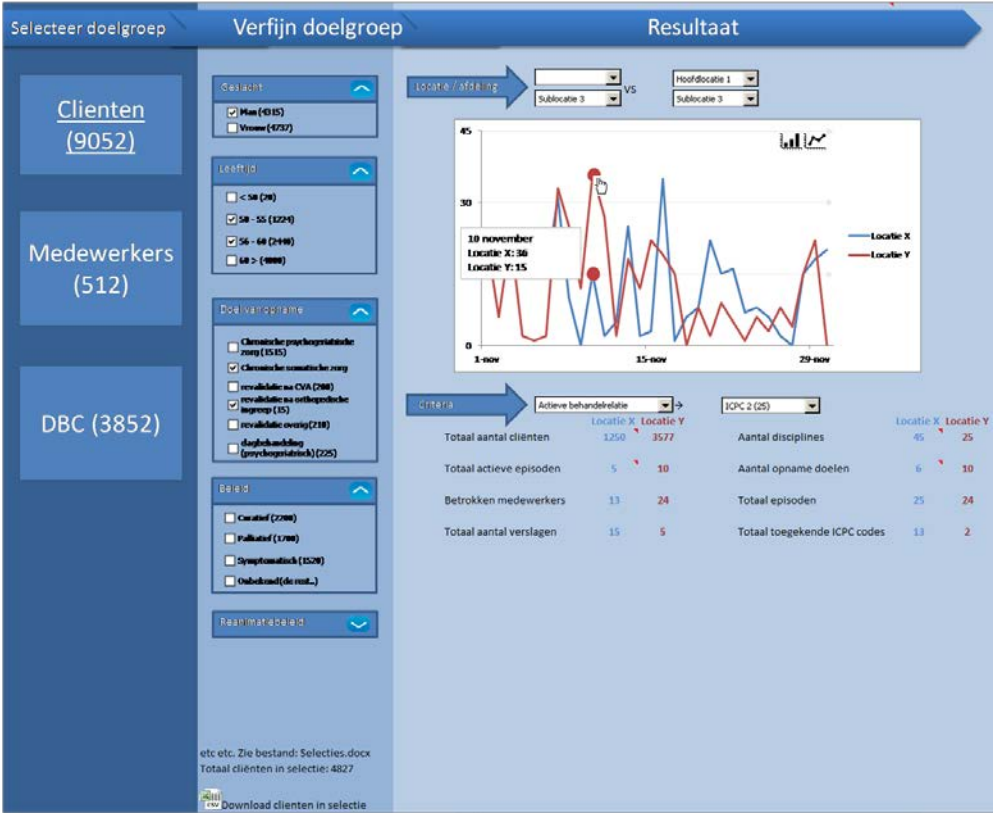*Figure 3: YBoard design version 1, sketched in MS Visio.*

Figure 4: YBoard version 2, the Clients screen, implemented in MS Excel.

The second sketch

The next sketch was made after doing more literature research and the interviews held with the medical professionals and end-users of the system. This second sketch in Figure 4 was made in Excel and is the basis for the final design of the dashboard, which is described in this section. It was decided to split the dashboard selection up into three different steps. Those steps, and where you are in the selecting process, are visually displayed with the status bar in the top of the screen. Even though it is just a quick three-step selection process, it is still important to give users as much feedback as possible about progress. The layout of the dashboard is explained below following those steps.

The third and final design

The final design of the management dashboard is a refinement of the second design as presented in Figure 4. The three steps in this dashboard are (1) select user group, (2) select population (of that user group) and (3) show the results of the selection. In this way, it is a very clear step-by-step approach to get to the final results. Figure 9 displays the steps in the selection process graphically. In the final design, the choice was made to always display the data with reference to one of more different branches or locations. This approach was tested with a couple of small use cases and specifically asked about in the

Figure 5: Conceptual lay-out of YBoard.

interviews. The interviewees all reacted positively on the possibility of comparing different locations with each other.
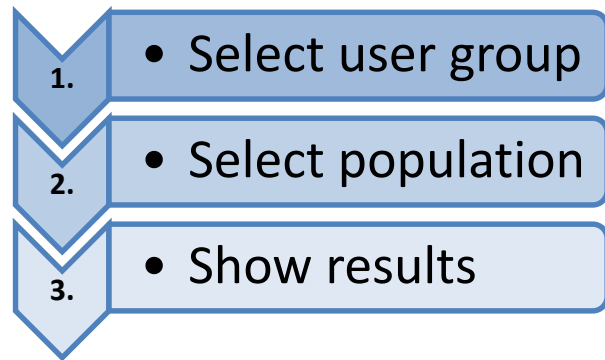
The first step

The first step in the dashboard is selecting the group whose data is shown in the next steps. The first step is shown in Figure 6.

This step allows the user to select the user group. This domain selection is about for which group you want to display information. There are three different groups in the domain selection; Clienten 'patients', Medewerkers 'employees' and DBC 'Treatment codes'. This differentiation is made because these are the three main groups about which information is recorded in YBoard. In this case, DBC is a special group of clients and therefore a separate selection.

DBC-clients are a relative new kind of client, and there are a lot of questions about those clients from the YBoard-users. It could be technically possible to place DBCclients within the client selection, but in consultation with the medical professionals and the CareSoft team, the choice was made to approach DBC-clients as a separate group.

Figure 6: Step 1.

For any other system those groups can be extended or narrowed to fewer or more user groups, depending on the groups in the system. In other systems, it may make sense to use the selection 'men' or 'women' or 'in house clients' and 'external clients'. The main reason for this first selection is to

narrow the group down to a specific target group, from where you can drill down as specific as wanted or needed.

The second step

In the second step shown in Figure 7, the user has to specify the population which he chose in the first step. The population can be selected by specific characters of the group selected. Specific characters applying to all groups are Geslacht 'sex' and Leeftijd 'age'. To give the user as much freedom as possible, the user can fill in an age range. Some selections are group-specific like Reanimatiebeleid 'CPR-policy' for clients or 'field of profession' for employees. All selection criteria, except for age, are checkboxes which means that it is possible to select more than one to make a selection as broad as possible. The advantage of working with a special step for making selections is that, in this way, the system is easily expandable. When more (patient or employee) information is added to YBoard, the selection step can easily be expanded with this information.

The different selection options are folded by default, and can be unfolded when needed. The selections in this step are filters, they apply when checked. Because in the YBoard system all selections are unchecked by default, it was decided to continue along this line in the dashboard so as to not confuse users. When none of the filters are active, the whole group selected in the first step is shown on the dashboard.

At the bottom of the selection, it is possible to download all the clients made in the selection above in a .csv file. This option was added in response to the specific wish of the interviewed end users.

Figure 7: Step 2.

The third step

This last step is the result screen as shown in Figure 8. In this last step, it is possible to select two locations for comparison. The numbers underneath the location give the information of four key information points. This makes it easy to compare key data of the selected locations. It is also possible to select 'all' locations, for a company-wide overview. In a later stage, the two locations are easily expandable if needed. The colours used in this screen are colour-blind friendly colours.

When hovering with the mouse over a point in the graph, information about that specific point occurs. In the top right corner, it is possible to switch between a line and a bar graph. Underneath that switch, there is the possibility of quickly selecting different time frames. Time frames can be today, the past week, the past year or the last year. The time frame can also be selected with a slider on the X-axis. On top of the Y-axis, there is a switch between percentage and absolute numbers. This is needed when the user wants to compare two different locations with different numbers of clients.

For some kinds of data, it is better to have a different X-axis than a specific time frame. An example is the length of stay in a specific location. In that case, it is better to have the different times of stay on the X-axis and the number of clients staying that specific time. The type of graphic can be changed with the dropdown box in the lower right corner. The choice of using a dropdown box for this is because of the ease of expandability. In this first version of the dashboard, at client level, it is only possible to see the movement of the selection in a specific time frame and to see the average length of stay of the selection. At the DBC
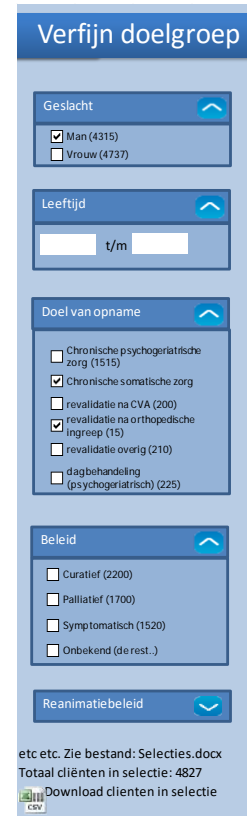
level, however, the possibility of viewing three different kinds of X-axis has already been implemented. It can be imagined that different kinds of graphics at client and employee level will be added in time.
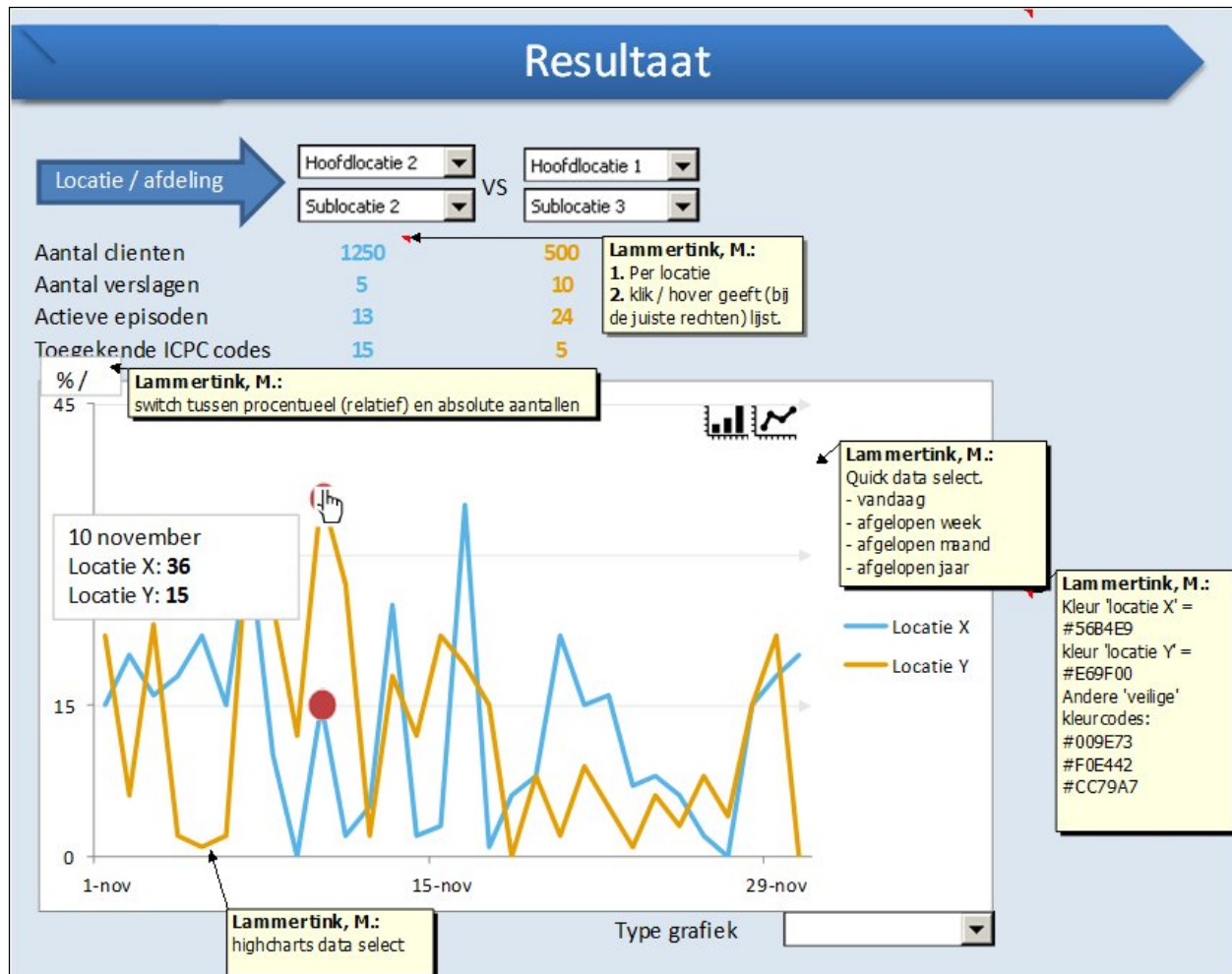

Figure 8: Step 3.

Applied laws from Gestalt Theory

Two of the greatest challenges in dashboard design are to make important data stand out, and to arrange disparate data in an effective way, giving it significance. The dashboard above is designed with regard to the *Prägnanz* principle, which means that following the steps in the dashboard has been made as regular, orderly, symmetric, and simple as possible. Therefore, most of the laws from *Gestalt* Theory are applied to the dashboard. This part describes which laws are applied and in what manner.

Law of Proximity – The Law of Proximity is used in the design of the second step. This step is always built up from the header and the subs of a selection grouped together, i.e. sex and the two different sexes. Because of the colour and borders for the grouping used, it is clear that 'men' and 'women' are choices on the 'sex' header. The Law of Proximity is also used in the statistics underneath the different location in the third step. The name of the statistic and the corresponding number is placed next to each other with the location above, which suggests correctly that that name, number and location belong together.

Law of Similarity – The first use of the Law of Similarity is that whatever first selection of user group is made, step two and three are the same. These steps may have different options, but the layout of step two and three is the same for all the groups selected in step one. Another application of the Law of Similarity is that in the second step all the different headers have the same layout. Therefore, the user concludes that underneath the other header(s) in that step there is some kind of submenu with a number of choices. A last application of the Law of Similarity is that the different locations are always the same colour, whatever selection criteria are chosen.

Law of Closure – The Law of Closure is used in the choice of the line chart. The line chart suggests that the space underneath that chart belongs to the chart.

Law of Symmetry – The Law of Symmetry is first of all applied in the width of the three columns. The first and second columns are both the same width, the last screen is three times that width. The selection boxes in the first and second step are also related to the same width, and therefore visually related to each other. This consistent use of sizes gives a feeling of symmetry to the system.

Law of Common Fate – The three steps approach in the design indicates the position of the user in the selecting process. The active step is highlighted by a different colour than the previous and next step(s). In this way, the step in the selecting process is clear to the user in the blink of an eye. An arrow-shaped path was chosen to indicate the path to follow. The Law of Common Fate is also used in the choice of colours. The colour range selected for the three columns, dark to light, suggests following the path in that direction, from dark to light.

Law of Continuity – This law is applied in the visual display of the data. The data is displayed in a line chart. The line charts can cross each other. For the user it is still clear what line they are following because of the colour and implied path of the line.

Law of Past Experience – The Law of Past Experience is applied in order to show the users they are still in the YBoard system, this with respect to the colours used in other parts of the system. The Law of Past Experiences is also used in the graphic visualization of the system. Because widely known and accepted graphic visualizations such as line and bar charts are used, people recognize the visual presentation and are able to read it in the way they should without any additional schooling needed.

Avoided common mistakes

In the theoretical background to this research in Section 2, common mistakes in dashboard design were reviewed. This dashboard has been designed with those common mistakes in mind, to avoid making known errors again. Those common mistakes are briefly described again in this chapter, and thereby the solution found to it in this design.

Exceeding the boundaries of a single screen – In this design, all data are shown in one screen. This is done with the use of selections that can fold in and out, in order not to exceed the boundaries of the screen. The most commonly used resolution worldwide was also kept in mind.

Supplying inadequate context for the data and displaying excessive detail or precision – In the design it is possible to compare different locations. As stated, this mistake is more common in financial dashboards and does not really apply here. The design uses filtering methods to counter the excessive detail mistake. The main group can be as detailed or as broad as needed for the desired results.

Choosing a deficient measure, choosing inappropriate or poorly designed display media – A mixture of visual and textual display was used to show the data. To easily compare key data between different locations possible, these data are displayed right underneath that location and next to each other. This allows the user to easily compare locations. This is, according to the theory and interviews, the most effective way of displaying the data.

Introducing meaningless variety or encoding quantitative data inaccurately – There is no meaningless variety in the dashboard, because only tables, bar and line charts are used with the axes starting at the zero point. In this way, it is clear how the data displayed must be interpreted.

Arranging the data poorly – The data are very well ordered. This refers to the step-by-step approach described earlier. Because of this step-by-step approach, it is clear where all data belong and what it adds to the overall view.

Highlighting important data ineffectively or not at all – In this dashboard, no highlighting data are used. This is because the dashboard does not give real-time day-to-day information to monitor.

Cluttering the display with useless decoration or design an unattractive display – There is no useless decoration in the design. Every bit of information is deliberately available and belongs in the dashboard.

Misusing or overusing colour – The colours used in this dashboard are all colour-blind friendly colours. Attention has also been paid to the background colours, which help users in following the path in the selection process.

Initial YBoard product release

After a month of development, a first version of the management tool was made available for use by the developers behind YBoard. This first version is based on the mock-ups above and was designed in line with the encompassing YBoard system. Because YBoard is a SaaS EHR, it is constantly updated to the latest version. In this first version, only the DBC tool is available because of the great need for this tool in the long-term healthcare institutes. Since then, other functions of the management tool, like employee and client, have been added as well to the online version of the tool. Figure 9 shows a screenshot of the DBC screen of the management tool in YBoard as of April 9, 2013.
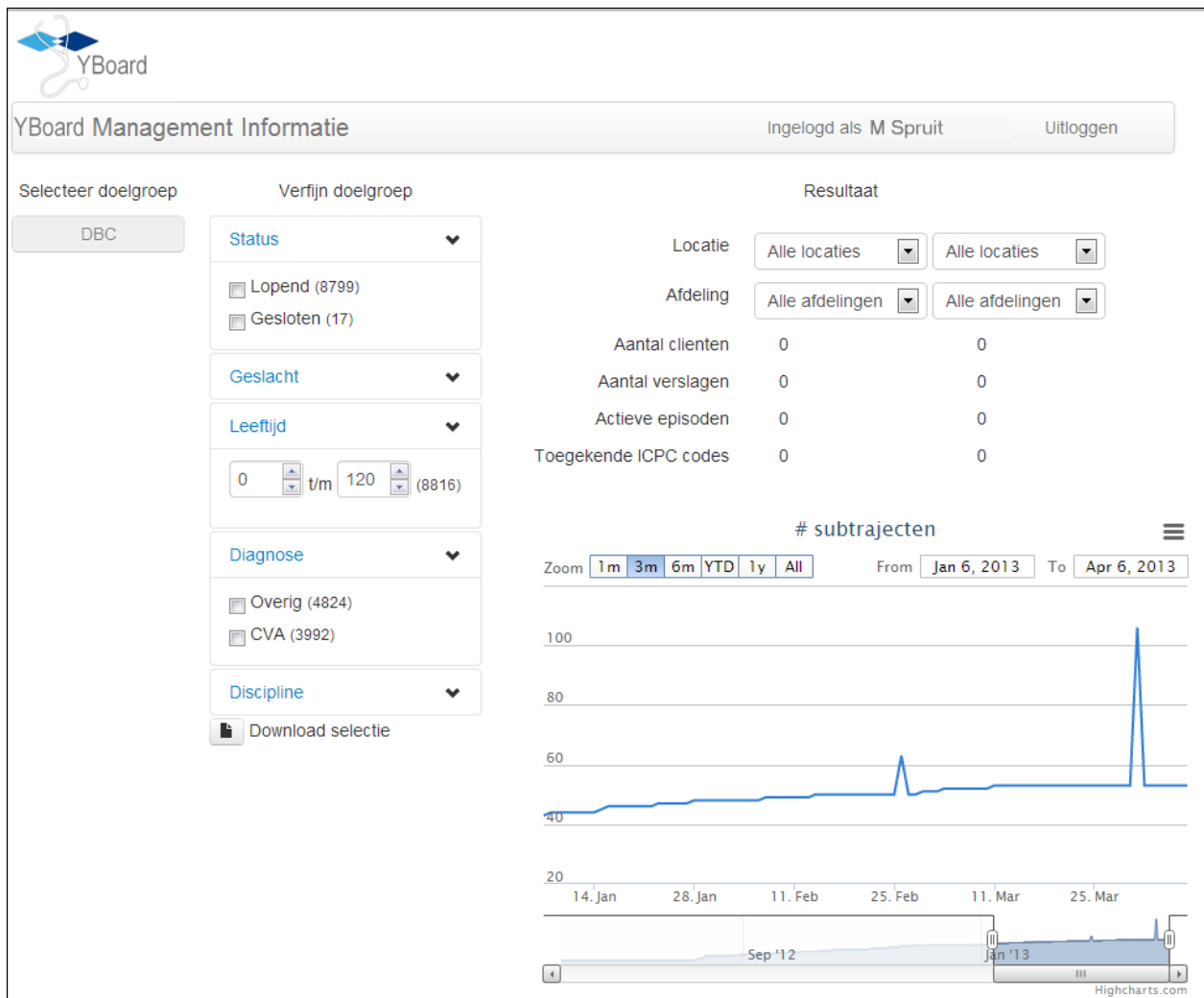
Figure 9: Initial product release of the management dashboard in YBoard 2.0.

RESULTS OF EVALUATION INTERVIEWS

The second round of interviews was held in week 10 of 2013 and was intended to discuss the designed prototype with the end-users, and to find improvements in this first design. The working prototype was barely finished that week, so the interview leaned largely on the sketches of the design. All of the interviews started with a short introduction about what was done in the last weeks. It was made clear that developing such a sytem in only a couple of weeks was something very unusual, and therefore special. Unfortunately, it was not possible for all of the interviewees from the first round to come to the second round of interviews. The three interviewees for the second round were employees from 4FlorenceCare, 5NoorderCare and 2OsiraCare.

The results of the interviews are described in this chapter under five different sub-headings. Those sub-headings are: General impression, Client selection, Employee selection, DBC selection and other remarks. This subdivision follows the pattern of the second round of interviews.

General impression

4FlorenceCare: "We already watched the prototype online and there a lot of ambiguities about the functionality of the management screens. We want more financial information in the system. We soon need to declare the first DBC costs out of YBoard. In our view, the layout is clear and simple, but there is still some work to do on the different selections. It is great however that we can download our selection in CSV format."

5NoorderCare: "Unfortunately we did not have time to go through the system beforehand, so this will be the first impression. On this first impression it looks good, with a clear distinction between clients, employees and currently most importantly: DBC's."

2OsiraCare: "We did not watch the management screens online, because we are still implementing YBoard. Not everybody has yet access to the YBoard system. What we see of the sketches is that it is very specific, maybe even too specific."

Client selection

4FlorenceCare: "In addition to the medical policy and reanimation headings, it is also important to add a heading for compulsory hospitalization. For some of the clients in the nursing homes the admission is compulsory, for example for elderly with dementia. It is important that the status of this is entered in the dossier. Further, the client selection is very extensive and most certainly helpful for doctors. It is a great tool to check the completeness of the dossier. "

5NoorderCare: "The big absentee in this list of selections is the heading for compulsory hospitalization. This will get more and more important, because there is a change in the law on this point underway. The selection with the different therapists is in our case too extensive. In addition to a music therapist, we have certain other therapists. They do not have to be named all separately. This can be on a joint heading 'therapists'."

2OsiraCare: "This list with selections is extensive, maybe even too extensive. It is a good thing that the headings which are not used can be folded. This makes it stay clear. On certain wards it is mandatory to have a compulsory hospitalization declaration. A compulsory hospitalization heading is most certainly a good extension to the current list of selections. With this client selection, the record keeping per ward can be checked. This is a needed function."

Employee selection

4FlorenceCare: "The male/female selection is a unnecessary addition to the employee selection. Interesting information on the employee selection is in our view for example: How many physiotherapists have a treatment relation with a certain client. It would also be interesting to see a list of all the medical professionals to do comparisons on workload, and treatment relationships with clients."

5NoorderCare: "It would be interesting to see if all the employees adhere to their own agreements. When there is the agreement to use certain forms in a particular group of employees, does everybody use those forms? It would also be useful to see the number of reports and clients per employee. This is useful for the managers, but also for the employees themselves."

2OsiraCare: "Interesting information would be how much time employees spend on direct and indirect work. It would also be a good addition to see if there are enough reports written by the employees. It is not

necessary to lead this back to certain employees; it would be enough to see this information by discipline per ward.

DBC selection

4FlorenceCare: "The DBC group is an important and a new group of clients. Depending on the amount of healthcare given to DBC clients, we get paid from the insurer. It is important that every employee keeps track and reports his or hers work regarding to DBC clients. What we miss in this screen is more financial information. A DBC route can be declared by the insurer when it is closed for 42 days. For us, it is important to see which routes are closed and are ready for declaration. In the screens now developed, we can see for how long clients are treated, but we cannot see how much that treatment will yield. We want to see of our costs and earnings are in line with each other. "

5NoorderCare: "We compared the selection possibilities in the YBoard management screens with our own wishes, and that turned out to be in high accordance. We do not particularly want financial information in YBoard, because we have other systems to take care of that. An interesting point can be an overview in absence days. The absence days are visible per client, but an overall view per location can be interesting. This does not have priority. All in all, the selection criteria are complete enough for now."

2OsiraCare: "The first use of this management tool is that we are able to see whether employees even register any hours. This is important for the declaration in a later stadium. In the diagnose heading, there is now a choice between only two options. There is a formal classification in four options, it would be better to use that formal classification."

Other remarks

4FlorenceCare: "It is very helpful that there is an export to Excel function. In that way we can do our own company-specific calculations on the data. The system now developed is a very extensive tool for doctors and other practitioners, but in our view not so much for other managers. We want to make our financial reports in YBoard, and use the management tool for these reports. Therefore, in our view it would be useful to make a fourth group in the first step, called financial."

5NoorderCare: "Is would be a great addition when it is possible to make an Excel sheet from the information in the management tool. We are happy with what is developed now, although we see that there is still some work needed to be done. It is important to realize that the information now presented in a line chart, are in fact separate dots. A bar graph would be more appropriate on this point."

2OsiraCare: "The answers you get on the interviews may be coloured because of the people you contacted for the interviews. It is possible that I focus on different points than other (future) users of the system. However, the first sketches are very promising and it is good to see that this first part of the system is ready for use. It is especially good to check the completeness of the client dossiers."

Evaluation summary

The second round of interviews confirmed that a good start with designing the dashboard had been made, but there was still work to be done.

General impression - The overall general impression of the management screens appeared to be good. The team at *4FlorenceCare* however, indicated that they expected more financial information. If and how this financial information belongs in the YBoard management system is a point of discussion, because most of

the YBoard clients do have other systems which provide them with financial management information from different sources. This is beyond the scope of this research.

Client selection - The client selection is one of the biggest and the most complete of the selections in the management screens. The interviewees endorsed the possibility of checking the records with this selection. They unanimously stressed the point that they missed the heading for compulsory hospitalization. This is a selection criterion which most certainly has to be added in the near future.

Employee selection - The employee selection was the one where the least selection criteria were possible. The most welcome addition here was to see which (groups of) practitioners had how many clinical relationships with clients. In that way, it is possible for the managers to see if there is any difference between different locations and practitioner groups. For most of the managers, it was not really needed to see this on an individual personnel level.

DBC selection - The DBC selection was the most discussed selection of all the interviews. This is because the DBC legislation is new since January 1ste 2013, and most of the companies have still to find their way of working with it. A welcome addition to the system would be an overview of which routes are ready to be invoiced. Those are the records which have been closed for at least 42 days. Another addition would be to show what the financial gains or losses are of the entire DBC sections. To accomplish this, a number of links between different systems are needed. It is not clear if this will be part of the YBoard system, being in essence an electronic healthcare record system.

Other remarks - As it has been shown, a welcome part of the system is the possibility of making an Excel export of the selection. Most of the managers, and controllers, in particular, want to do the calculations for their own company for a specific date, which is not possible without a database export. Also, ad-hoc hypothesis testing guided by knowledge discovery methods such as CRISP-DM or 3PM (*e.g.* Vleugel *et al.*, 2010) needs to be accomodated. Furthermore, for the interviewees it was difficult to determine which parts belonged to the management screens and which to other YBoard system parts. The interviewer had to point out multiple times in each interview that the particular question was outside the scope of that interview.

Overall the interviewees where happy with the first results, but they stressed that it was important that more development needs to be done on the tool to support extra features.

CONCLUSION

This research focused on an effective and efficient dashboard design for chronic and long-term healthcare. The result of this work was the actual design and realization of the management dashboard for the YBoard 2.0 system. The design decisions in this investigation were based on human perception and computer interaction theory—in particular Gestalt theory—whereas the empirical interviews with medical professionals supplied valuable additional insights into what the users wanted to see in a dashboard in their daily practices. This study shows how effective and efficient dashboard design can benefit from theoretical insights related to human perception and computer interaction such as Gestalt theory, in combination with integrated end user requirements from daily practices.

FUTURE RESEARCH DIRECTIONS

A problem with this way of working is that all end users have different views on the dashboard, depending on his or her position within the organization. For a controller, financial information is essential. For a practitioner, completeness of the medical record is crucial. Future research could, therefore, focus on better alignment of Business Intelligence end-users, tasks and technologies (Tijssen *et al.*, 2011). This, in turn, might then facilitate the transition towards a more data-driven health practice (Menger *et al.*, 2016).

Obviously, it is really valuable to investigate a complete software development cycle within the scope of the research, to be able to interact with the end users from solliciting requirements to evaluating a working version of the proposed system. The evaluated version, however, remains under constant development and it is important for the developers to remain aware of the designs presented here. Otherwise, it is not unlikely that, should developers loose track of the reasoning behind certain design decisions over time, this might ultimately result in an increasingly less user-friendly system in the future. Future research could, therefore, focus on maturing the organization's software product management function to incrementally assess and improve the YBoard development process, taking into account requirements management, release planning, and product planning (Bekkers & Spruit, 2010). Ideally, this improvement process should be executed based on the organization's unique set of characteristics to avoid negative consequences such as unnecessary implementation of capabilities, and the wrong order of priority when implementing capabilities or over-implementing of capabilities (Baars *et al.*, 2016).

To conclude, in the YBoard dashboard we attempted to take all the wishes of the potential end users of the system into account. It is designed to be flexible and extendable, i.e. with more specific selections and more kinds of X-axes. Extending the design will be an on-going process, as is the whole development of YBoard. Because of the design choice to position YBoard and the electronic health record 'in the cloud' as a SaaS solution, accomplishing this on-going extension process will be easy. One pitfall of this constant extension of the system may be to listen too much to users' wishes. In some cases, users want extensions to the dashboard which do not belong in this dashboard. An example of this is integration of extensive financial information. In most cases, users have other systems which should provide them with this financial information. After all, it is a dashboard for managers in the healthcare. Therefore, we argue that effective and efficient dashboard design should always build upon theoretical insights from relevant research fields related to human perception and computer interaction, as well as sollicit and integrate end user requirements from daily practices.

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