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Human-Centered Computing (HCC)

Designing and Implementing a Descriptive User Dashboard as a Basis for Reflective Learning

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Abstract

Physicians tend to be occupied throughout their work days and have little time to reflect on events that occur throughout the day. During the process of reflection one thinks deeply about previous experiences and from this deliberation extract new insights and ideas which could lead to a change, for example in behavior or thought process. The scenario in which this thesis paper is based on is that assistant physicians ask the DocTalk chatbot questions as needed, usually pertaining to diseases and symptoms. Their specific questions are then taken and visualizations are created and put within a user dashboard using Grafana to aid in their reflection over their personal questions. The goal is to find out the extent to which the dashboard motivated reflective learning through reaching the different levels of reflection based on Fleck and Fitzpatricks framework [15]. The Human Centered Design process was used to collect information and create the dashboard prototype using expert interviews, researching similar software, electronic journals, and creating design rationales. The resulting user dashboard is then evaluated using synchronous remote usability testing with user participation in a controlled setting. The participants were not interested in the visualizations pertaining to the timing of their questions, but instead preferred visualizations related to the content of their questions and found the user dashboard to be overall favorable. The R0 level of reflection was met, along with signs of R1 as well. The dashboard supports the foundation for further reflection levels and can be expanded on in the future.

Zusammenfassung

Ärzte sind in der Regel während ihres gesamten Arbeitstages beschäftigt und haben wenig Zeit, über die Ereignisse des Tages nachzudenken. Während des Reflexionsprozesses denkt man tiefgründig über frühere Erfahrungen nach und gewinnt aus diesen Überlegungen neue Einsichten und Ideen, die zu einer Veränderung führen könnten, zum Beispiel im Verhalten oder im Denkprozess. Das Szenario, das diesem Bachelorarbeit zugrunde liegt, ist dass Assistenzärzte dem DocTalk Chatbot bei Bedarf Fragen stellen, die sich meist auf Krankheiten und Symptome beziehen. Ihre spezifischen Fragen werden dann aufgegriffen und in einem Benutzer Dashboard mit Grafana visualisiert, um sie bei der Reflexion über ihre persönlichen Fragen zu unterstützen. Ziel ist es, herauszufinden, inwieweit das Dashboard das reflektierende Lernen durch das Erreichen der verschiedenen Reflexionsebenen auf der Grundlage von Fleck und Fitzpatricks [15] Rahmen motiviert. Der Human Centered Design Prozess wurde verwendet, um Informationen zu sammeln und den Dashboard Prototyp zu erstellen. Dazu wurden Experteninterviews geführt, ähnliche Software recherchiert, elektronische Journale ausgefüllt und Design-Begründungen erstellt. Das resultierende Benutzer-Dashboard wurde dann durch synchrone Remote Usability Tests unter Beteiligung der Benutzer in einer kontrollierten Umgebung evaluiert. Die Teilnehmer waren nicht an den Visualisierungen zum Zeitpunkt ihrer Fragen interessiert, sondern bevorzugten stattdessen Visualisierungen zum Inhalt ihrer Fragen und fanden das Benutzer Dashboard insgesamt positiv. Die Reflexionsebene R0 wurde erfüllt, und es gab auch Anzeichen für die Ebene R1. Das Dashboard bildet die Grundlage für weitere Reflexionsstufen und kann in Zukunft weiter ausgebaut werden.

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1 Introduction

This introduction section brings up reasons for the project creation for this thesis paper. First the motivation and case description explains the scenario and leads reasons for the projects creation, then the specific goals and research questions are presented to provide an overview of the background information.

1.1 Motivation

The field of Human Computer Interaction studies the multitude of options in which humans and computers interact with one another. One possibility is through the use of a conversational interface, for example a chatbot, which opens up a whole new array of opportunities to explore the possibilities of interaction. An example of a theoretical background that aids in exploring the benefits of these options, along with its shortcomings, are through reflective learning. According to Baumer et al., reflection consists of "reviewing a series of previous experiences, events, stories, etc., and putting them together in such a way as to come to a better understanding or to gain some sort of insight" [9].

There are many approaches to encourage reflection. Li et al. states that personal informatics consists of data collection, reflection, and elaboration on personal data in order to gain a deeper understanding of oneself [20]. Li et al. continue by mentioning that their aim is to discover insights and understand oneself through the collection of personal data, and that users can explore patterns and trends in their personal data with the assistance of information visualizations [20]. Since a main component of reflection is reviewing information from the past, and our focus in this paper is on the personal information of assistant physicians, one approach to help this reflection is through the use of visualizations, which help them explore their personal data. Using this, data from a user is first collected and stored and is then revealed to the user in visualizations, typically using various types of graphs. According to Nussbaumer, information visualisations are "the transformation of abstract data and information into a form that can be recognised and understood by humans. In this sense, information visualisation can be seen as an interface to abstract information spaces" [24]. Once information is collected from a user, the information itself will have to be abstracted to become more understandable for the user, and through this they can then explore and learn from this interface of processed information. Using this idea, patterns in behaviour and trends over time can be viewed and explored, which would normally be difficult to do without the aid of technology.

1.2 Case Description

One field where reflective learning is especially important is in the field of medicine. Gustafsson et al. mentions that life-long learning is essential for professionals in a field where change is constant, allowing them to prepare for this change [17]. Physicians are constantly learning and have a continual influx of new information each day. Time critical situations can occur frequently throughout the day, not leaving many opportunities for assistant physicians to speak and reflect with senior physicians. They can receive extra assistance and information through the use of chatbots and other resources. It can be difficult to gain an overview of all of their information and experiences, especially when they tend to be actively engaged in their work and not have much spare time to analyze and reflect on their data. Dashboards serve to inspire awareness, understanding, and reflection, according to Verbert et al., as a result of acquiring and visualizing learning activities [30]. A user dashboard is a page that one can examine where data is displayed to the user through information visualizations. This allows important data to clearly and swiftly be viewed by the user and give an overview of information which can keep assistant physicians informed and can allow them to reflect throughout the day.

One possible scenario for the DocTalk chatbot is that residents ask it questions pertaining to specific diseases and possible symptoms related to a disease. They might ask questions whenever they need assistance, and they will receive a response via Amboss. The focus here will be on the types of topics and questions the residents would ask the chatbot, along with how the user interacts with the user dashboard. The initial plan is that the participants use the dashboard primarily for reflection level 0, where information is kept as a reference for the future, which is in itself not reflective [15]. As to how deep the resulting reflection goes, for example if it surpasses the lowest level of reflection, will be examined throughout the study.

1.3 Goals

The aim of this bachelor thesis is to create a user dashboard, using Grafana [3], for assistant physicians which visualizes important information about their DocTalk chatbot interactions clearly and concisely to possibly aid in their reflection. The Human Centered Design approach will be used throughout the whole process. According to the ISO 9241-210:2019 international standards, one type of design that is applied to systems design and development is “Human Centered Design”, which focuses on how people interact with interactive systems, and also applies knowledge and techniques related to usability and human factors with the goal of making these systems more usable [16]. These international standards continue to describe interactive systems, which enable users to accomplish distinct goals through interaction with the system, and usability which is the degree in which a system, product or service can be used

efficiently, effectively, and with satisfaction by established users in a particular context [16]. To further elaborate on the three aspects of usability, the international standards define effectiveness as the level of accuracy and completeness a user obtained while completing a goal, efficiency as what resources were needed to complete the goal, and satisfaction as the extent to which a users needs and expectations are met through the system [16].

Based on the methodology of the Human Centered Design definition, throughout the process of creating the user dashboard the different types of visualizations that were used were based on the information and opinions collected from the participants throughout the whole process. Some examples for data that was collected are the types of information the participants are interested in receiving from the chatbot and the types of questions they might ask, which will be collected through the use of an electronic journal over the course of eight days.

Through creating and implementing this user dashboard, the goal is that assistant physicians will have the opportunity to explore their personal information and interactions with the DocTalk chatbot and become aware of trends and patterns that they might not otherwise have noticed. The creation of this prototype will be based on the results of expert interviews, similar software research, related literature, and design rationales. Some possible examples of realizations are that they become more aware of the types of questions they ask the chatbot, or that they use certain keywords very often. Becoming aware of this could help them tweak their behaviors and habits in a positive way, if that is what they desire. This could be, for example, reformulating their questions to the chatbot.

Some central questions are: what types of information based on their chatbot messages are users most interested in viewing? What types of questions will the users want to ask the chatbot throughout their day? How deep will the resulting reflection go, based on the levels of reflection from Fleck and Fitzpatrick [15]? The primary central research question is: how far can the user dashboard, a planned feature of the DocTalk chatbot, visualize information using Grafana as a result of their conversations with the chatbot, and with these results lead to reflection in assistant physicians on the different levels based on the framework from Fleck and Fitzpatrick [15] and thus motivate reflective learning?

2 Related Work

This section provides a short introduction into the topic of reflective learning and continues by describing some of the vast array of existing literature on topics such as user dashboards, reflective technologies, reflective learning, and design elements for the project, and ends with a list of collected requirements for the user dashboard based on the research. All sections take related works and use it as a basis for explanations and some design decisions for the dashboard.

2.1 Reflective Learning

Information can be collected from interactions between humans and chatbots and the findings can be visualized back to the users. Through this, it can form a basis for reflection that has the opportunity to, but must not necessarily, lead to reflective learning. According to Boud et al., "reflection in the context of learning is a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations" [10]. Boyd and Fales state that "Reflective learning is the process of internally examining and exploring an issue of concern, triggered by an experience, which creates and clarifies meaning in terms of self, and which results in a changed conceptual perspective" and "Reflective learning emphasizes the self as the source of learning and is, therefore, inherently an individual and ipsative process" [11]. Reflective learning is focused on the individual and their personal experiences. They explore these experiences and can come to conclusions about their behaviors and actions. Depending on how they receive and process this information, they may learn from these conclusions and take action, possibly by revising something about themselves, for example the learner's perspective and perception of knowledge and behavior.

2.2 Literature Review

One definition of reflection, as stated by the Cambridge Dictionary, is "serious and careful thought". [1] A universal definition of reflection, however, doesn't seem to exist. According to Fleck and Fitzpatrick there is a lack of clarity in HCI literature in the interpretation of reflection, and there is little value in defending or synthesizing one definition for reflection; it would be more fruitful to instead synthesize several aspects of reflection based on literature

[1] https://dictionary.cambridge.org/dictionary/english/reflection

for design considerations [15]. In almost every article or paper, there appears to be a different definition for reflection. One could try to find the "best" definition or merge them all together, but that would not help the search for effective and supportive design decisions for reflection. Here a few different definitions for reflection will be mentioned to provide an idea of the different interpretations in literature and what could be focused on, but these ideas will be looked into further to extract more concrete ideas to be implemented within the user dashboard.

The definition of reflection by Prilla et al. states "Reflection is a frequent and ubiquitous task performed explicitly and (more often) implicitly during and after everyday work: People think about whether they acted appropriately in a certain situation [...] and how things can be improved" [26]. This definition is more work focused, emphasizing that reflection can occur in different work scenarios daily. It consists of thinking back to something that happened and analysing it, and coming to new insights about the topic. Baumer et al. also feel that in literature there is not an explicit definition for reflection, and often felt there was not even a definition at all [9]. They define reflection as "reviewing a series of previous experiences, events, stories, etc., and putting them together in such a way as to come to a better understanding or to gain some sort of insight" [9]. This definition is similar to the last one, except it is not work based and has to do with every aspect of a persons life. It does however have the same premise of thinking back to something, analysing it, and coming to new insights. The definition from Daudelin states that "When a person engages in reflection, he or she takes an experience from the outside world, brings it inside the mind, turns it over, makes connections to other experiences, and filters it through personal biases" [13]. This definition emphasizes the focus on one experience and analysing an experience in great detail, as opposed to multiple experiences in the manner of the definition from Baumer et al. [9]. It also mentions a point that the others do not, that it needs to go through personal biases, since each person has their own thoughts, feelings, and opinions that can affect how they process information and come to new conclusions.

According to Fleck and Fitzpatrick, there are different levels of reflection, with the lowest level of reflection called R0 [15]. This level consists of the documentation of events that occurred, which can then be reviewed at a later time. Fleck and Fitzpatrick explain further that this level in itself is not reflective, however it has the possibility to, but does not necessarily have to, spark reflection in one of the higher levels: for example level R1 where there are explanations in addition to the documentation, level R2 where relationships between information is explored, level R3 where reflection has the intent of changing something, and level R4 which also includes social and ethical implications [15]. This documentation of information assists memory since people need not remember every piece of new information and it allows them to re-

view it as needed. These levels of reflection will be a basis for comparison to analyze how far the reflection resulting from the user dashboard will go, if at all. The main goal is to provide a foundation for level R0, any higher reflection levels would be a bonus.

Prilla et al. state that "Returning to own experiences is central to reflection, but human memory is limited: memories fade and thus, returning to past experiences is hard. Therefore, reflection can be supported with data describing past experiences" [26]. Li et al. also write about human memory, how "people have limited memory, cannot directly observe some behaviors [...], and may not have the time to constantly and consistently observe some behaviors" [19]. Pirzadeh et al. mention on a similar note that disadvantages of depending on memory could be to fail to remember or overlook certain information and have an inability to notice patterns and trends [25]. According to Dr.McLeod, humans can only hold a limited amount of information in their minds, with the average adult able to keep seven, plus or minus two, items in their short term memory. [2] If people would try to remember every experience that happened throughout the day or every message they received, it would be impossible to keep it all in conscious memory and recall it at any given moment, especially with a constant influx of new information. Providing a space for these new experiences to be collected and reviewed when needed would greatly help reduce the strain of new information, along with aid the ease in comparison of separate moments which would then be all placed together as opposed to all moments just being in ones memory, making it more difficult to compare and find patterns.

Müller states that on-the-job training is an important element for medical professionals to gain experience, for example learning to work with residents and patients, and self-reflection can support this process [23]. The assistant physicians, however, might be too busy with their daily work and studies which results in them not being aware of their habits and possibly not having the time or energy to conduct these reflective practices. According to Sengers et al. it is important to bring "unconscious aspects of experience to conscious awareness, thereby making them available for conscious choice" [29]. By visualizing and disclosing information this brings it to users attention and helps them become aware of new information that they might not otherwise have noticed, for example their habits and behaviors, and they can then reflect on the given information and can decide for themselves if they would want to take action and change something. This can be supported through exploring organized knowledge, for example collecting personal data about a user and turning it into graphs. Data visualization is also very helpful because, according to Li et al., observations may be incorrectly interpreted by individuals because they lack the ability and proficiency to do so [19]. By extracting relevant information about the user and conveying it with visualizations that the user can

[2] https://www.simplypsychology.org/short-term-memory.html

understand and interact with, this provides users with assistance and guidance on where to focus their reflections.

Li et al. state that personal informatics systems involve the systematic collection and analysis of information related to oneself, which enables self reflection and awareness [19], and Baumer et al. mention that personal informatics involves "collection of data about the self followed by presentation of the data back to the self" [9]. The data that is collected from users are processed, put into graphs to make the data more understandable, and shown back to the user. This allows them to explore and process their personal information and possibly gain a new and better understanding about themselves, perhaps leading to reflection. The key point here is that it all revolves around the user; they input information or it gets collected, and the results are then projected back to that same user. We also do not know a lot of things about ourselves, for example some aspects we might not notice, and others we might not want to notice which we unintentionally ignore. By bringing these aspects to our attention we can become aware of it and come to new understandings.

Boud et al. state that when re-examining something from the past, to find out if these associations are worthwhile and beneficial to users they must be processed; this can be encouraged through visual tools which illustrate associations and correlations between different pieces of information, helping users connect seemingly disparate pieces of knowledge so they can visualize associations between them [10]. This emphasizes what was discussed earlier, that it is important to bring certain information to the users awareness and help them see patterns and trends, which also further points to the use of information visualizations. Sometimes seeing individual information pieces will mean nothing to the user, however once it is combined in a helpful way the user will realize they do have meaning together. This will assist in the processing of information, and thus could help lead the user to new understandings and reflections about their data and themselves. Rivera-Pelayo et al. explains the aspect of context relating to the revisiting of experiences, how values can be compared with one another, and through this trends and outliers can be seen [27]. This contextual focus is also supported throughout the use of a dashboard and visualizations, which greatly eases the discovery of these trends and outliers as one can usually see this immediately while looking at a graph or a series of graphs. Finding these specific traits can further bring people to notice new insights.

Mcmillan explains that participation is a function of user control [22], and according to Wise and Reeves, through interactive technology users can control their experience with the system through being able to choose when they want information to be presented to them [31]. As for customization, Shade states that giving users an option to customize an interface enables them to choose and arrange what they would prefer to view and customize the information displayed to them, thus giving users control over their interactions and

improving their experience with the system [8]. Shade also states that personalization primarily involves matching tailored content to specific needs and interests of users without any effort on the part of the users [8]. Users should have some control over what they see, which will aid in providing the feeling of personalized customization. Santos et al. mention that users should not be given a white screen and be expected to customize an entire application on their own, they need to be provided with a starting point; they also mention that dashboard personalization enables users to pick which visualizations they want to view based on their specific goals and backgrounds [28]. Even though users require some guidance, they should not have everything predetermined for them. A standardized starting view has to be given to the users first, but then providing the users with options to move visualizations around within the user dashboard based on their personal preferences are an important option to give them and also provides an increased feel of user control and customization.

Mann et al. discuss some problems that can arise during the attempt of reflection: users can have many different learning styles, and each user will perceive and process a problem differently [21]. What may help one user reflect will not necessarily help or could hinder another user. The user dashboard has a few modes of interaction and customization, but as a result of it having a more limited scope it might not help every user, both with learning and reflecting. The user dashboard has a focus on the visual representation of information, which will be more helpful to some users than others.

2.3 Requirements

Based on the reviewed literature and different opinions and examples that were found, for this thesis paper an informed decision was made to create a user dashboard with information visualizations which will help support their memory, based on ideas from Prilla et al. [26] and Li et al. [19] [20], and to gain insights into participants' opinions throughout the entire process. The participants will be given an initial standardized starting view filled with a few visualizations, which they will then have the option to customize by moving the visualizations around, both ideas taken from Santos et al. [28]. They are also provided with options for customization, idea from Amy Shade [8] which, through support found in literature, can be beneficial for the participants. As a result of this, opportunities to personalize the user dashboard will be given to the participats, taken from Santos et al. [28]. This will allow them to explore their personal information, which will both keep their actions documented as well as present them with information they may not have previously realized, and should provide them with an increased feeling of user control, taken from Mcmillan [22] and Wise and Reeves [31]. The possible resulting reflection will be compared to the levels of reflection by Fleck and Fitzpatrick [15].

3 Procedure

This section goes through all the different steps that were achieved throughout the process of creating and testing the project. As mentioned and defined earlier in Section 1.3: Goals, the Human Centered Design process was integrated into each step of creating the user dashboard, meaning users were involved in each step of the procedure. Steps of the Human Centered Design Process according to the ISO 9241-210:2019 international standards are: determine the context in which the project will be used, identify the requirements of the user, and develop and evaluate design solutions based on these requirements [16]. This lead to expert interviews being held and design requirements being derived early on before any concrete plans were made for the dashboard. After thorough research into literature, a list of requirements for the user dashboard was created: memory support, standardized starting view, customization, personlization, interactivity, information exploration, user control, and levels of reflection. This was mentioned in further detail in Section 2.3.

3.1 Expert Interviews

After the requirements were derived, structured expert interviews with prepared questions were then conducted with two Charité project members. The English version of the expert interview questions is appended as Appendix Part One, in Section 5.1. The expert interviews were recorded and later transcribed and the results analysed. The questions for this were created in such a way as to gain an insight into: Figure 5.2 section 3 how the physicians currently think about past events, Figure 5.1 section 2 questions they might have during their work day, Figure 5.2 section 4 find out the ways in which they already track information and what specifically they track, and Figure 5.3 learn about existing dashboards that they use. At the end of each expert interview, see Figures 5.4- 5.6, two existing user dashboards were shown to the participants to collect ideas of their preferences and where they lost interest about sections of the dashboards and as to whether it was understandable, to gain more of an idea of how the user dashboard for this thesis should be created and what should be avoided. These dashboards were chosen based on research into similar software. The dashboards that were shown was Daylio [7], a mood tracker where just screenshots of the dashboard were shown, and Faction A [4], a natural language dashboard focusing on online retail where an example of the dashboard can be found online and can be directly interacted with. The project members also had the opportunity to give their opinions, insights, and

thoughts throughout the expert interviews and also as they used and explored the existing user dashboards.

Due to the limited number of participants, advanced evaluation techniques cannot be used here. The results of the expert interviews showed a mix of similar but also contradicting opinions. Similarities showed up when both participants either mentioned the exact same opinion, or they both made statements that were going in the same direction. For example both project members mentioned that they do not ask questions during specific periods of the day, but instead spontaneously. They both tended to ask questions about symptoms, medications, and diseases that they do not know too well. They thought back to experiences and conversations mainly when it was complicated, and when they did not know something they would look it up more in detail later. Both track their steps mainly to support their personal health, for example they get a notification whenever they have not walked much that day, and they can see visualizations about their steps. As to what they would prefer to see in the dashboard about their questions to the chatbot, they were both interested in viewing the previous questions that they have asked.

Contradicting opinions appeared when each participant mentioned opposite thoughts, had differing preferences, or only one participant mentioned something. Some differences are that participant 2 (P2) asks multiple questions throughout the day whereas participant 1 (P1) usually only asks about one question per day. P2 mentioned that she felt too busy to track a lot of information or goals. P1 would be interested in seeing, related to the questions that she asks, the most asked questions and answers along with recommended literature, which she feels would help save time and find answers quicker; P2 would be interested in viewing her questions, and have options to rate and save the answers she receives, which she feels would aid in memory and learning progression. Out of the two existing dashboards that were shown, P1 preferred the mood dashboard because it had a good overview, was easy to understand, and had good visualizations, but did not take an interest in the online retail dashboard because it lacked a good overview, was difficult to understand, and was too complicated. On the other hand, P2 took no interest in the first dashboard because it felt too playful and not professional enough for a medical environment, but on the other hand favored the online retail dashboard because of the clear design; she found the visualizations interesting, and imagined how it could be used with her questions, but she also felt the dashboard was a little complicated and overwhelming. The stark difference in opinion between the two existing dashboards shows how each person has different preferences, and it would be difficult to come up with a universal dashboard for everyone without providing some modes of customization and personalization, which could also help each persons specific goals and allow them to view what they desire.

After the expert interviews the project members were asked to fill out an

electronic journal during eight work days. They were not asked to restrict themselves to the diseases and symptoms questions of the project scenario, but instead to just write down any questions that come to mind as to not influence what they would write down. Journaling, according to Pirzadeh et al., is a method that provides a way to record stories about a persons own experiences, speculations, and observations and understand them [25]. They were given an excel document and asked to input the time they had the question, the question itself that they would want to ask the DocTalk chatbot, and any other comments they had.

3.2 Design Rationales

Based on the reviewed literature, research into similar software, and the expert interview results, design requirements were identified and translated to design rationales, see Section 2.3 and 3.1 for more details. The design rationale diagram can be seen in Figure 3.1, here the graphical issue-based information system, or gIBIS [14] structure is used which is a process oriented technique where issues/design questions (chat bubbles), positions/possible solutions to these design questions (ovals), and arguments that support or object the positions (green and red rectangles, respectively) are used. This helps explain the reasons behind the design decisions for the user dashboard.

One example from the design rationale to help understand the flow is: creating a user dashboard is the starting point from which all design decisions originate. One design question here would be what platform should the dashboard be created on, possible solutions being Grafana or Rasa Open Source. Rasa Open Source is used by the chatbot but is complicated and takes time whereas Grafana is simple to use both for creator and user but has limited customization options. This is however the better choice for the thesis and one can then look at the argument simple for user use, and a further design question that arises is what interaction options the user should have, and so forth. The chosen design solutions are shaded blue.

3.3 Design and Implementation

Based on the design rationale described in Section 3.2, Grafana [3] was used for the creation of the user dashboard prototype. Grafana is an open source software that allows users to create visualizations of their choosing and work with analytics. With Grafana one can use many different options of data sources where each has different uses, for example: Google Cloud Monitoring [1], MySQL [6], and TestData [2]. It is mostly focused on time-series data, but with the TestData database one can input their own data and thus expand the options of visualizations that can be created and presented to users.

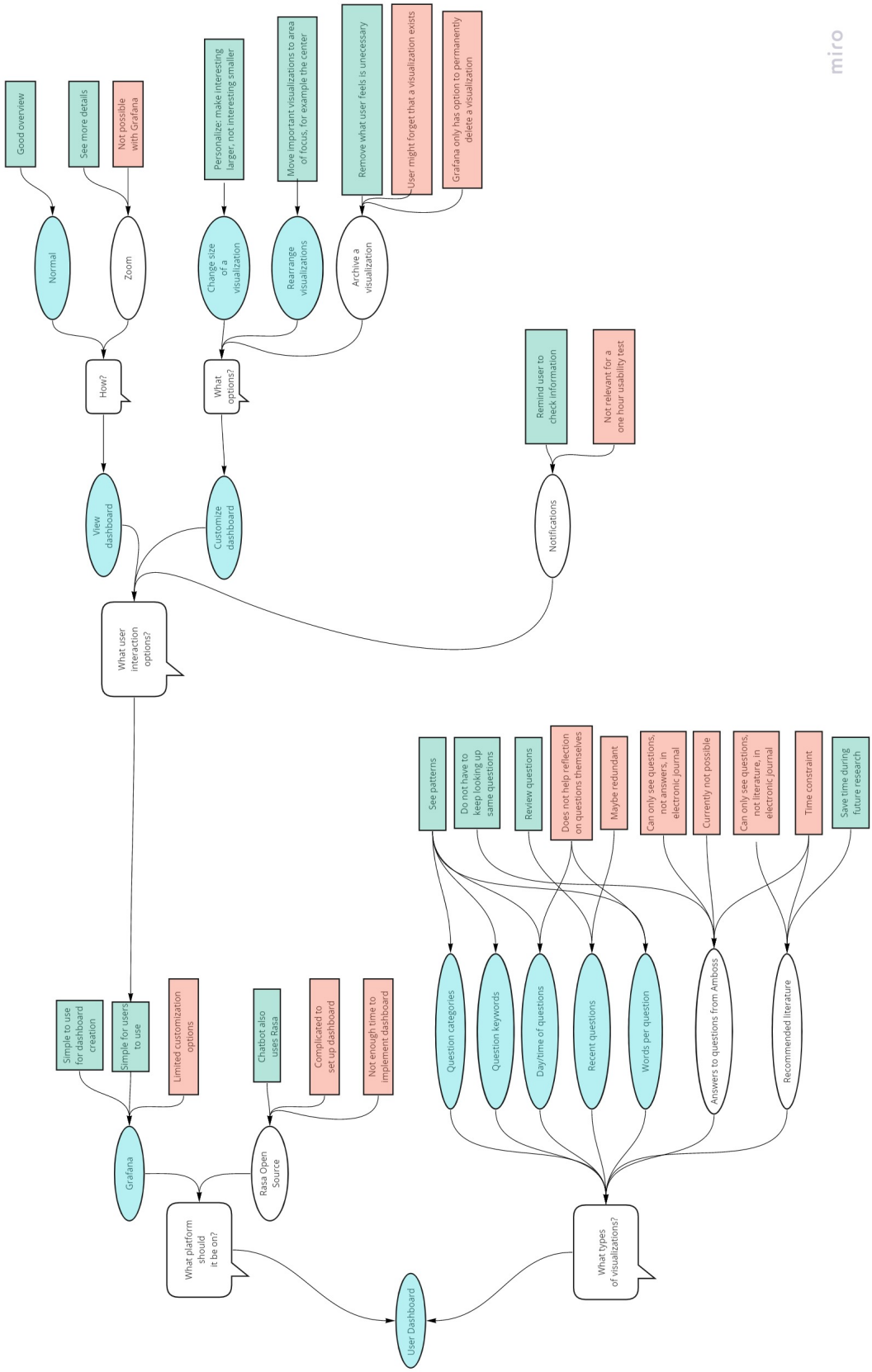

Figure 3.1: gIBIS Design Rationale, created using Miro [5]

The visualizations were created using data based on the questions that the participants kept track of in a journal for eight days, which hopefully sparks analysis and new insights. The visualizations can be added using an "Add Panel" option and the visualization type determined using a drop down menu option provided by Grafana. The TestData database was utilized because through this, under a "Scenario" option, "CSV content" can be chosen to manually input the collected data to create the visualizations. The size of each individual visualization can be edited by the user at any time along with the overall layout of the dashboard. The same types of visualizations and standardized starting view was given to each participant, the difference being that the data for each graph was based on the questions of the respective participant.

Further design decisions that were affected through the evaluation of design rationales were that all the listed visualization ideas were implemented, except for showing the answers the participants received from Amboss and the recommended literature based on their questions. These were left out because it was not possible to collect all the needed information. Additionally to this, the electronic journals only contained the questions of the participants. The remaining visualization ideas were kept because it seems that they could spark reflective thought in the participants along with help them see patterns in their questions. As to Grafana itself, for viewing the dashboard participants could either view it normally or zoom in on a part of it. The zoom option could not be found in Grafana so it was left out. It was debated if notifications should be included, which could assist users in remembering to check the dashboard, but seeing as the usability test would only be around an hour per person, it would serve no purpose and was left out. For customization options, users could change the size of visualizations, which allows them to increase the size of what they find interesting, and they could move the visualizations around so that their preferences could be in the center of their focus. Archiving a visualization would also be a good option for users who could then hide that which they would not want to see. Unfortunately Grafana only had the option to permanently delete visualizations, so this option was left out.

The dashboard fulfills the requirement of memory support since it stores the information and presents it back to the user. Each participant was given a predetermined standardized starting view which they could then customize based on their own personal wishes by moving around and resizing the visualizations, which also provides the feeling of user control. Based on the opinions of the participants during the expert interviews, their previous questions are listed in one visualization. A compromise was attempted to be reached between the two previously shown dashboards during the expert interviews, where there would be a balance in the amount of shown information but still look professional and understandable.

The layout of the specific visualizations were not put in any specific order, and it was attempted to make them all around the same size and fill out

the screen as best as possible. Presented in Figure 3.2 and 3.3 are the two extended versions of the user dashboards which also contain dummy data as if the electronic journals were filled out over multiple weeks, the first one being for participant 1 and then the second for participant 2:

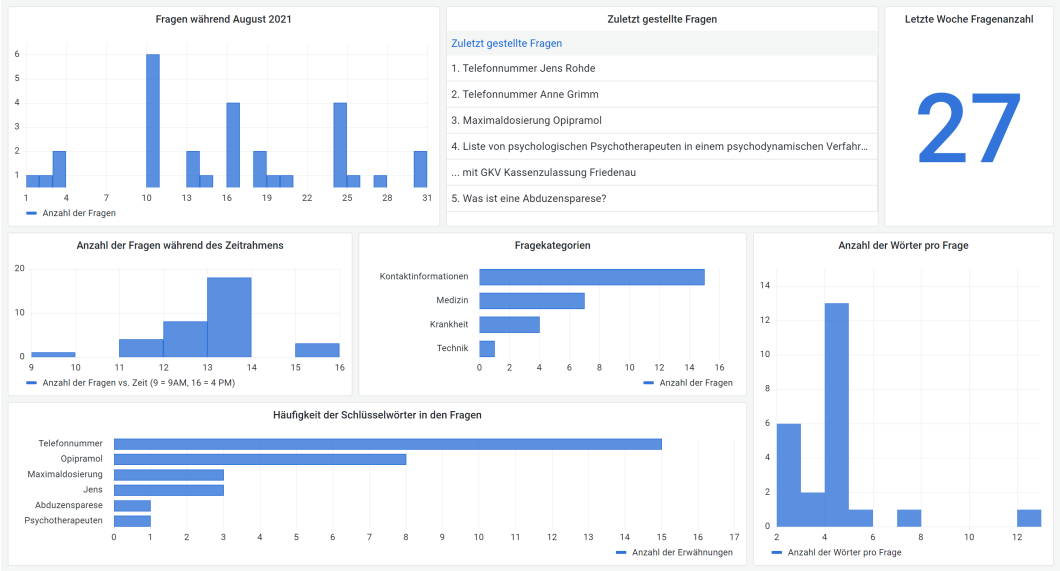

Figure 3.2: Dashboard: Participant 1

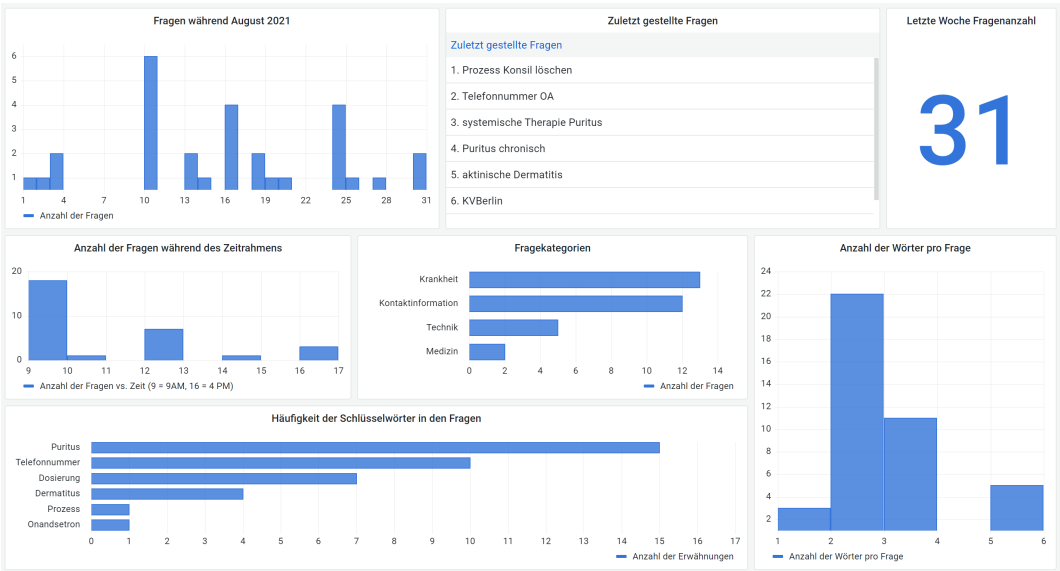

Figure 3.3: Dashboard: Participant 2

3.4 Usability Testing

The implemented user dashboard was then evaluated using synchronous remote usability testing with user participation in a controlled setting. The English version of the procedure and questions is appended as Appendix Part Two, in Section 5.2. The participants signed letters of consent and online meetings were held where the participants shared their screen and audio, which was recorded and later transcribed. The participants were the same project

members that were interviewed earlier in the process. The two members were shown dashboards based on their own respective questions. They were first told a short scenario out loud, seen in Figure 5.7 section 1d: that they have been asking questions to the DocTalk chatbot for multiple weeks and that their data was collected and turned into this user dashboard. They had a spare minute and decided to check the dashboard to gain insights into their questions. First they were shown a simpler version of the dashboard that was just based on their questions, and then shown an extended version of the dashboard with extra visualizations and extra dummy data that shows how the dashboard could appear if it was used over the course of multiple weeks, see Figure 3.2 and 3.3. In combination with observing the participants interactions with the dashboard, the think aloud method [14] was used while the participants explored the user dashboard and visualizations, where they spoke all their thoughts out loud during the exploration, to gain insight as to whether they favored the dashboard and visualizations, and found them useful in the sense that it made them think deeper about their questions. The participants were also asked to complete some simple tasks, seen in Figure 5.7 section 2, for example to resize the visualizations and change the order of the visualizations by moving them around.

At the end of each usability test session self reported metrics were asked to the participants, see Figure 5.8, such as questionnaires and open questions. This allowed them to critique the user dashboard and chosen types of visualizations along with provide suggestions as to what they feel could be improved on in the future. The observations of the participants along with their answers to open questions provided qualitative data, whereas the questionnaire provided quantitative data. The SUS (system usability scale) [12] and UEQ (user experience questionnaire) [18] test level questionnaires were taken into consideration to be used. The SUS consists of ten five-point Likert scale questions to assess the usability of a system relating to complexity, learnability, and ease of use. [12]. Seeing as the dashboard for this thesis mostly consisted of viewing the dashboard with a few basic interaction options, this questionnaire was too focused on the actual usage. It did not help answer the research questions in the sense of finding out if it helped support the collection of information and reflection. The UEQ consists of twenty-six seven-point Likert scale questions to assess user experience, for example the aspects of attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty [18]. The types of questions here however also did not help evaluate the research questions because they were too focused on specific aspects that were not relevant such as how predictable, easy to learn, and conventional it is instead of more documentation and reflection related questions. The questionnaire used here was more based on the SUS questionnaire, where the questions were changed to be more relevant while still having the same format of ten questions and using the five-point Likert scale format.

The results of the usability test was then analyzed and visualized to see if the participants favored the user dashboard and information visualizations, and to see if it was useful in the sense that it made them think deeper about their information. It was analyzed by looking at trends from the Likert scale question results between the two participants, along with seeing if they mentioned similar opinions during the open questions section. Through this it was seen if it satisfied the participants interests and aided in their possible reflection through documentation, along with analyzing how far the resulting reflection went in the different levels of reflection by Fleck and Fitzpatrick [15], if at all. See Section 4 for more detailed information.

4 Evaluation

This section describes the evaluation of the usability test of the user dashboard that was conducted with the participants. During the exploration of the user dashboard, both participants seemed a little confused on what to do at first when given the standardized starting view, but they quickly figured out what the visualizations meant and how to navigate within the dashboard. They went through each visualization and started to compare what was shown to them, which includes the dummy data, to how they would actually have asked questions throughout multiple weeks. They immediately also mentioned the graphs that they did not care for, plus their preferences and what extra options they would want to be able to see. They seemed to feel mostly in control by the end of the session and felt that the dashboard kept a good documentation of their information. They also changed around the size and order of visualization based on personal preferences, which all shows that the requirements mentioned in Section 2.3 were fulfilled and that the design rationales mentioned in Section 3.2 were implemented well.

P1 felt that there were too many statistics within the dashboard and would prefer to remove the ones she did not care about. When asked to change the size of the visualizations and to move them around, she customized it to her own personal preferences. She reduced the size of the graphs she was indifferent towards and clumped them together in the upper right corner of the dashboard, and then enlarged the other interesting graphs and stacked them on the left side. P2 on the other hand centered and enlarged the visualizations that she found most interesting. The other graphs she put to the sides, and shrunk them. P2 finds it positive that there is an ample mix of different diagram types, for example horizontal and vertical bar graphs, lists, and a single number.

As for possible improvements, P1 mentioned that instead of just showing absolute frequencies one could also give the option to show relative frequencies with percentages. P2 mentioned that at first she thought some of the bar graphs were showing shapes because one bar was too close to another, so spacing them out more would be beneficial. P2 would also want to see the answers to her questions when she clicks on a previous question, which she feels would save time and help facilitate learning. She mentions this way the dashboard could also be similar to a “second memory” and later described the dashboard as being “my blue conscious second brain”. P2 also suggested that under the question categories, for example diseases, when one clicks on one bar it shows the specific types of diseases that were asked. P2 continued by

mentioning having an option to set goals, and to compare the data of different weeks would be interesting.

For the research question of finding out how far the resulting levels of reflection will go: since this was the participants' first time seeing their data in the user dashboard during the usability tests, reflection level R0 was most often seen, where there is a documentation of information. Both participants felt that the dashboard provided a place where their data was documented and where they could get a good overview and keep track of their data. Both participants mentioned reflection at some point during the usability test. For example, P2 mentioned that seeing that she asked a lot of questions in that week would help her reflect on how busy she was and P1's description of the dashboard in five words was: "übersichtlich, strukturiert, durchdacht, überladen, reflektionsanregend", so it stimulates reflection. There were also some signs that the R1 level was achieved, where there are explanations in addition to documentation. This could be seen because both participants were explaining why some of the dummy data was incorrect and what it should be instead, for example P1 mentioned that in real life she would not look up a certain medicine that often or that she would look up psychotherapists a lot more often. During the think aloud they were also rationalizing why data could be accurate. For example P2 noticed the graph depicting the time of the day that most questions are asked. She noticed it was mostly in the morning, midday, and afternoon, which she said makes sense because she prepares work in the mornings, gets back to her desk around lunchtime, and writes reports in the afternoon, all of which would be times where questions could arise. Correcting information they felt was wrong, along with giving explanations to the information they saw, both point towards the dashboard stimulating the participants to also think about explanations of their information, which could be a sign of R1 reflections. Signs of the higher levels R2, R3, and R4 were not observed during testing.

As for the questionnaire of perceived usefulness of the visualizations, usefulness here meaning it helped them think more in depth about their data and questions, the two participants had mostly similar opinions, as seen in Figure 4.2. They did not care for and did not feel that the visualizations pertaining to the frequency, timing, and length of their questions made them think deeper about their data. They were instead more interested in the visualizations that showed them information about the content of their questions themselves, for example what the last questions were, key word frequency, and categories. This answers one research question, of which visualizations they would be interested in. Perhaps an idea for the future could be to focus on visualizations that are purely based on the questions themselves.

Looking at Figure 4.1, for the questionnaire pertaining to the dashboard overall, the ratings for all the questions received a three or higher, except for

the question about the participants changing how they ask questions in the future, which points towards low or lack of reaching the R1 level of reflection and engaging in reflective learning. This could be due to the short time they had to interact with the dashboard, not allowing enough time to reflect on their data, and it was only based on eight days worth of questions. They found the dashboard overall favorable, the functional aspects they found to be a little better than the visual aspects. They felt that the dashboard helped them get a good overview of their information and it helped them track and understand their data, which further points to the R0 level of reflection being achieved. It seems that they would be interested in using the dashboard in the future, which shows promise for the research question about reflective learning, if used over a longer time period this might occur in the future. P1 gave slightly lower scores than P2 did. Overall the usability of the system seems promising and the dashboard could thus be expanded upon in the future in a similar direction.

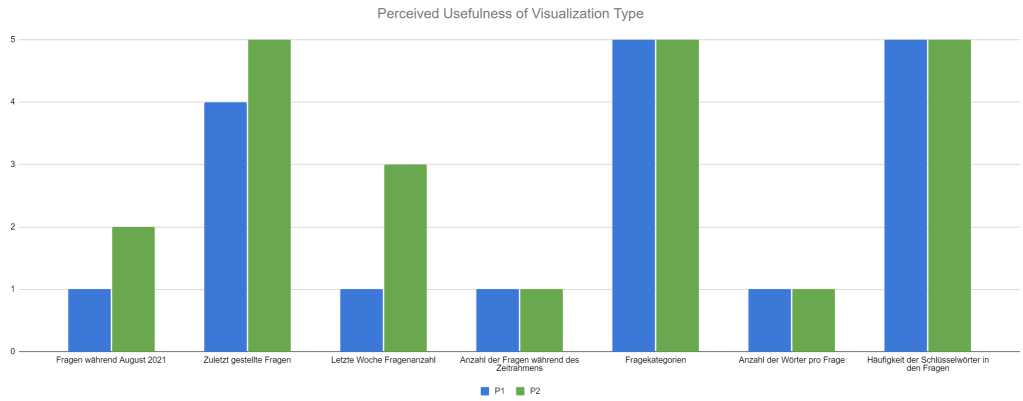

Figure 4.1: Perceived Usefulness of Visualization Type

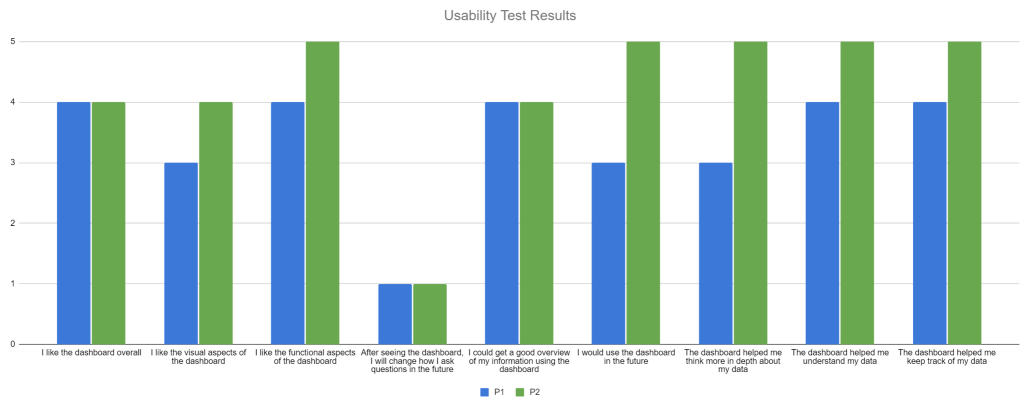

Figure 4.2: Usability Test Results

5 Conclusion and Outlook

This section summarizes the findings that were collected throughout the project creation and testing process, along with discuss the limitations and outlook for future research opportunities.

The project scenario, where the participants ask questions pertaining to diseases and symptoms of these diseases, was seen to occur through the use of the electronic journal. The questions were not however exclusive to the scenario and ended up branching out to other topics, for example contact information. This shows that the types of questions originally thought were exclusively going to be asked were actually part of a larger variety of question types. This could affect the evaluation of the research questions, but they could also implicitly be expanded upon to include these types of questions since the scenario was not explicitly stated there.

The R0 level was well supported, seen through the information of the participants being well documented for reviewing as needed. As a result of this the user dashboard is a basis upon which further reflection can be built upon and possibly higher levels of reflection could be reached, for example R1, R2, or R3. Some possible R1 traces were also seen, as the participants were explaining some of the data they saw in the dashboard while exploring it. This further shows that the dashboard has potential for helping users reach higher levels of reflection and engage in reflective learning. To see how far reflective learning was achieved through the use of the dashboard, more time would be needed to see the influence of the participants findings on their behavior and actions.

One could also, for future research, take the findings from the first prototype and use it as the first iteration, idea from [14], in a larger study with more participants. It could also be conducted over a longer time span so more data could be collected, for example over the course of a few months, and users could then interact with the dashboard over the course of a few weeks. These tests could have also been conducted directly with the assistant physicians instead of Charité project members. P1 mentioned during the usability test that a longer test period would motivate her to use the dashboard in the future, since all the data would then be her personal data, as opposed to also having dummy data which was the case for this thesis paper. Based on these findings the prototype could then be iterated on, for example question content based visualizations could be focused on, removing date-based visualizations, and finding a platform where archiving visualizations is an option. During this time more questions could be filled out by the participants to provide more personal data for the

visualizations. Through all of this a second user dashboard iteration could be created and another usability test could be conducted with the same procedure and questions, except the questions about specific visualizations would have their names changed to the names of the new visualizations. The results would again be analyzed and compared with the results of the first usability test to find out if improvements were made. The specific improvements or lack thereof would have been analyzed and then conclusions would be made about how this dashboard affects the levels of reflection as compared to the first iteration. Some of these steps were originally planned for the thesis paper, for example to work directly with assistant physicians, create a second prototype, and compare the results, but these steps had to be excluded due to time restrictions.

Overall, the user dashboard was clear and understandable for the participants. They each had slightly differing opinions on the visualizations they favored or did not care for based on their personal preferences, but the general consensus was that the focus should be on the content of the questions themselves. The dashboard did support level R0, along with slightly sparking level R1. These are promising findings, and a good first step where further research in this area could go a long way to assisting assistant physicians in their reflective learning journeys.

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Appendix

5.1 Appendix Part One

Bachelor thesis paper: Interview Questions (~1 hr.)

Stefanie Bosch

1. **Introduction (~5min)**
    a. Hello, my name is Stefanie Bosch and I am conducting these interviews to gain some insights that will help me with the creation and writing of my Bachelor thesis paper, which I am conducting at the Freie Universität Berlin.
    b. We know that your work keeps you very busy and that there is little time to think back to the day's events and gain new insights. You tend to be busy with patients throughout the day and may have some time at the end of your day to contemplate what has occured. We also know that as part of the DocTalk collaborative project, one of the plans is for residents to be able to ask questions to DocTalk, which will be answered using Amboss by the chatbot.
    c. The following interview questions deal with questions that you have that may come up for you during the week. Examples could be that you ask a colleague for advice, but also questions that you would address to the chatbot in the future, and questions that come up when you think back to what you experienced in your daily clinical routine.
    d. I would like to record the video of the conversation to facilitate the evaluation of the information received. The recordings will be kept confidential and shared only with FU DocTalk project members. The recordings will be partially transcribed and subsequently deleted. Do you agree to the video recording of the conversation?

2. **Own Questions (~5min)**
    a. Approximately how often do you ask questions during the day?
        i. When during the day do you ask questions?
        ii. What general types of questions do you ask?
            1. Could you give a few examples?

Figure 5.1: English Expert Interview Questions: Page 1

3. **Thinking Back (~10min)**
    a. In what ways do you think back on conversations or experiences throughout the day?
        i. To what extent do you think about your questions after you have asked them?
            1. Do you think more about the answer you received or the way you phrased the question?
    b. What usually makes you think back to a past experience during the day?
        i. Perhaps through a conversation, another experience, or an object?
        ii. Why does this make you think?

4. **Tracking Information (~10min)**
    a. What types of information do you usually keep track of?
        i. For example steps, mood, cell phone usage.
        ii. How do you keep track of this information?
            1. For example mentally, in writing, in an app?
        iii. What motivates you to track something consistently?
    b. How do you track progress?
        i. What motivates you to track progress?

Figure 5.2: English Expert Interview Questions: Page 2

5. **Existing dashboards (~30min)**
    a. A user dashboard is a page that one can examine where data and information, including information visualizations, are displayed to the user. This allows important data to clearly and swiftly be viewed by the user and give an overview of information.
    b. Which user dashboards do you like to use?
        i. What do you like about the dashboard?
        ii. Is there a particular feature that you find helpful?
            1. Why is the feature helpful?
        iii. What interaction features do you like in the dashboards that you use?
            1. What do you like about them?
        iv. In what ways do the dashboards support you thinking about what you are doing?
    c. One scenario for the use of the DocTalk chatbot is to ask it questions about diseases and symptoms. Based on your own questions you might want to ask the chatbot, what types of information would you like to see visualized?
        i. What benefit would it have for you to see this information?
        ii. Do you have goals where visualizations would help your motivation?
            1. How would it help?
    d. I will now show you two existing dashboards and ask a few questions to get your opinion on the functionality and look of these dashboards. (~10min per dashboard)
        i. What do you think about this user dashboard?
            1. General thoughts.
            2. What do you/do you not like?
            3. Is it easy to understand?

Figure 5.3: English Expert Interview Questions: Page 3

i. Daylio: mood, https://daylio.net/

1. 

Figure 5.4: English Expert Interview Questions: Page 4

2.

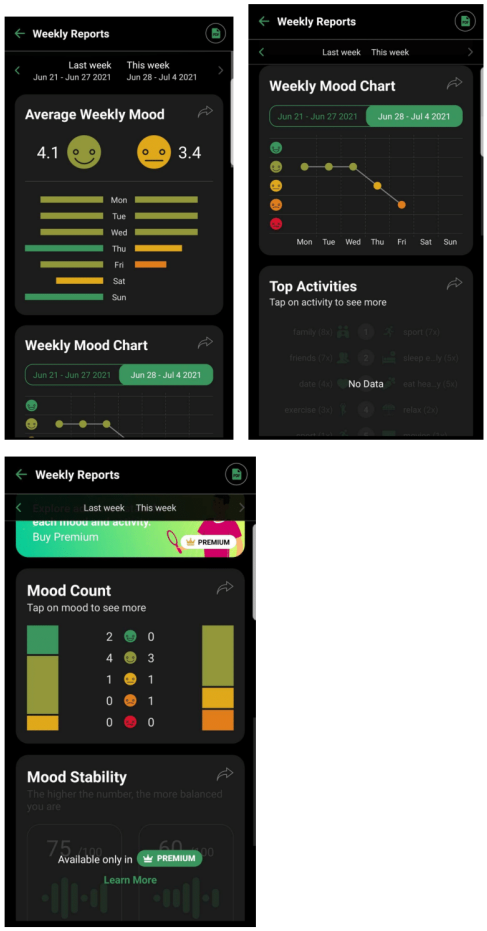


Figure 5.5: English Expert Interview Questions: Page 5

ii. Microsoft Power BI: Faction A: online retail, https://powerbi.microsoft.com/en-us/partner-showcase/faction-a-sentiment-analysis-dashboard/

1. 

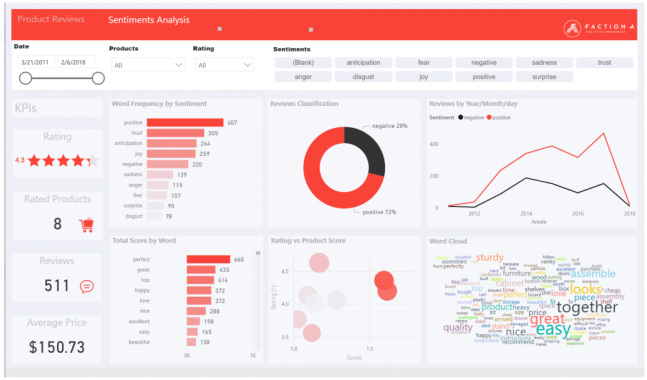
2. 

Figure 5.6: English Expert Interview Questions: Page 6

5.2 Appendix Part Two

Dashboard Procedure and Usability Test Questions

Stefanie Bosch

1. **Introduction to Dashboard**
    a. I took all of your questions that you wrote down in the week and a half in the electronic journal and based on this I created this user dashboard using Grafana.
    b. To make the dashboard look more like it would if questions were collected over many weeks, I made an extended version of the dashboard where I filled it with extra data that I can see having happened if you had used the dashboard for multiple weeks. I will first quickly show you the simple dashboard, then the extended version.
    c. Here within the user dashboard you can see multiple visualizations, each focusing on a different perspective of your questions.
    d. One scenario for the use of the DocTalk chatbot is to ask it questions about diseases and symptoms. For this scenario you have been mainly asking the chatbot these types of questions for the past few weeks, along with a few other types, and your questions have all been collected and turned into this user dashboard. You decide to check up on the dashboard and are looking at it to gain a deeper insight into your questions.
    e. I would like to record the video of the conversation to facilitate the evaluation of the information received. The recordings will be kept confidential and shared only with FU DocTalk project members. The recordings will be partially transcribed and subsequently deleted. Do you agree to the video recording of the conversation?

2. **Task based think aloud protocol**
    a. You will have 15 minutes to look at and explore the dashboard, take as much time in those 15 minutes as you want. While doing this please state all of your thoughts out loud, both what you are thinking while looking and while interacting with the dashboard.
    b. First just look at and explore the dashboard however feels natural/makes sense to you.
    c. Look at the visualizations and let me know if you see any patterns or anything that you did not expect when you wrote your questions down.
        i. Look at and explore the dashboard again however feels natural/makes sense to you.
    d. Try to resize some visualizations.
        i. Look at and explore the dashboard again however feels natural/makes sense to you.
    e. Try to move the visualizations around and change the order.
        i. Look at and explore the dashboard again however feels natural/makes sense to you.

Figure 5.7: English Usability Test Procedure and Questions: Page 1

3. **Post-Test Questions**

a. 5 point likert scale (1: strongly disagree, 2: disagree, 3: neutral, 4:agree, 5:strongly agree)
   i. I like the user dashboard overall.
   ii. I like the visual aspects of the dashboard.
   iii. I like the functional aspects of the dashboard.
   iv. Useful: here in the sense that it makes you think more in depth about your data and questions
      1. The visualization "Fragen während August 2021" was useful.
      2. The visualization "Zuletzt gestellte Fragen" was useful.
      3. The visualization "Letzte Woche Fragenanzahl" was useful.
      4. The visualization "Anzahl der Fragen während des Zeitrahmens" was useful.
      5. The visualization "Fragekategorien" was useful.
      6. The visualization "Anzahl der Wörter pro Frage" was useful.
      7. The visualization "Häufigkeit der Schlüsselwörter in den Fragen" was useful.
      8. The dashboard was overall useful to me.
   v. After seeing the dashboard, I will change how I ask questions in the future.
   vi. I could get a good overview of my information using the dashboard.
   vii. The dashboard helped me find patterns in my data.
   viii. I would use the dashboard in the future.
   ix. The dashboard helped me think more in depth about my data.
   x. The dashboard helped me understand my data.
   xi. The dashboard helped me keep track of my data.

b. Short answer/open questions
   i. What are the main things you like about the dashboard?
   ii. Which visualizations did you like the most?
   iii. What did you dislike about the dashboard?
   iv. What would you have done differently if you had designed and/or created the dashboard yourself?
   v. How easy was it to understand the dashboard?
   vi. Did you gain any benefits from looking at the dashboard? Please give examples.
   vii. How does viewing your data make you feel?
   viii. What would motivate you to keep using the dashboard in the future?
   ix. How did the dashboard help you or not help you think more in depth about and understand your data?
   x. Describe the dashboard in five words.

Figure 5.8: English Usability Test Procedure and Questions: Page 2