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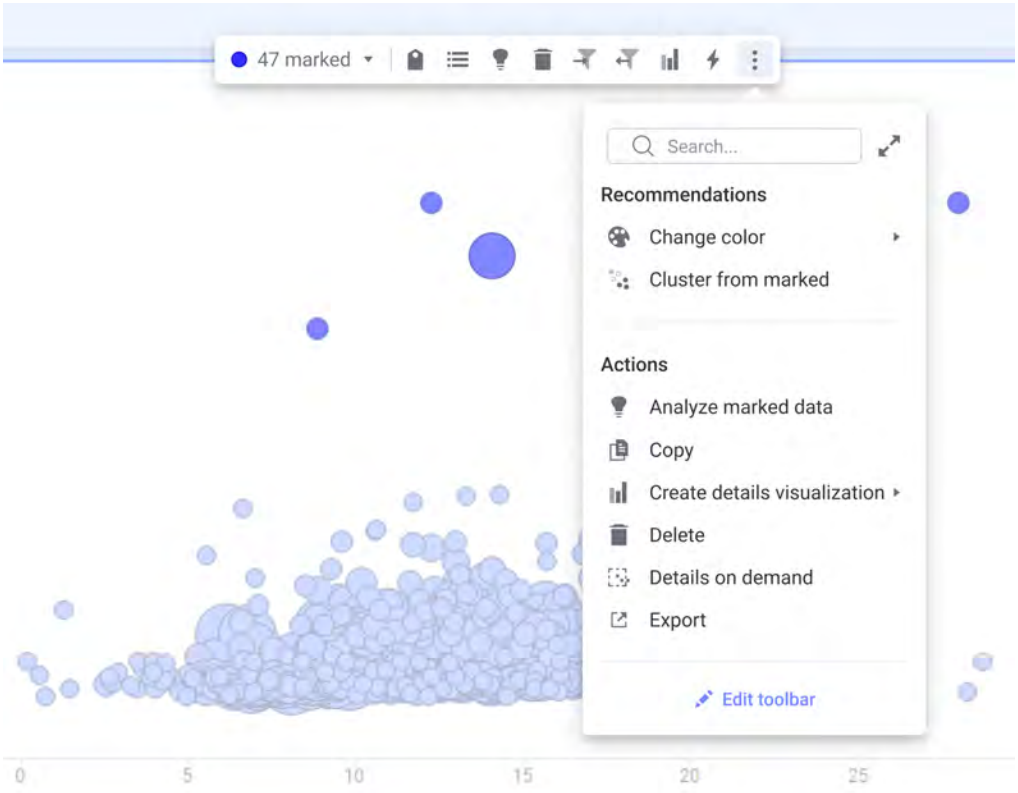

Presenting Actions in Analytics Softwares

Design Considerations for a Contextual Presentation of Options for Acting on Selected Data in Analytics Softwares

Master's thesis in Computer Science and Engineering

LOUISA RECK

TOVE SVANLUND

Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
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Gothenburg, Sweden 2024

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Supervisor: Staffan Björk, Department of Computer Science and Engineering
Advisor: Gustaf Carlberg, The Company
Examiner: Morten Fjeld, Department of Computer Science and Engineering

Master's Thesis 2024
Department of Computer Science and Engineering
Chalmers University of Technology and University of Gothenburg
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Final design of the presentation for acting on selected data.

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ABSTRACT

Analytics platforms enable the analysis of data through visual representations, and support users in uncovering insights from their data and making business-critical decisions. In order to ultimately be able to make these decisions, it is important to be able to act on the data that is selected in the various visualizations. With this in mind, the purpose of this thesis project was to answer the following research question:

> *In analytics softwares, what should be considered when designing how to present relevant options for acting on selected data in visualizations?*

The project was conducted in collaboration with a visual analytics company, where an iterative design process was carried out in order to answer the research question. The process followed Design Thinking and was initiated with a pre-study followed by two design iterations, to finally end up with a design and a set of eight guidelines. Throughout the project, the design and the guidelines were iterated upon alternately, and the final design serves as an example of how the guidelines can be implemented. The final set of guidelines serve as a foundation for what to keep in mind when making decisions on future designs when presenting actions for selected data in analytics softwares.

Keywords: data exploration, information visualization, visual analytics, interaction design, acting on selections

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1
INTRODUCTION

As of today, data is produced at an incredibly high pace, resulting in information overload. Visual analytics aims to bridge the gap created where people's ability to collect and store a large amount of data exceeds their ability to analyze it (Keim et al., 2008). They also explain that visual analytics allows decision-makers to interact directly with information to compile and extract valuable insights from large, complex data sets. Keim et al. (2008) argue that visual analytics therefore decreases the cognitive work needed using visual representations and interaction techniques. Ware (2021) confirms this by arguing that visualizations are essential to cognitive systems and are valuable for perceiving a large amount of data when communicating from computer to human. To better understand data, an essential part is to be able to select items in visualizations and take actions upon that data (Heer & Shneiderman, 2012).

A company specialized in visual analytics is based in Gothenburg and will be referred to as The Company in this report. Information can be explored and processed efficiently and immersively with The Company's analytic software, referred to as The Software, which features data discovery through interactive visualizations. The Software offers a variety of capabilities, such as geospatial technology, AI recommendations, and streaming analytics with real-time data, to facilitate the exploration of information. The Company claims that the immersive experience of The Software makes it possible to load data, visualize it and explore the data further by adjusting the visualization setup or applying filters. Once the user has discovered interesting subsets of data and has selected it to explore the subset further, there are a lot of possible actions to perform. Currently, these actions are spread out across the interface and different actions have different access points. Actions can for example be found through menu items in the navigation menu, in a contextual menu accessed by right-clicking, or through custom floating action buttons in the visualization area. The Company has noticed that this results in users not always knowing which actions are available, implying that valuable functionality is not utilized. Relevant actions for acting on selected data can also differ depending on the context and the data. However, acting on selected data is currently something that The Company believes disrupts the user's workflow and thus, The Software's immersive experience. The Company has briefly approached this problem in the past, but due to limited time and resources it could not be explored as thoroughly as they would have wanted. However, it is still a challenge that The Company wants to address and find a solution for.

This master thesis was conducted at the Interaction Design & Technologies master program at Chalmers University of Technology, within the Department of Computer Science and Engineering. The thesis, conducted in collaboration with The Company and with guidance from a supervisor at the university, focused on analyzing the user experience of The Software. More specifically, the thesis aimed to explore how different options for acting on selected data can be presented to achieve a good user experience.

1.1 Research Question

Discussions with The Company and the thesis supervisor resulted in the following research question, considering the user experience when acting on selected data in The Software:

> *In analytics softwares, what should be considered when designing how to present relevant options for acting on selected data in visualizations?*

1.2 Goals and Deliverables

An iterative design process will be conducted to answer the research question. The aim is to end up with guidelines to facilitate the development of a non-intrusive design for presenting relevant options for acting on selected data in a visual analytics software. The intention of the guidelines is to help achieve a streamlined workflow without disruptions and reduce the cognitive load. As an expected result, users can focus on gaining insights from the selected data instead of searching for relevant actions. In addition to the guidelines, the aim is to develop a high-fidelity prototype to exemplify and test the implementation of the guidelines.

1.3 Limitations

This project comes with a few limitations to consider. Within an analytics tool, there are multiple different visualization types. The available actions a user can perform with a subset of data differs between the different types of visualizations. Due to time constraints in this project, it will not be possible to consider the actions for all visualization types. However, by considering a variety of different visualization types, the aim is to develop guidelines that can be applied across most visualization types.

In addition, The Software is designed for both real-time data and data at rest. Data at rest, where users analyze historical data, is most common and will thereby be the main focus for this project. There are many different types of users of The Software, with different experiences of analytics tools and who use The Software from different devices. In this project, one limitation is that it will only focus on the most common type of user, who works independently in The Software using the desktop version.

Another potential limitation is to find experienced software end users. The Company has expressed that contacting customers is both time-consuming and challenging since they mostly are in contact with the sales team which are not the end users. In addition, many

users work with confidential data. Due to the limited time frame of this project, The Company has therefore suggested conducting the data gathering and evaluations with employees from The Company that are familiar with The Software. Including internal stakeholders from The Company with different roles and experience of working with The Software can therefore act as a substitute target audience.

Although the aim is to construct general guidelines for acting on selections of data, the project does not include applying and evaluating these guidelines in any context other than within The Software. However, benchmarking will be conducted on The Company's competitors since acting on selections is a common feature in most visual analytics softwares. As a result, the guidelines and conclusions will, to a great extent, be applicable for visual analytics tools in general.

Additionally, the prototype and guidelines will be evaluated with formative rather than summative studies since the time frame of this project is relatively short. By evaluating the prototype formatively, the intent is to create an optimized design solution for the guidelines to be based upon. The guidelines will be iterated upon and assessed continuously, where each new version will be modified to better answer the research question.

1.4 Ethical Considerations

In order to minimize the risk of ethical concerns, it is essential to consider potential ethical issues during the design process. Protecting the user's privacy and data is an important ethical consideration (Schloesser, 2023). The project will conduct several usability tests and interviews involving users, and thus, GDPR will be considered when collecting data.

Accessibility is another ethical consideration when designing digital interfaces. For this project, accessibility will not be the main focus, but considerations will be taken when deciding how to present options for acting on selected data. The presentation of actions should, for example, not hide or make it difficult to access different actions or data. In terms of accessibility, there's also the possibility of excluding certain user groups. The presentation of options for acting on selected data should not favor certain user groups or outcomes, potentially leading to unfair treatment. Whether the user is advanced or novice, they should be able to understand which actions they can perform with the selected data.

An additional concern is that, depending on how the options for acting on selected data are presented, false conclusions could be drawn on suitable following actions for a particular subset of data. How the options are presented could potentially influence the users' own thinking and decision-making of suitable actions for the selected data, causing biased results. However, Sharp et al. (2019) emphasize that evaluation is an essential part of the design process to improve and prevent problems with a design. The aim is, therefore, to avoid false conclusions and misunderstanding of suitable actions by evaluating the design thoroughly with users.

2
BACKGROUND

The following chapter presents The Company and The Software, including user roles and the use of markings and selections. The Company's competitors and how actions can be performed upon selections on their softwares are also described.

2.1 The Company

The Company where the thesis was conducted was originally founded in 1996 and has since undergone a number of restructurings. As of today, The Company is part of a larger organization serving over 100 million users around the globe, as its own business unit. The Company, specialized in business intelligence and analytics, has its headquarter in Gothenburg, Sweden. Customers of The Company exist within several different industries, such as energy, manufacturing, financial services, life-sciences, logistics and transportation as well as telecommunication.

2.2 The Software

The Software (Figure 1) that this thesis was based on is a visual analytics tool, enabling users to prepare, analyze and explore their data, as well as to take different actions. The Software offers an installed client but it can also be used through a web version with slightly limited functionality. Users bring their data into The Software and can then build interactive dashboards using different visualizations, allowing real-time data exploration to get insights, mitigate risks and make predictions. An essential part of visual analytics softwares, is being able to interact with the data and highlight different data rows, to make *selections*. Heer and Shneiderman add to this by explaining that generally "Analysts must be able to select items or data regions to highlight, filter, or operate on them." (Heer & Shneiderman, 2012, p. 7) within visual analytics. Having selected data in The Software, possible actions can be to view details, tag, delete or change shape, among others.

Within The Software, a concept related to making selections is *markings*. When making selections in a visualization in The Software, a marking color is used to distinguish the selected data from the rest of the data. Within an analysis, one or several different marking colors can be used. If several visualizations in a dashboard use the same marking color, marking items in one visualization will automatically also mark items in the other visualizations using the same marking color, as long as they use the same or a related data

table. Using several marking colors on the other hand, can be useful if two different data tables are used, to minimize the risk of interpreting the marked data in the two data tables as being related to each other. Using a specific marking to limit what data is displayed in a visualization is another feature related to making selections in The Software.

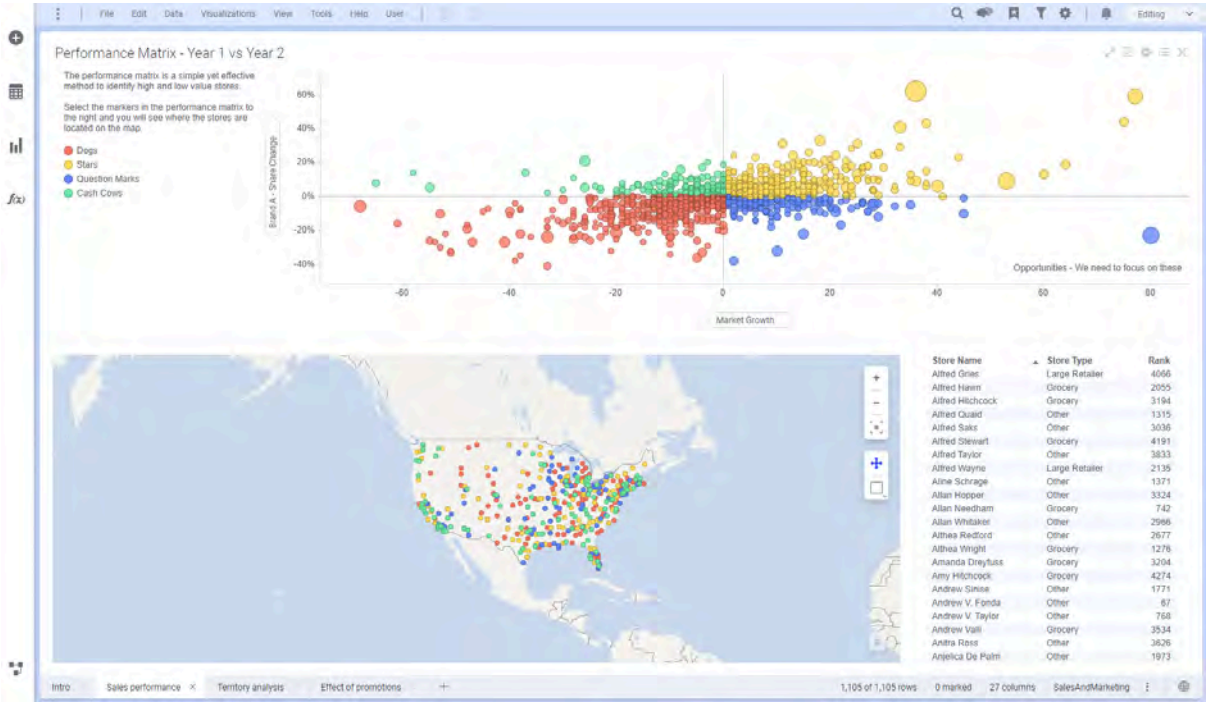


Figure 1. Overview of The Software

2.2.1 Primary User and Typical Context of Use

In The Software, there are three types of roles a user can be assigned: *Analyst*, *Business Author*, or *Consumer*. Which role a user is assigned affects what functionality they have access to. The Analyst is recalled as the primary user and has the most authority. The Analyst has access to all capabilities, and can connect to all supported data sources, transform and visualize the data. Dashboards created in The Software can be consumed on tablet and mobile devices but to create dashboards the Analyst role and desktop version of the Software is the most common setup. The user typically works independently within The Software, using multiple screens and with mouse and keyboard. Moreover, they mainly analyze complex data at rest, meaning that the data is up to date but a snapshot and not constantly updated. Within The Software, it is also possible to analyze real-time data, in order to get instant insights and make time-critical decisions. However, this is not the primary context of use and therefore out of scope for this project.

2.3 Competitors

In the field of visual analytics softwares, there are several large companies on the market. The following section presents the main competitors of The Company and how their softwares present possible actions that can be performed upon a data selection.

2.3.1 Tableau

Tableau (Figure 2) is a visual analytics platform founded in 2003, striving to help people understand and make the most out of their data by utilizing data exploration and data management to discover and share insights (Tableau, n.d.).

In Tableau, possible actions to perform with selected data are presented in different ways. For example, when a selection has been made and the selected data is hovered upon, a tooltip appears, showing possible actions to perform (Figure 3). Another way of presenting actions in the software is through right-clicking, where possible actions are listed within a contextual menu (Figure 4). It is also possible to configure actions via a dialog, reached from the Worksheet menu item (Figure 5).

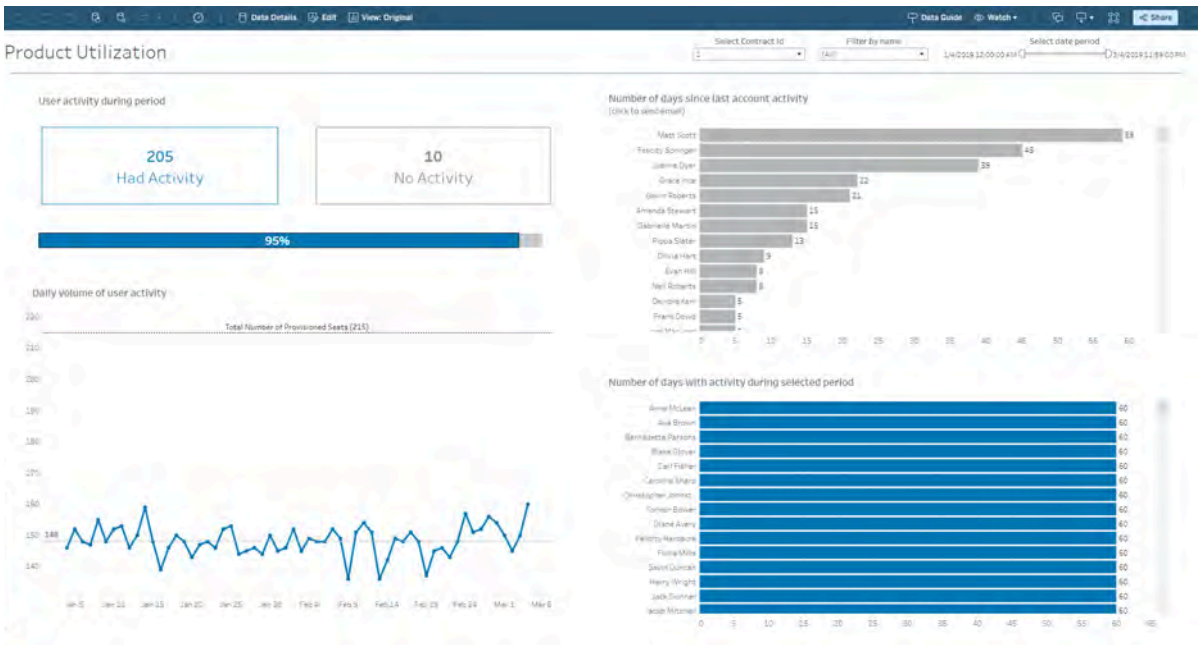


Figure 2. Overview of Tableau

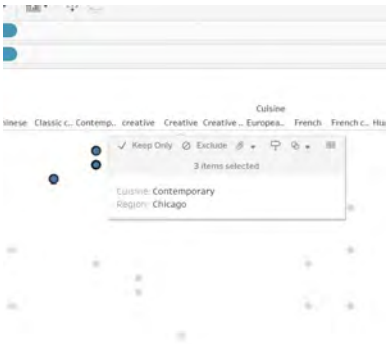


Figure 3. Tooltip appearing when hovering over selected data in Tableau

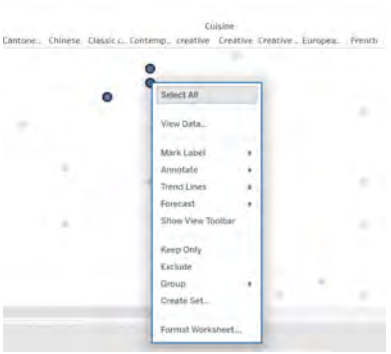


Figure 4. Contextual menu appearing on right-click in Tableau

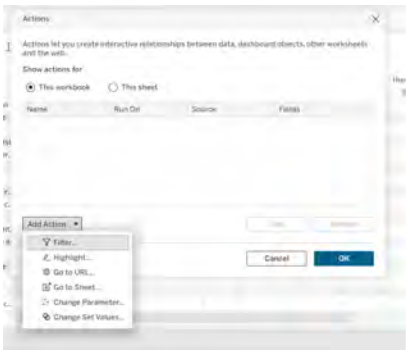


Figure 5. Actions dialog accessed through the Worksheet menu item in Tableau

2.3.2 Qlik Sense

Qlik Sense (Figure 6) is a visual analytics tool, making use of artificial intelligence and machine learning, automated insight generation, connections to hundreds of data sources as well as interactive visualizations to turn data into useful business outcomes (Qlik, n.d.-b).

In Qlik Sense, different ways are used to present possible actions to perform with selected data. When any data has been selected, a tooltip appears (Figure 7), showing actions related to the selected data. In the toolbar, a selection item (Figure 8) indicating which data has been selected is presented. If clicked, a popup appears, showing the data along with additional possible actions. Similar as for Tableau, actions to perform with the selected data are also presented in a contextual menu reached by right-clicking on any selected data. Additionally, a "Selection tools" button will open a view where all selections for a sheet can be handled. Actions (Figure 9) can also be applied to sheets, which can be configured through the properties panel (Qlik, n.d.-a).

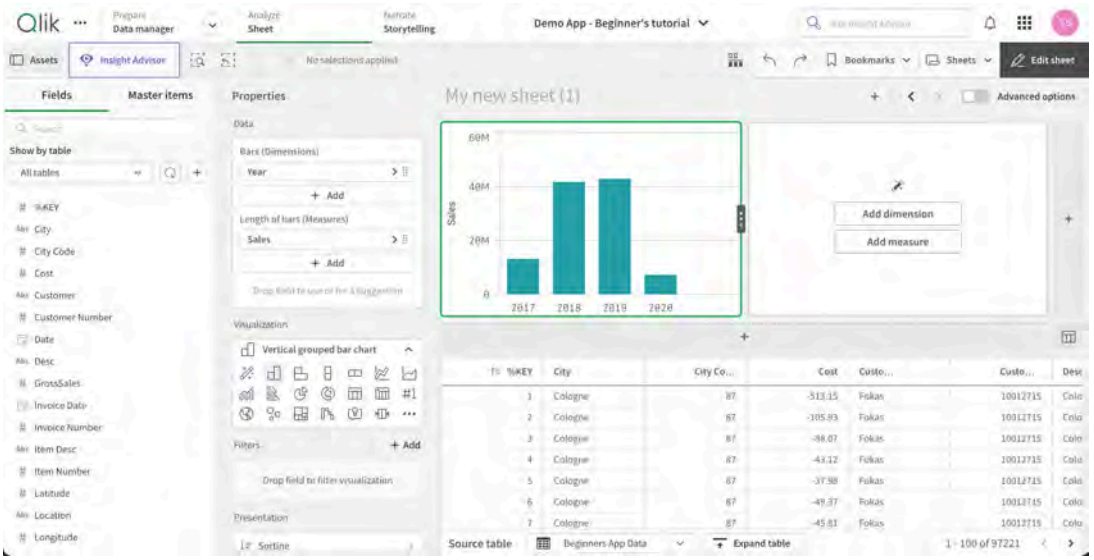


Figure 6. Overview of Qlik Sense

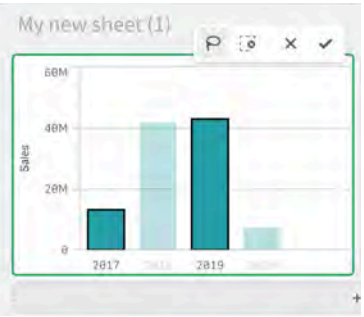


Figure 7. Tooltip appearing when data has been selected in Qlik Sense

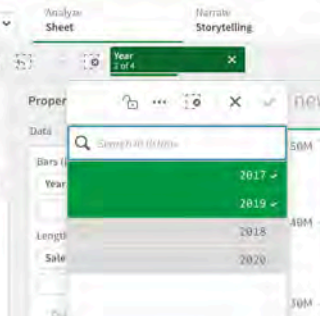


Figure 8. Selection item with popup in Qlik Sense

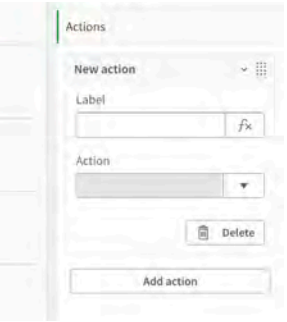


Figure 9. Sheet actions in Qlik Sense

2.3.3 Power BI

Power BI (Figure 10) is a self-service and enterprise business intelligence tool, where users can connect to and visualize any kind of data (Power BI, n.d.). The software focuses on uncovering insights and infusing those insights into applications used on a daily basis (Power BI, n.d.).

Similar to Tableau and Qlik Sense, Power BI presents actions for selected data through, among other things, hover and right-click. When data points are hovered upon, a tooltip (Figure 11) with a few actions appears. More actions are presented in a contextual menu (Figure 12), accessed by right-clicking on selected data.

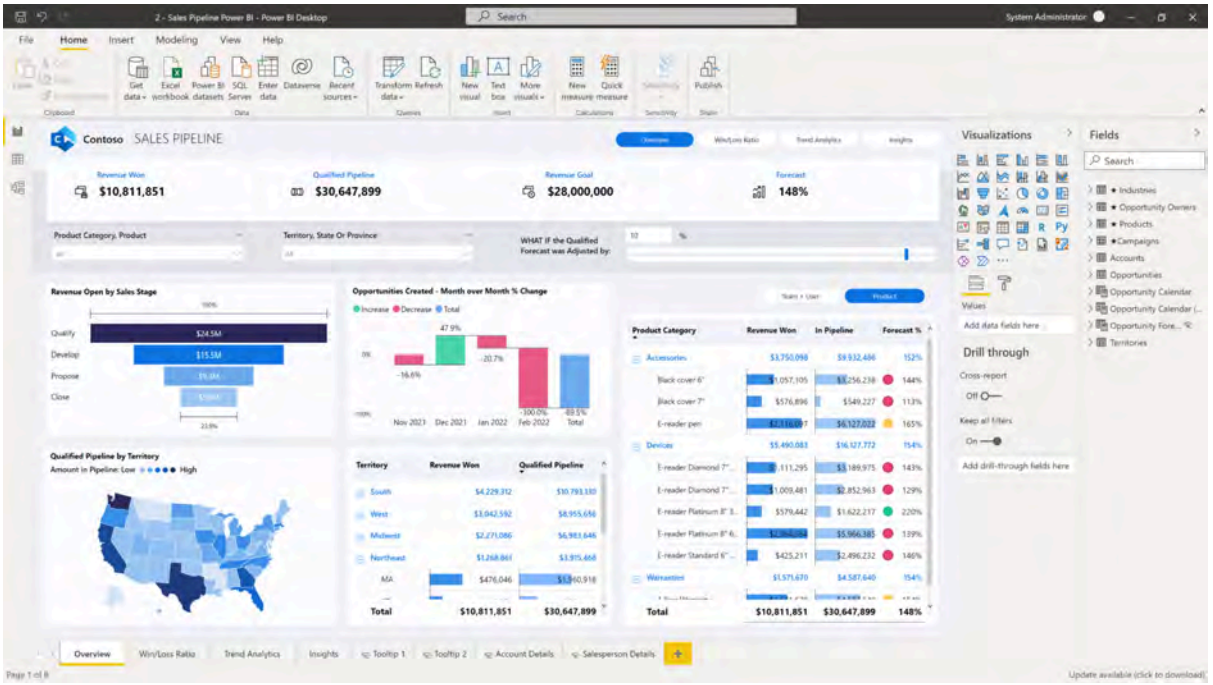


Figure 10. Overview of Power BI

Figure 11. Tooltip that appears on hovering in Power BI

Figure 12. Contextual menu appearing on right-click in Power BI

3
THEORY

This theory chapter explains different theories and concepts relevant to the project. This includes a description of the three overlapping fields Information Visualization, Visual Analytics and Business Intelligence. However, in this chapter each of the fields are described separately. In addition, User Experience, Design Patterns, Heuristics and Guidelines are also explained in this chapter.

3.1 Information Visualization

Information Visualization can be defined as "...the use of interactive visual representations of abstract data to amplify cognition." (Card et al., 1999, p.7). Due to the abstract nature of data, Information Visualization differs from scientific visualization, which focuses on spatial relationships and physical properties (Shneiderman & Plaisant, 2004). Information Visualization, on the other hand, often involves categorical rather than continuous variables and focuses on discovering patterns, trends and relationships.

Card et al. (1999) describe visualizations as adjustable mappings that convert data into a visual and comprehensible form to humans. To elaborate on this concept, the authors introduce a reference model that can be seen in Figure 13. The model illustrates how data transformations are mapped to raw data in unique formats. The raw data, including metadata, is converted to data tables that are more structured sets of relations, making it easier to map to visual representations. Card et al. (1999) point out that information is often gained or lost during the transformation from raw data to data tables. Raw data can, for example, contain errors or missing values, which must be addressed before it can be visualized. Moreover, the authors explain that data tables are excellent formats for recognizing patterns and relations. In the model, data tables are translated into various visual structures, with the view transformations increasing the amount of visualized information and thereby transforming data structures into accessible views. The final part of the reference model is the human interaction that completes the loop between data and visual form.

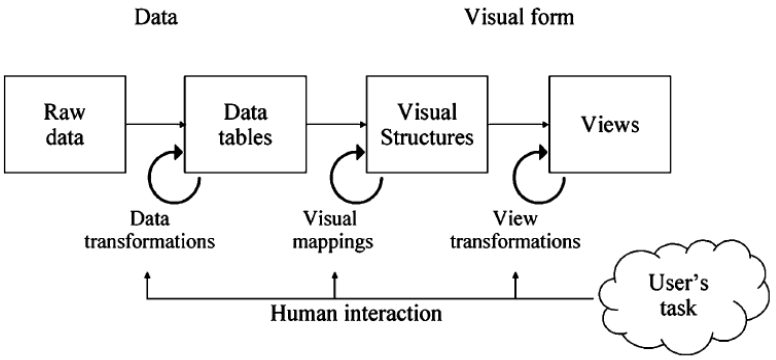


Figure 13. Information Visualization Reference Model (Card et al., 1999)

Furthermore, Ware (2021) argues that visualizations are essential to cognitive systems and are valuable tools for perceiving large amounts of data when communicating from computer to human. In addition, humans are very good at finding patterns, and if the visualizations are well structured, the data is likely perceived successfully. A mental model can be defined as "...an internal representation of external reality." (Spence, 2014, p.29). According to Spence (2014), visualization can be explained as forming a mental model of something and thus making it easier to understand. Further, Spence (2014) explains that there are three important aspects of visualizations: the nature of data, its dimension and the characteristics of the user who will interpret it. These aspects help create visualizations corresponding to the user's mental model.

3.2 Visual Analytics

Today's applications can often generate large volumes of data, leading to information overload (Keim et al., 2008). While retaining and collecting data has improved significantly over the years, Keim et al. (2008) state that the ability to analyze large volumes of data has developed at a slower pace. Analyzing data and extracting relevant information is essential in various fields and greatly aids decision-making. *Visual Analytics* aims to extract information from large amounts of data as efficiently as possible, bridging the gap between collecting and analyzing data (Keim et al., 2008).

Visual Analytics has evolved from Information Visualization and can be defined as "...the science of analytical reasoning facilitated by interactive visual interfaces." (Thomas & Cook, 2005, p.4). Furthermore, Visual Analytics is an iterative process comprising information gathering, data preprocessing, knowledge representation, and decision-making, thus combining human factors with data analysis (Keim et al., 2008). By considering human factors, Visual Analytics decreases the cognitive work needed by using visual representations and interaction techniques. Further, Keim et al. (2008) explain that Visual Analytics allows decision-makers to directly interact with information to compile and extract valuable insights from large and complex datasets. In addition, the authors present a four-step Visual Analytics mantra, where the first step requires modifying the data before it can be analyzed. Secondly, only the most essential information should be shown before further zooming in, filtering, and analyzing the data in the third step. Lastly, the data should give insightful details on demand.

3.3 Business Intelligence

The term *Business Intelligence* (BI) was first introduced in 1958. However, it did not gain traction until 1989, when Howard Dresner introduced the BI as an umbrella term comprising a selection of concepts and methods for improving business decision-making using fact-based systems (Grossmann & Rinderle-Ma, 2015). BI is a way of facilitating decision-making by delivering the appropriate, actionable information to the right people in a suitable form. With BI systems, it is possible to "...combine data gathering, data storage, and knowledge management with analytical tools to present complex internal and competitive information to planners and decision-makers." (Negash, 2004, p. 178). In other words, BI can help understand a business's capabilities and assist in strategic and operational decision-making.

3.4 User Experience

User experience (UX) is a term widely used, especially within the field of design. Despite that, there is no unified definition of the term. According to Roto et al. (2011), UX can be seen as either a phenomenon, a field of study, or as a practice. Generally, they describe UX to be about "...studying, designing for and evaluating the experiences that people have through the use of (or encounter with) a system. This use takes place in a specific context, which has an impact on, or contributes to, the UX." (Roto et al., 2011, p. 5). Sharp et al. (2019) explain that user experience is about how products are used, and about people's feelings and emotions when interacting with a product. They claim that UX includes people's overall impression of a product, including feelings and perceptions of using, holding, looking at, opening and closing a product. In Hassenzahl's model of user experience, which Sharp et al. (2019) explain is one of the most well-known models, key elements of UX and their functional relations are presented. The model implies that a product, based on its features, conveys a character which in turn affects how a product is experienced (Hassenzahl, 2004). This character is composed of two types of attributes, *pragmatic* and *hedonic*. The pragmatic attributes refers to manipulation and the fulfillment of one's behavioral goals, how functional or easy-to-use the product is. The hedonic attributes refers to one's psychological well-being and how stimulating and evoking the product is, as well as how much pleasure it brings. Hassenzahl (2004) explains that a desired product is indicated by a combination of strong pragmatic and strong hedonic attributes.

In a white paper written by Roto et al. (2011), the importance of considering the full cycle of experience, the *time spans of* UX, is described. In the paper, four time spans are presented: *anticipated*-, *momentary*-, *episodic*-, and *cumulative* UX. Anticipated UX relates to the period before the first use, when imagining what the experience will be like. Momentary UX is described as the changes of feelings during interaction, whilst episodic UX refers to the evaluation of an experience, taking place after a use session. The last time span, cumulative UX, refers to the experience of the system as a whole, when the product or system has been used multiple times.

Hassenzahl (2004) states that UX is subjective. Further, he explains that experiences depend on the person interacting with the product, as well as the situation in which it is being used. User experience can not be designed, only be designed for (Sharp et al., 2019). When designing interactive products, Sharp et al. (2019) state that it is central to consider the usability, functionality, aesthetics, content, look and feel, as well as the emotional appeal to create preconditions for good user experiences. An important factor that affects user experience is human perception. Sharp et al. (2019) explain that perception refers to how information is acquired from the environment through different senses. For sighted people, vision is the most dominant sense, and in regards to interaction design it is important to consider how information is presented. Further, they explain that structuring information by for example chunking pieces of information together or using visual distinctions can help human perception.

An important concept within user experience is the concept of *Flow*. The concept of flow originates from psychology and was first described by Mihaly Csikszentmihalyi in the book *Flow: The Psychology of Optimal Experience* (Cooper et al., 2014). Flow can be described as the phenomenon of people concentrating to the extent that they forget about their surroundings or passage of time (Csikszentmihalyi, 2008). Cooper et al. (2014) explains that a major advantage of this concept is that users who reach a state of flow can be highly productive. Due to the positive effects, designing for an enhanced flow, as well as making sure that the user flow does not get interrupted, should be aimed for.

3.5 Design Patterns, Heuristics and Guidelines

When striving to create the conditions for a good user experience, there are various tools to make use of. These include design patterns, heuristics and guidelines which are described in the following section.

Within the field of interaction design, there is a concept called *design patterns*. The pattern term however, originates from architecture, where Christopher Alexander created a pattern language as a basis for how to build houses (Alexander, 1977). Alexander describes a pattern as a part of an interconnected system, not existing alone but relying on other bigger and smaller patterns around it to make sense. The design pattern term got a boost when the book *Design Patterns*, written by Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides, was published in 1995 (Hunt, 2013). Hunt explains that the book, often referred to as GoF Design Patterns book, contains a collection of design patterns for how parts of design and software can be reused in object-oriented programming.

Design patterns can be seen as building blocks for user interfaces, and are based on how people perceive and use a software, as well as the tasks people perform with a software (Tidwell et al., 2020). These represent components and functions designed to enhance the usability and utility of a software. Crumlish and Malone (2009) explain that interaction design patterns can be used to create interactive user experiences by combining several patterns, or by combining a pattern with other parts or content of the interface. Further, they describe that an interaction design pattern is used to "...give guidance to a designer for

how to solve a specific problem in a particular context, in a way that has been shown to work over and over again." (Crumlish & Malone, 2009, p. 10). Design patterns can be divided into different categories depending on what purpose they serve, such as patterns for getting around (navigation, signposts, and wayfinding), for listing things and for doing things (actions and commands), to name a few (Tidwell et al., 2020). Patterns for getting around include breadcrumbs, menu pages, escape hatches or progress indicators, whilst patterns for listing things can be cards, carousels or pagination.

Interaction design principles, or *heuristics*, are a set of broad rules that address behavior, form and content, aiming to support users' needs and goals while creating positive experiences (Cooper et al., 2014). Further, Cooper explains that these principles can be applied throughout the design process to help translate tasks and requirements into formalized interface structures and behaviors. Shneiderman and Plaisant (2004) explain design principles as more fundamental, widely applicable and enduring than guidelines, but in need of more clarification. Further, they describe guidelines as more narrowly focused and specific, developed from practical experience or empirical studies. Moreover, there are several recognised sets of heuristics and guidelines. Jakob Nielsen has developed ten general principles for interaction design, called 10 *Usability Heuristics for User Interface Design* (Nielsen, 2020). Another known set of principles, similar to Nielsen's, is Shneiderman's *Eight Golden Rules* (Shneiderman & Plaisant, 2004). The *Gestalt Principles* created by Max Wertheimer, Kurt Koffka, and Wolfgang Kohler is another example, consisting of twelve principles of human perception (Interaction Design Foundation, 2024).

Out of Nielsen's ten Usability Heuristics, the fourth explains the importance of maintaining a consistent user interface and complying to standards (Krause, 2021). Krause (2021) explains that this includes both internal and external consistency, where the internal refers to using the same patterns everywhere inside a product or product family and the external refers to using established conventions that are web-, platform-, and domain-specific. Utilizing interaction design patterns and making sure similar design problems are solved in the same way will form consistent interfaces, which will in turn lower the learning curves and ensure user satisfaction, as users are familiar with how tasks are solved based on previous experiences.

4
METHODOLOGY

The following chapter describes design research and how it relates to wicked problems. In addition, different iterative design processes are explained. Lastly, this chapter presents various relevant tools for the project.

4.1 Design Research

Frayling (1993) states that research is fundamental for effectively teaching design principles and methods. The author also explains that design research can be divided into three main categories: research *into*, *for* and *through* art and design. Research into art and design is the most common and straightforward type, as it focuses on research about design such as historical, aesthetic and perceptual or theoretical research. Research for art and design emphasizes research less because it involves gathering reference materials and inspiration incorporated into a designed artifact. The last category is research through art and design, which means researching the design process and communicating the different steps and iterations for future reference.

Furthermore, exploratory, generative and evaluative research are three valuable methods in research through design (Klein, 2016). Exploratory research is typically conducted in the early stages of the design process and aims to better understand what already exists (Martin & Hanington, 2012). However, generative research gives user insights through user research and often results in new ideas and hypotheses (Klein, 2016). Evaluative research is a method to determine if these ideas and design concepts are valid.

In order to explain and contextualize the design action, Martin and Hanington (2012) emphasize the need to document the design process. In addition, the authors point out that research through design recognises the design process as research and enhances design practice by applying theory and building knowledge. Additionally, Gaver (2012) argues that research through design is fundamentally about generating new ideas rather than trying to prove or disprove existing ones. Zimmerman et al. (2007) emphasize that research through design can be used to encounter complex problems. The authors also state that addressing these problems through science and engineering methods often is challenging.

4.2 Wicked Problems

Complex problems that do not have one specific solution are called *Wicked Problems* (Rittel & Webber, 1973). Rittel and Weber state that wicked problems can be defined through different characteristics. One of the characteristics is that they are not possible to define until a solution has been found. For instance, every wicked problem is unique and no definite formula could be applied to all wicked problems to find a solution. In addition, a solution for a wicked problem is neither right nor wrong since it can only be considered good or bad. There is also no guarantee that the solution is good since there is no way of knowing when a solution is final. As a result, wicked problems can seem impossible to solve and a linear design process is therefore insufficient when working with wicked problems. Buchanan (1992) connects wicked problems to the design field and suggests an iterative design process to tackle these problems. An iterative design process allows the designer to redefine the problem later in the process.

4.3 Iterative Design Process

An iterative process is a process where all steps are not followed linearly in the order they are described, but where steps can be repeated or carried out in a different order. Such processes are used to ensure that the needs of the users are fulfilled, and that their situation is understood (Wikberg Nilsson et al., 2015).

There are many different iterative design processes. *Double Diamond* is a design model developed by The Design Council of the United Kingdom, which captures the shared principles among various design approaches across diverse fields of design (Sharp et al., 2019). The Double Diamond model is divided into four phases: *Discover*, *Define*, *Develop* and *Deliver*. The first two phases constitute the first diamond, the problem definition, whereas the last two constitute the second diamond, the solution. In short, the process goes from collecting information about the problem and framing it, to iteratively creating and evaluating concepts and prototypes, ending with finalizing, producing and launching the product. Based on the Double Diamond, a developed version has been created, which is often referred to by the name *Triple Diamond*. Google describes this model as consisting of six steps: *Understand*, *Define*, *Sketch*, *Decide*, *Prototype* and *Validate* (Google Design, n.d.-b). Compared to Double Diamond, the Develop phase is split up into three separate phases – *Sketch*, *Decide* and *Prototype* – where the idea is more or less the same, but where each of these phases has a separate emphasis. Wikberg Nilsson et al. (2015) present a design process consisting of four phases: *Plan*, *Explore*, *Create* and *Prototype*. Their proposed process is in many ways similar to Double Diamond and Triple Diamond, but also includes an initial planning phase, focusing on exploring the project and determining the intention of the project. Another process is *Contextual Design*, a user-centered design process that drives innovative design by using field research (Holtzblatt & Beyer, 2015). The fundamental principle of Contextual Design is to understand the users in their settings and use it to develop insights into their lives that can be applied to a design problem. Furthermore, Holzblatt and Beyer (Holtzblatt & Beyer, 2015) explain that Contextual Design can be divided

into three different phases consisting of field research and data gathering, ideation and concept development as well as prototyping and testing.

Another iterative design process is *Design Thinking*, a problem-solving approach centered around understanding the people designed for and how they interact with products (Interaction Design Foundation, 2016). With the goal of creating innovative solutions, Design Thinking focuses on constantly questioning current knowledge and acquiring new. In this way, the problem can be redefined and new solutions not initially evident can emerge. Design Thinking is divided into five phases: *Empathize*, *Define*, *Ideate*, *Prototype* and *Test* (Figure 14). The steps of the process should not necessarily be seen as sequential, but can be performed in parallel or iteratively (Interaction Design Foundation, n.d.). Interaction Design Foundation (2016) brings up out-of-the-box-thinking, immediate action-taking and constant iterations as conditions for solving ill-defined problems, and proposes Design Thinking as a suitable approach for tackling wicked problems.

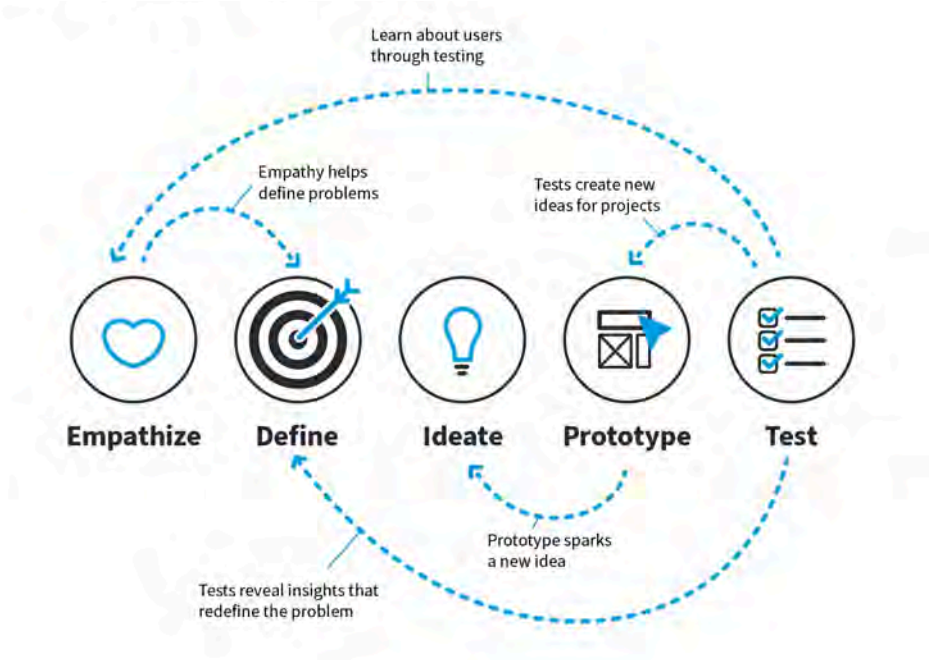


Figure 14. Design Thinking process from Interaction Design Foundation

4.3.1 Empathize

The first phase of Design Thinking is Empathize. Central for this phase is to gain a personal understanding of the problem, users and their expectations and motivations (Dam, 2023). The objective is for designers to suspend their personal biases or beliefs, in order to gain empathy and fully understand the needs and desires of the users. Wikberg Nilsson et al. (2015) explain that this phase focuses on collecting information from users, but also from other stakeholders such as competitors, standards and guidelines, as well as from analyzing current solutions.

To collect and analyze research within the field of interest, Martin and Hanington (2012) propose a method referred to as *literature reviews*. The purpose of the method is to

synthesize information from former research or projects that can be useful for the current project, by structurally gathering and categorizing relevant literature from credible sources. Literature reviews can be time consuming due to the wide range of information available, but Martin and Hanington explain that considering *how* the information informs the design investigation is essential when selecting literature. *Benchmarking* is another method which, just like literature reviews, is used to gather information useful for the project. One of the elements of benchmarking, the *competitor analysis*, is essential in terms of mapping the scope and identifying weaknesses and strong points of similar design (Komninos, 2019). Komninos explains that by looking at direct competitors with the same goal, but also by looking at indirect competitors that fulfill a different purpose but solve the same sub-goal, important lessons can be learned. DaSilva (2020) adds to this by stating that understanding the experience of a competitor's design can enable strategically designing one's own product in a better way.

In order to understand the users and their needs, and to capture their experiences, attitudes, perceptions and motivations, *interviews* can be conducted (Martin & Hanington, 2012; Mortensen, 2020; Wikberg Nilsson et al., 2015). Martin and Hanington explain interviews as a qualitative user research and state that there are two types of interviews, *structured* and *unstructured*. Further, they claim that structured interviews where the interviewer follows a script are useful as they are easier to analyze and easier to monitor in terms of questions and timekeeping, but can be perceived as impersonal and formal. Unstructured interviews are flexible as they allow diversions in the conversations, thus creating a more relaxed situation for the person being interviewed. However, this structure places great demands on the interviewer, who needs to make sure to get all the information needed, within the time frame of the interview. Wikberg Nilsson et al. (2015) claim interviews can be structured in three ways and in addition to structured and unstructured interviews, they also mention *semi-structured* interviews. Semi-structured interviews are described as a combination where a number of areas or questions must be answered, but where the order of how these are addressed is flexible.

Another way of empathizing with the users is through *observations*. Observations can be performed in two ways, in real use situations or arranged in controlled situations (Bligård, 2015). Observations in real use situations are useful to understand the behavior in the true context, whilst observations in controlled situations can be used to gather more detailed knowledge by looking at factors influencing the situation. Unlike with interviews, through observations it is possible to understand the user's situation without influencing their behavior. Bligård (2015) explains that observations are used to figure out what users actually do, not what they claim to be doing.

Focus groups can be another method to gain insights into users and their contexts, and are often carried out with users within a specific area, where they should have discussions covering specific issues or themes (Wikberg Nilsson et al., 2015). Unlike interviews and observations, the insights from focus groups can be rather general. However, focus groups can be useful as participants can extend each other's thoughts, revealing insights that with other methods would not have come to light.

Dam (2023) explains that approaching the user in their context can be useful in order to develop a more profound and personal comprehension of the user and the problem. Martin and Hanington (2012) confirm this by stating *contextual inquiry* as a method for gathering qualitative data about the users and their contexts. Further, they explain contextual inquiry as a combination of interviews and observations, taking place where the work happens. Martin and Hanington claim this to be an essential part of understanding the ongoing experience and the underlying factors influencing the experience.

Questionnaires are a self-reporting method for gathering both qualitative and quantitative data about users and their situations (Martin & Hanington, 2012). Martin and Hanington explain that questionnaires can be used on their own, but suggest using them in combination with other methods to ensure that personal insights are captured and to substantiate the self-reported answers from the questionnaires.

To understand the sequence of actions a user goes through to achieve their goal, a *Hierarchical Task Analysis* (HTA) can be used (Bligård, 2015). The purpose of the HTA is to identify all steps a user needs to go through to achieve their goal, and in which order these steps need to be performed. This is done by identifying an overarching goal, which is then broken down into subordinate actions until no further actions can be identified.

4.3.2 Define

The second phase of Design Thinking is Define. In this phase, focus lies on organizing and analyzing the information from the previous phase (Dam, 2023). Insights should be summarized and the users needs and problems should be spelled out (Interaction Design Foundation, n.d.). Dam (2023) explains that the problem definition should be described from a user-centered perspective, stated as the designers perception of the users needs and not as wishes from the designer or The Company.

One way of compiling all the information and the requirements that emerge is through a *list of requirements*. Wikberg Nilsson et al. (2015) describe a list of requirements as consisting of requirements and wishes, where the requirements are things that must be fulfilled while wishes are desirable and will add value to the experience. Further, Wikberg Nilsson et al. (2015) explain that the list of requirements can be used as a tool to evaluate whether different solutions measure up against the requirements and that the list will be iterated upon during the entire design process. Bligård (2015) adds to this by explaining that there should be an alternating interaction between the design work and setting requirements.

To be able to structure the information collected in the Empathize phase and to categorize insights, *Affinity Diagramming* can be used (Martin & Hanington, 2012). Martin and Hanington explain Affinity Diagramming as a bottom up approach, where insights are written down and grouped based on affinity, and not based on predefined categories. Bligård (2015) describes this method as an efficient way of compiling large sets of data and getting an overview.

One way to describe users and their needs is through *personas*, where the material collected in the previous phase is used to formulate a fictional description of a person from the target group (Wikberg Nilsson et al., 2015). Martin and Hanington (2012) explain that the aim with personas is to provide meaningful and relatable descriptions of sample users, where behavior patterns and themes of commonality are captured. Further, they describe personas as useful throughout the entire design process, and especially as a human reference for developing, discussing and presenting ideas. A similar way of describing the users and their context is through *storyboards*. Storyboards are used to visually capture the essence of the context in which a product will be used, including social, environmental and technical factors (Martin & Hanington, 2012).

4.3.3 Ideate

The third phase of Design Thinking is Ideate. Based on the solid understanding established and defined in the former two phases, ideas and innovative solutions will be generated in the third phase (Dam, 2023). *Brainstorming* is an established method to generate ideas (Wikberg Nilsson et al., 2015). The purpose of brainstorming is to come up with many ideas in a short time rather than focusing on whether the ideas are feasible. Moreover, according to Wikberg Nilsson et al. (2015), many alternative brainstorming methods exist. *Brainwriting* and *Braindrawing* are two alternative methods where the participants' ideas are built upon each other. These methods aim to take advantage of the group's creativity and ensure that the created ideas belong to the group and not to one specific individual. In contrast to Brainwriting, Braindrawing uses sketching to develop new ideas instead of writing. Another brainstorming variation that utilizes fast sketching is *Crazy 8*'s (Google Design, n.d.-a).

In addition to generating a broad scope of ideas, (Dam, 2023) explains that the Ideate phase also includes sifting through the ideas to bring only a few to the next phase. Wikberg Nilsson et al. (2015) explain that the Ideate phase includes different stages of *divergence* and *convergence*. In the divergence stage the goal is to come up with a lot of different ideas. The convergence stage ensures that these ideas are narrowed down and fulfill the list of requirements. These different stages are then repeated until the solution space is explored thoroughly. Methods that can be used to narrow down ideas according to Wikberg Nilsson et al. (2015) are *Dark Horse* and *Six Thinking Hats*. These methods encourage thinking outside the box and seeing these ideas' potential. *Scamper* is another method to develop previous ideas further (Wikberg Nilsson et al., 2015). An additional method based on narrowing down ideas and developing concepts is a *Morphological Chart*, which is an excellent method for generating ideas based on different requirements (Wikberg Nilsson et al., 2015).

Furthermore, (Wikberg Nilsson et al., 2015) state that it is essential to have different methods to decide on final concepts. The authors state that there are several methods to evaluate concepts and compare them to each other. Examples of these methods are *Concept Score Matrix* and *Pugh Matrix* (Wikberg Nilsson et al., 2015).

4.3.4 Prototype

The fourth phase of Design Thinking is Prototype, which aims to investigate the ideas created in the former phase to find the most appropriate solution for the defined problems (Dam, 2023). This phase is an experimental phase, where several prototypes are created and evaluated to understand how users interact with- and perceive the prototypes. *Prototyping* can be described as "... the tangible creation of artifacts at various levels of resolution" (Martin & Hanington, 2012, p.138). Sharp et al. (2019) explain that prototypes can take many forms, from a paper sketch to complex software. Prototyping can also be used to communicate ideas in a design team, effectively test designs with users, or present ideas to other stakeholders. The authors also mention that there are two common properties of prototyping called *horizontal* and *vertical* prototyping. A horizontal prototype contains a wide range of functions but few details, while a vertical prototype has many details but only a few functions. However, various types of prototypes serve different purposes and are often defined by their type of fidelity. In addition, prototypes often go through various stages of fidelity within the Ideate phase.

Sharp et al. (2019) state that *low-fidelity* prototypes are helpful in the early stages of the design process and often are used as proof of concept. In addition, low-fidelity prototypes are often simple, cost effective and very quick to produce. That way, they allow for quick revision and encourage the exploration of various kinds of ideas. Some standard low-fidelity prototyping methods are *sketching* and *scenarios* in combination with storyboards. *Wizard of Oz* is a common low-fidelity prototyping method for digital applications (Martin & Hanington, 2012). This technique enables the user to interact with the prototype as with the actual application, but the responses are simulated by a human operator instead. Wizard of Oz is an excellent technique for exploring how users feel and perform using a proposed solution.

A *high-fidelity* prototype is a prototype that often contains more functionality and gives a sense of what the final product will look like (Sharp et al., 2019). Martin and Hanington (2012) describe that high-fidelity prototypes are often helpful in a later stage of evaluation with users since they can provide more feedback on usability and interactions. However, Sharp et al. (2019) argue that a disadvantage of high-fidelity prototypes is that they require many resources and are time-consuming. Another consequence of using high-fidelity prototyping is that it can be confused with the final product, and users may be hesitant to give honest feedback.

4.3.5 Test

The fifth phase of Design Thinking is Test. This is the phase where the prototypes are thoroughly evaluated (Dam, 2023). As Design Thinking is an iterative process, this phase is not necessarily the last. Dam (2023) describes that the results from the evaluations often are used to redefine problems and might loop the designer back to an earlier phase again for further iterations, due to increased knowledge and understanding. There are two types of evaluations, *formative* and *summative* evaluations (Joyce, 2019). Joyce explains that the phase of the design process dictates which type is more suitable. Formative evaluations are

suitable throughout the design process as it includes testing and making modifications to the design. The essence is to understand which aspects of a design function effectively and which do not, and this type of evaluation is usually carried out multiple times. Summative evaluations on the other hand focuses more on understanding the overall experience of a design and identifying how well a design performs. This type of evaluation is suitable towards the end of the design process, where the design is compared to a competitor or an earlier version.

In order to evaluate a prototype and detect possible areas of improvements, *usability testing* can be conducted (Martin & Hanington, 2012). Usability testing is a method where users are asked to perform a set of realistic tasks under observation, and Martin and Hanington describe it as effective for detecting parts of the interface that cause confusion or frustration. In addition, Sharp et al. (2019) explains that usability tests are performed in controlled settings and this method can include collecting data through other methods such as experiments, interviews or observations. To end up with the best results, Nielsen (Nielsen, 2000) suggests conducting multiple tests with no more than five participants. Within five tests, he claims that 85% of all usability problems with a design are identified and not many new findings will be revealed. Thus, to discover most of the remaining 15%, it is better to perform several tests with few users where the design is updated as insights are revealed.

A/B Testing on the other hand, is a method used to compare two versions of a design against set goals to see which of the designs meet the goals better (Martin & Hanington, 2012). This method is suitable for comparing similar designs where small modifications have been made. A drawback of A/B Testing however, is that it lacks the ability to understand why one design performs better than the other. Martin and Hanington propose to complement the method with qualitative methods to evaluate customers' experiences and needs.

A *Cognitive Walkthrough* is another method for evaluating an interface (Lewis & Wharton, 1997). In a Cognitive Walkthrough, the correct way to solve a task is determined by an analyst. The steps required to solve the task are then reviewed by the analyst to decide whether the appropriate actions will be taken, or whether problems will arise. Sharp et al. (2019) describe Cognitive Walkthrough is an efficient method of evaluating designs without access to users.

4.4 Tools

This section includes information about some of the most relevant softwares and tools for this project. These include Figma, Axure RP and UserTesting.

4.4.1 Figma

Figma (Figure 15) is an online interface design tool optimized for team collaboration (Figma, n.d.-a). In Figma it is possible to visualize and present design ideas and create high- and

low-fidelity prototypes of different interfaces. Figma also enables the creation of interactive and animated prototypes in different ways, to show and test possible interactions. In addition, Figma has a developer mode that facilitates translating designs into code more efficiently.

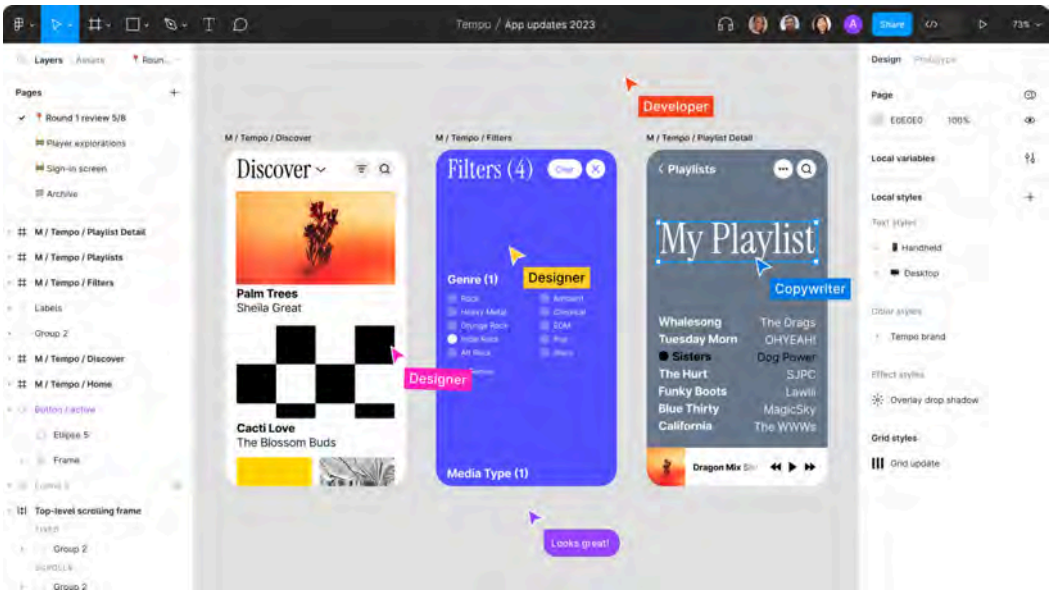


Figure 15. An overview of a collaborative dashboard in Figma

Furthermore, Figma also offers an online whiteboard feature called FigJam (Figma, n.d.-b). FigJam (Figure 16) can be used to collaborate when brainstorming, conducting workshops, creating flowcharts, project timelines and more. Additionally, FigJam also offers various templates to facilitate different stages of a project.

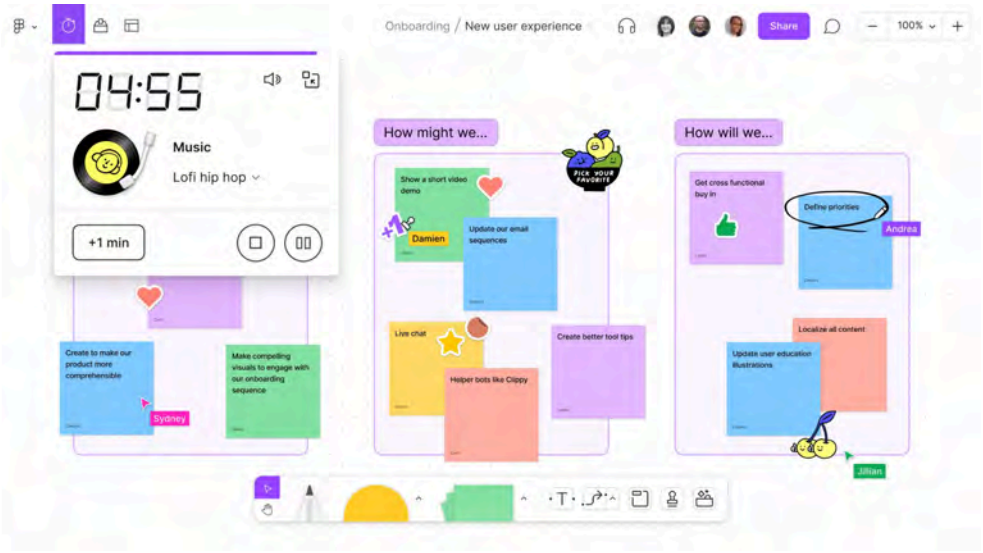


Figure 16. An overview of a collaborative FigJam whiteboard

4.4.2 Axure RP

Axure RP (Figure 17) is a prototyping tool used to create more advanced interactive and dynamic user interface prototypes (Axure RP, n.d.). The design tool is specialized in high-fidelity prototypes by offering implementation of event triggers, conditions and actions without the need for code. However, Axure RP can also create wireframes and low-fidelity prototypes.

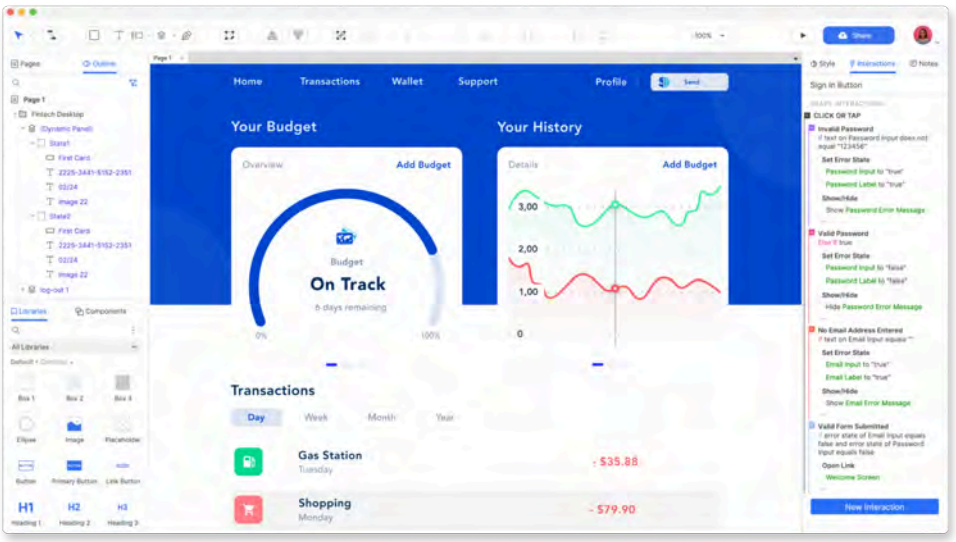


Figure 17. An overview of Axure RP

4.4.3 UserTesting

UserTesting (Figure 18) is a platform that can be used to test the user experience and get feedback on, for instance, digital prototypes, websites and mobile apps (UserTesting, n.d.). The platform allows the design team to create a usability test with specific tasks and questions. UserTesting also facilitates the recruitment of participants by providing a network with users from different target audiences. The tests can be conducted live through video calls or by the participant recording their screen and voice.

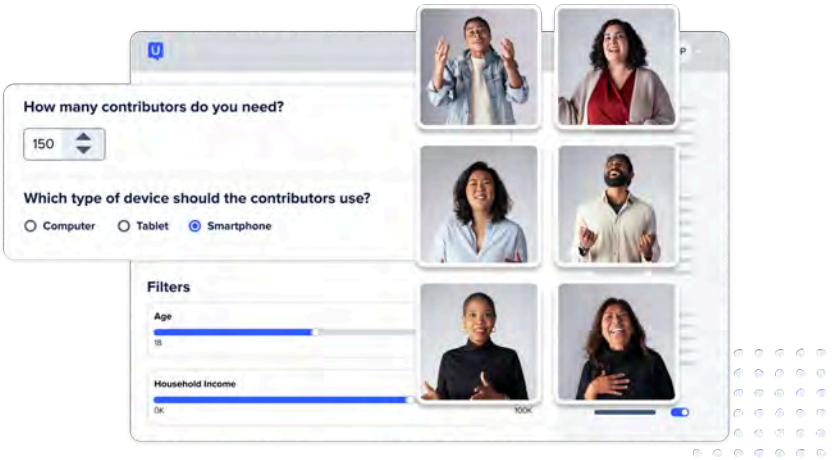
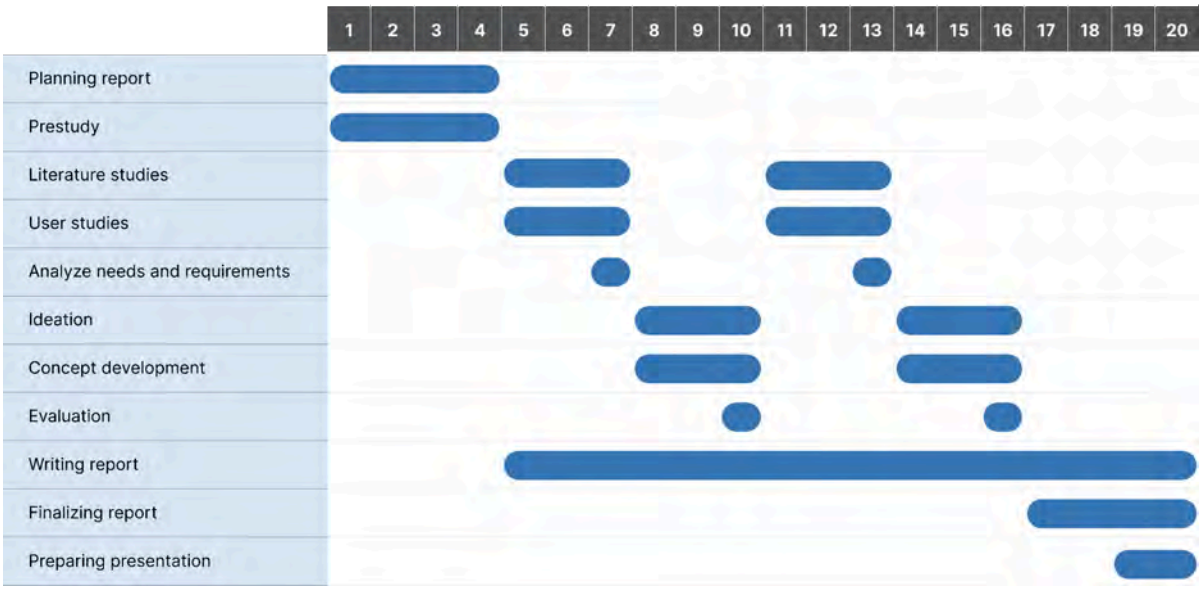


Figure 18. An overview of UserTesting

5
PLANNING

This chapter introduces the initial planning of the project, including the initial time plan that is summarized in Table 1. The time plan shows that the project will be initiated with a prestudy, along with writing a planning report. The prestudy was planned to include benchmarking to examine how other products present options for acting on selections. It was also planned to include reviewing literature and exploring The Software. The project was intended to follow a research through design approach, where the insights gained throughout the design process would be used to answer the research question. The iterative design process that would follow the prestudy was planned to contain an exploratory stage where literature and user studies will be performed, accompanied by analyzing users' needs and requirements. The exploratory stage was planned to be followed by a developing stage, where ideation, concept development and evaluations would be executed. Iterations were planned to be performed to revise and refine the work. The design process was intended to be divided into two main iterations to ensure that the design would be iterated and the solution space thoroughly explored. A report gathering the process and findings was planned to be conducted continuously throughout the project and finalized during the last weeks. Further, to ensure that the project's objectives were fulfilled, weekly meetings with both The Company and the thesis supervisor were planned to be conducted.

Table 1. Initial time plan



6
EXECUTION

The following chapter describes the process for the project, presented in chronological order. The chapter is initiated with the prestudy, followed by Iteration 1 and Iteration 2. Both of the iterations follow the Design Thinking process, and are divided into: Empathize, Define, Ideate, Prototype and Test, followed by a reflection of each iteration. The guidelines have been iterated and refined continuously during the entire execution. The different drafts of the guidelines are presented at the end of the prestudy, as well as under Define for the two iterations.

6.1 Prestudy

At the beginning of the project, time was spent understanding and exploring The Software. A literature review and a benchmark were also conducted before defining the initial guidelines. The project's time plan was updated and refined to further describe the different steps in the process. During the prestudy, a planning report was also written.

6.1.1 Literature Review

A literature review was conducted to understand the scope of the project and gain insights for future design decisions and the formation of guidelines. Initially, literature about information visualization, visual analytics and business intelligence was collected from books, scientific papers, and articles. Once more knowledge of the overall topics related to visual analytics was gained, literature regarding user experience, design patterns, guidelines, and different best practices for contextual menus was collected. The literature review also covered literature regarding design methodology and useful methods for the thesis project. Whenever a resource was considered relevant to the project, the source was added to a library in the reference handling software Zotero (Zotero, n.d.). This literature library was then studied in more detail, and the most relevant sources were chosen.

Most books used during the literature review were provided by The Company or borrowed from Chalmers Library. In order to get access to the online sources, different search engines were used, such as ACM Digital Library (*ACM Digital Library*, n.d.), Google Scholar (*Google Scholar*, n.d.), IEEE Xplore Digital Library (*IEEE Xplore*, n.d.) and Chalmers Library (*Chalmers Library*, n.d.). Google Search (*Google*, n.d.-a) was used to find additional information and

websites relevant to the project. During the process of finding relevant literature, some used keywords were Visual Analytics, User Experience and Design Patterns.

The insights gained during the literature review were used to create a theoretical framework, presented in chapter 3, and used as a foundation for understanding the scope of the project. In addition, a methodology chapter gathering different design processes and methodologies was created and is presented in chapter 4. Furthermore, the most relevant information was used as a foundation to create the initial set of guidelines.

6.1.2 Benchmarking

As a complement to the literature review, a benchmarking was conducted. The benchmarking included a competitor analysis, as well as an analysis of other websites and softwares that make use of different patterns to present options to act on selections. The competitor analysis examined the main competitors of The Software: Tableau, Qlik Sense and Power BI. These were analyzed by actively using trial versions of the softwares to examine how available actions are presented, but also by reading through their user guides and documentation. The results from the competitor analysis are presented below, and some additional examples of design solutions can be found in chapter 2.4.

To investigate other ways of presenting contextual options, tools and websites including Figma (Figma, n.d.-a), Outlook (Microsoft, n.d.-b), Google Maps (*Google Maps*, n.d.), Pages (*Pages - Apple*, n.d.), Alias (Autodesk, n.d.-a), The Sims 4 (Electronic Arts, n.d.) , AutoCAD (Autodesk, n.d.-b) , Canva (Canva, n.d.), Google Slides (Google, n.d.-b) and Word (Microsoft, n.d.-a) were also analyzed. The purpose was to investigate commonly used design patterns for presenting actions for selections, but also to identify opportunities and challenges with these. The aim was to consider a wide range of tools, for both novice and expert users. Frequently used tools were examined, but also more niche tools such as games and expert softwares.

To summarize the results from the benchmarking, a FigJam file gathering screenshots and comments about the different presentation methods was created (Figure 19). This compilation was then analyzed further, and the findings were presented as three categories, *Good*, *Bad* and *Common* (Figure 20).

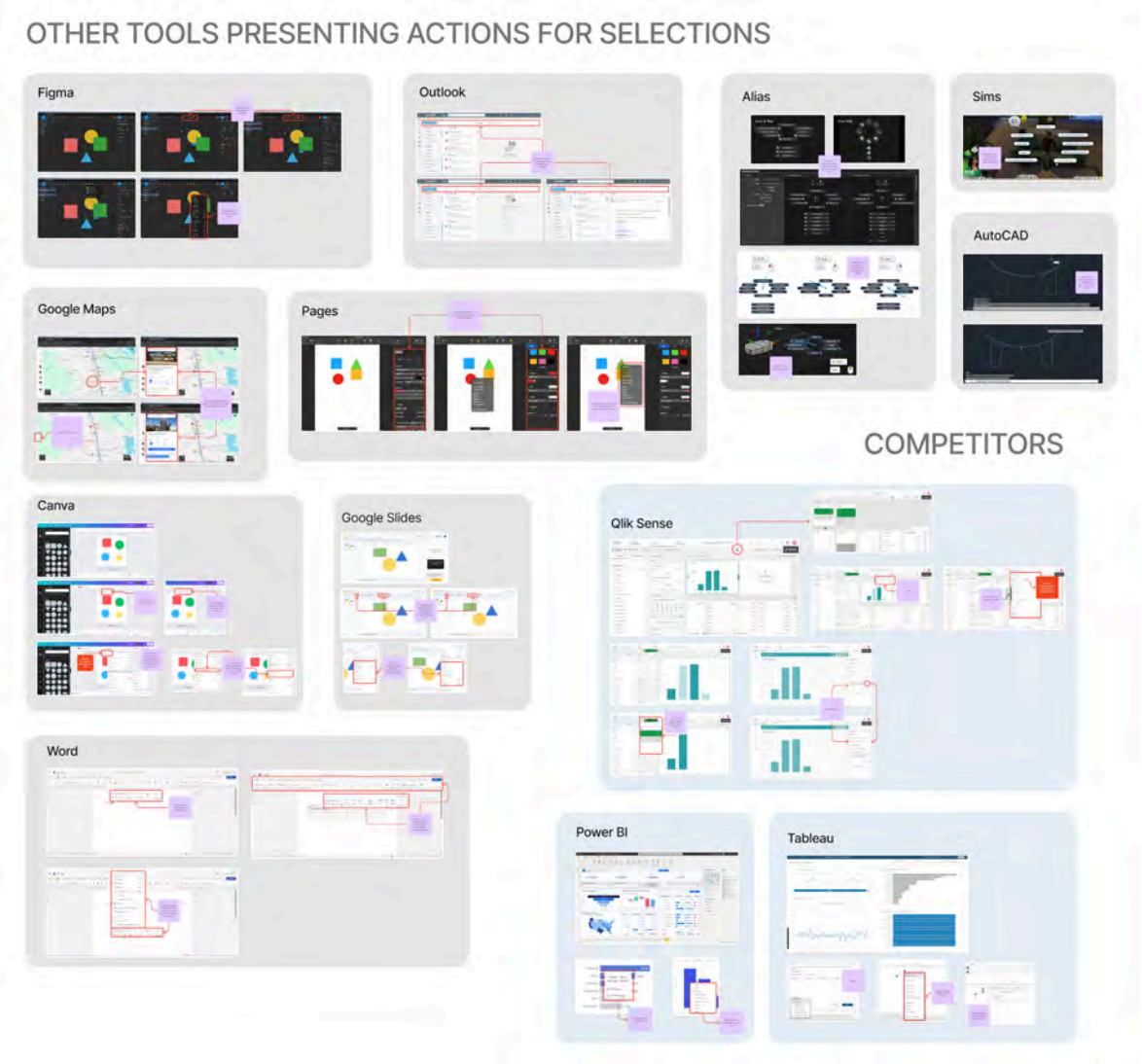


Figure 19. FigJam file gathering screenshots and notes collected throughout the benchmarking

Figure 20. The findings from the benchmarking, divided into Good, Bad and Common

Three main conclusions could be drawn from the compilation of the benchmarking. Firstly, a common way to present actions for selected data was through a contextual menu accessed by right-clicking. This pattern was used in a majority of the examined tools. Secondly, the content of contextual menus often changes based on what has been selected and which actions can be performed. This was seen as good, as the actions presented were then perceived as applicable for the selected objects. Lastly, a common design pattern for presenting actions was through a toolbar, accessed when selecting objects or when hovering over the selected objects. The toolbars generally included only a few items, and were not used to present a large number of actions.

Seemingly good ways of presenting actions for selected objects was through compact and non-intrusive ways, where the content on the screen was not hidden by any menu or component. Outlook uses a toolbar on the top of the page to present a variety of actions (Figure 21). This presentation style is a compact way of including many actions, without being intrusive or covering the rest of the content on the screen. The Outlook toolbar includes actions which are not available for the current selection. These unavailable options are distinguished by reducing the opacity, and thus clearly informs the user of which actions are available for the current selection while also informing that the disabled actions can be available for other selections. Another more dynamic way of presenting actions can be seen in Figma, where the toolbar changes depending on the selected object (Figure 22). The toolbar in Figma only presents available actions for the current selection, and in this way users know which actions they can take for the current selection.

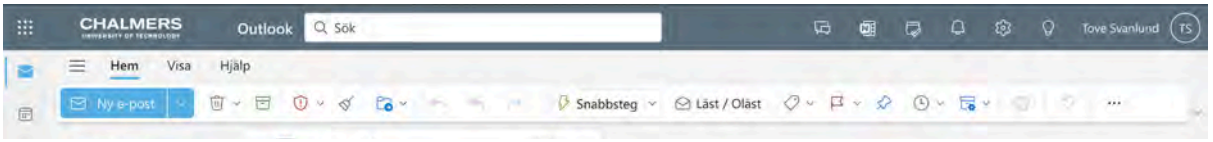


Figure 21. The toolbar in Outlook with unavailable actions included

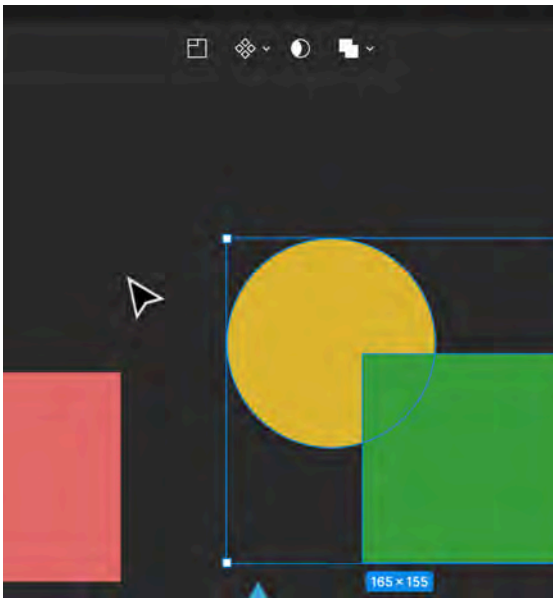


Figure 22. The dynamic toolbar in Figma

Furthermore, toolbars can be useful as they appear close to the selected objects, informing the user that the content in the toolbar is related to the selection. Even though this way of presenting actions is based on the gestalt law of proximity (Interaction Design Foundation, 2024), it can be a bad way of presenting actions as it can cover parts of the content or other components.

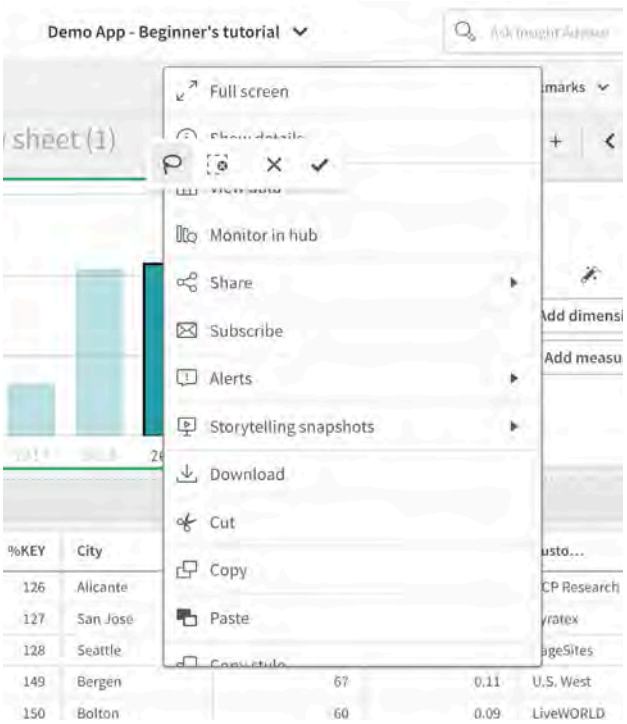


Figure 23. Toolbar covers content in a contextual menu in Qlik Sense

An example of this can be found in Qlik Sense, where a toolbar covers content in a contextual menu (Figure 23). Another limitation identified in Qlik Sense is an automatic drill down functionality. As soon as a selection of data has been made, the visualization drills down and removes the data that has not been selected (Figure 24). This might result in a perceived feeling of lack of control, which is not desired.

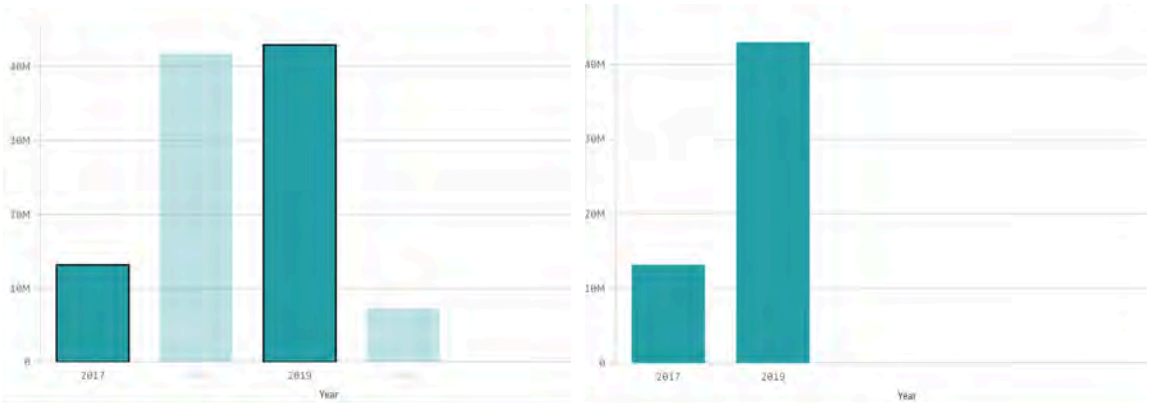


Figure 24. Automatic drill down functionality in Qlik Sense

Google Maps uses a flyout panel (Figure 25) to enable users to perform multi-step actions on-the-fly, where it is possible to explore information such as hotel availability or route directions without the need of changing context. It holds many actions and lots of information while a show/hide functionality ensures a non-intrusive way of presenting actions. It is also possible to continue exploring the content on the map with the panel present if desired.

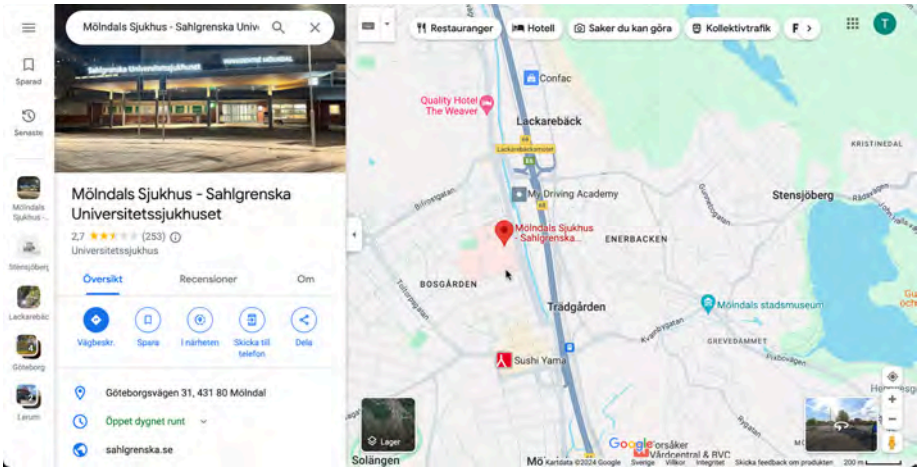


Figure 25. Flyout panel in Google Maps

A seemingly less common pattern for presenting options for acting on selections is through circular context menus. This presentation style is used in Alias, where the actions appear in a radial distribution around the mouse with equal distance to all alternatives (Figure 27). Alias allows for three different sets of actions, one for pressing the left, one for the middle and one for the right mouse key. In Alias, the pattern allows for customization, where the user can themselves choose which actions to include at which position and whether to include text or only include icons. This way of presenting actions allows for a large number of actions to be presented although it comes with some challenges. Firstly, in this pattern there is nothing indicating how to access the actions. If users don't know this pattern is used, it may be hard to know how to access the actions. Secondly, it requires users to remember which action is located on which mouse key. If the actions presented in the circular menu are frequently used, the actions and their location will soon be remembered, however if they would be less frequently used it would most likely cause frustration.

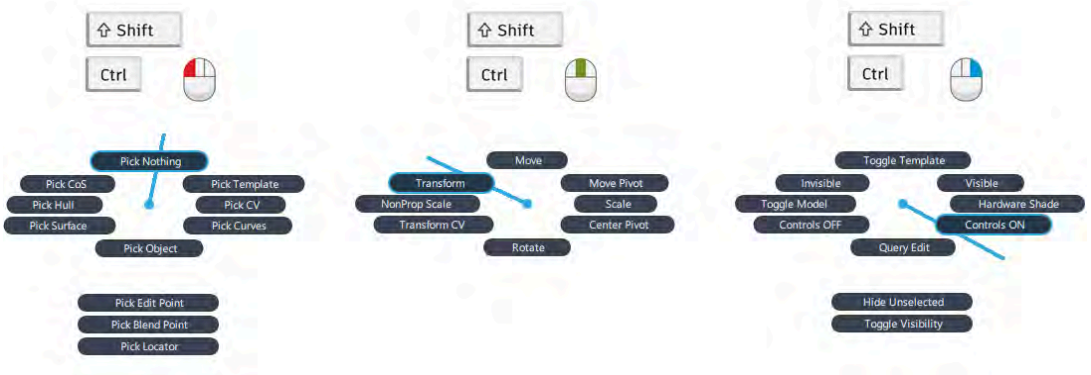


Figure 27. The circular context menu from Alias

6.1.3 Understanding The Software

The available documentation and user guides were studied to understand The Software better. The primary focus was to understand how actions for selections are presented in the interface and which actions are available. To get more practical experience, a dataset was analyzed using The Software. Additional knowledge of The Software was gathered during an interview and a demo of The Software conducted with an internal stakeholder at The Company. The stakeholder explained the purpose of selections and demonstrated how this concept relates to different actions users might want to perform. Problems and challenges with the current presentation of actions were also discussed. The interview and demo provided a more profound knowledge of The Software's capabilities and current interface.

6.1.4 Planning of Design Process

The initial time plan was refined at the end of the project's prestudy, as more knowledge within the field was gathered. The aim was to make the time plan more detailed and understandable and ensure that the final guidelines would be iterated thoroughly. More iterations of the guidelines were included in the revised time plan, which is divided into three phases and shown in Table 2.

Table 2. Revised time plan

Phase 1

In the revised version of the time plan, the literature studies were presented in another way compared to the initial time plan presented in chapter 5. To clarify that the prestudy phase includes a literature study, overlapping with the Empathize phase, the first literature study was set to be ongoing from week one until week six. Reviewing most of the literature at the project's beginning was intended to ensure a solid foundation for the upcoming project and before starting the first iteration. Despite adapting the duration of the literature studies, the plan was to study literature when necessary during the two iterations.

Phase 2

The second phase was planned to focus on conducting practical work. The two iterations were intended to break down the problem into smaller parts, making them more approachable. Each iteration was planned to consist of the five design thinking phases: Empathize, Define, Ideate, Prototype, and Test (Interaction Design Foundation, n.d.). The idea was to carry out interviews, observations and a contextual inquiry (Martin & Hanington, 2012) to emphasize with the users. The choice of using contextual inquiry as a method was based on the fact that it combines interviews and observations in the users' context and gives an idea of the current user experience. Even though the method focus group (Wikberg Nilsson et al., 2015) serves a similar purpose of getting to know the users more in-depth, the method was not intended to be used. Another planned method for the Empathize phase was HTA (Bligård, 2015). This method was chosen because it would be useful for gathering an overview of the different actions possible to perform with the selected data. However, The Company mentioned that gathering a complete list of actions would be challenging. As a result, an HTA might not provide a complete overview for this project. After gathering data, the plan was to structure and analyze it with an Affinity Diagram (Martin & Hanington, 2012) and thereafter create initial requirements and guidelines. If qualitative data would be missing, the idea was to send out a digital questionnaire to gather additional information from users effectively.

During the Ideate phase, a combination of Brainwriting (Wikberg Nilsson et al., 2015) and Braindrawing (Wikberg Nilsson et al., 2015) was planned to be conducted to ideate solutions. A combination of these methods was chosen since it is often easier to explain ideas by sketching and writing annotations. In addition, these methods enable building on each other's ideas. Crazy 8's (Google Design, n.d.-a) is another method that was planned to be used during the Ideate phase to generate a variety of ideas quickly. Workshops with a team from The Company were also intended to be conducted since they have more experience working with The Software and have an insight into currently used design patterns. Moreover, different methods, such as a Morphologic Chart (Wikberg Nilsson et al., 2015) and Six Thinking Hats (Wikberg Nilsson et al., 2015), were considered as methods for generating concepts. These two methods will thoroughly investigate the solution space and help combine different ideas to develop new concepts.

The concepts were planned to be prototyped and evaluated with, for example, usability testing (Martin & Hanington, 2012). This type of testing shows if the users can accomplish the intended tasks and where potential problems occur. If two competing designs should be evaluated, the intention was to use A/B Testing (Martin & Hanington, 2012) since it is an excellent method to compare different solutions directly. Furthermore, the suggested methods in the revised time plan for the project's second phase were supposed to be able to be updated or replaced depending on the progression of the project.

Phase 3

The third phase was planned to be ongoing throughout the whole project. The idea was that it would include writing a project diary to capture the project's progress, as well as writing the report. The purpose of the diary would be to also capture important decisions and

findings which could be used as support when writing the execution chapter for the report. The project report was intended to be written continuously throughout the project to balance the workload. Towards the end of the third phase, time was planned to be set aside to entirely focus on finalizing the report and preparing for the final presentation.

6.1.5 Initial Guidelines

The prestudy served as a foundation for the project, where valuable knowledge was collected. The literature review, benchmarking and interview with an internal stakeholder, along with hands-on experience from exploring The Software, resulted in knowledge about Visual Analytics and related fields. The prestudy also contributed with knowledge around best practices and heuristics, as well as an understanding of different patterns for presenting options for acting on selected data.

Based on the findings from the prestudy, a set of initial guidelines was created. The guidelines are presented below and are inspired by guidelines and heuristics from the book *About face* written by Cooper et al. and articles from Nielsen Norman Group. Apart from these resources, the takeaways from the prestudy have also served as inspiration for the guidelines.

> **G1. Frequently used actions should be immediately in reach.** The order of the presented actions should be based on how frequently they are used, where the most frequently used should be closest to reach.
>
> **G2. Let the user focus on the goal rather than the interaction.** The presented actions should not disturb the users workflow and let the user focus on their goal, rather than to direct the focus to the interaction for the desired action.
>
> **G3. Limit the number of actions presented simultaneously.** Presenting too many actions at the same time can result in unnecessary time being wasted looking for the desired action and the choice of a suboptimal action.
>
> **G4. Indicate the access point for the presented actions.** It should be clear to advanced as well as novice users where possible actions for the selected data can be found and how they can be accessed.
>
> **G5. Reduce navigational excise.** Within the presentation of possible actions, hierarchies should be avoided and the number of places the user can navigate to should be kept to a minimum.
>
> **G6. Do not hide important information.** The presentation of actions must not hide or affect important information in the interface.

G7. Internal consistency should be considered. The presentation of actions should use the same visual style as the rest of the interface, including color, language and sizing.

G8. Facilitate the workflow for multi-step actions. Increase the user's sense of control by requiring less cognitive load for actions that require several levels of interaction.

G9. Increase accessibility by allowing keyboard navigation. To support expert users who prefer quick commands, but also people who have certain disabilities and have trouble using the mouse, keyboard navigation should be available to navigate the presentations of actions.

6.2 Iteration 1

The first iteration was divided into the five different Design Thinking phases: Empathize, Define, Ideate, Prototype, and Test. The Empathize phase focused on understanding the problem and in this phase, interviews with internal stakeholders were conducted. During the Define phase the interviews were analyzed to define the users' needs. Additionally, the initial guidelines were defined further and updated. During the Ideate phase, ideas were generated and concepts were developed. The ideas were narrowed down and refined during the Prototype phase and evaluated with internal stakeholders at The Company during the Test phase.

6.2.1 Empathize

The focus of the Empathize phase was to gain insights about potential challenges connected to presenting options for selected data in The Software. Interviews were therefore conducted with internal stakeholders at The Company.

Interviews with Internal Stakeholders
Six interviews were conducted with internal stakeholders at The Company to better understand The Software and problems connected to presenting actions. The goal of the interviews was to gain a better understanding of common actions for selected data and how they are currently presented in The Software. The interviews lasted about 45 minutes and were held either online or in person. The interviewed stakeholders worked within different fields at The Company and had different backgrounds and insights related to The Software. Two of the interviewed stakeholders were UX designers and will be referred to as I1 and I2 in this thesis. In addition, three interviews were held with product managers at The Company, referred to as I3-I5. Lastly, one technical account manager was also interviewed and will be referred to as I6.

The interviews were semi-structured to shape the interview to some extent according to the interviewees' answers and to have the opportunity to ask follow-up questions. The questions were primarily open-ended, so the interviewees could answer the question

however they wanted. This was primarily done to allow the stakeholders to give specific responses and to gain as valuable information as possible. The questions differed slightly depending on the interviewees' roles at the Company, but some general questions were asked to all stakeholders. The general questions focused on what they consider to be the most commonly used actions for selected data, the most significant challenges when presenting options in the current interface of The Software, as well as what a potential dream scenario would look like.

The responses to the general questions showed that The Software offers a lot of different actions that can be performed on selected data. One interviewee (I5) mentioned that which actions are commonly used depends on the use case. However, most interviewees mentioned creating a *details visualization* as one of the most common actions. Furthermore, the interviewees mentioned several challenges with the presentation of actions in the current interface of The Software. Three interviewees (I2, I4, and I5) expressed that actions are scattered around the interface as they have different access points and, therefore, can be hard to find. Another interviewee (I1) pointed out that external actions are complex to perform and require more navigation in the interface. The dream scenarios for presenting options for selected data were primarily related to the presentation being adaptable, easily discoverable, and not disrupting workflows or requiring a change of context. One interviewee (I2) talked specifically about the ability to customize and add actions depending on the use case.

UX designers were included in the interviews as they understand the interface well and have knowledge about different design patterns and general UX principles. The intent of interviewing the UX designers was to understand the most significant challenges with presenting actions. The questions during the interview focused on exploring why selections are an essential concept, where different actions are currently accessed in the interface, and why specific actions are located in the contextual menu. One interviewee (I1) had worked with a similar project a couple of years ago and questions specifically targeting that project were also asked.

During the interviews with the UX designers, it became apparent that selections are used to explore data further. Interviewee I1 explained that selections are used to get insights and analyze data further, while interviewee I2 emphasized that selections are essential to interact with the data. Furthermore, the responses showed that important and more generic actions are placed in the contextual menu in The Software's interface. Interviewee I2 explained that the actions in the contextual menu are used to access the desired data, while other actions focus more on analyzing the selected data.

Three interviews were also conducted with project managers (I3-I5). The project managers were included as they had extensive experience working with The Software and frequent contact with customers. The goal was to gather their insights and ideas to gain inspiration for the project. The specific questions posed to the product managers focused on exploring important considerations related to The Software, when designing the presentation for

acting on selected data. Questions were also asked about customers' feedback regarding acting on selections and how the presentation of actions has changed over time.

Important design considerations expressed by two interviewees (I3 & I4) were the importance of compromising between actions being easy to find and non-intrusive. The responses regarding customer feedback showed that there were no specific complaints about the presentation. One interviewee (I4) mentioned that customers often do not express these complaints. Another interviewee (I3) mentioned that customers wished to drill down data directly in the visualization. In contrast, others wished to integrate external actions better in the interface. Moreover, how actions can be performed for the selected data has changed significantly as new actions have been implemented in The Software. Interviewee I4 mentioned that every new action has a new access point, which explains why they are scattered around the interface.

One interview was held with a technical account manager (I6) since they work in close contact with customers and have experience using The Software. The interview aimed to better understand customers' opinions about the current presentation of actions, and the questions focused on customer feedback. During this interview, it became clear that customers had not explicitly expressed problems with the current presentation of actions for selections. However, Interviewee I6 mentioned that customers express that some features are hidden in the current interface.

Overall, the interviews gave valuable insights into what the stakeholders considered important or challenging, as well as what they would like to implement regarding acting on selected data. The fact that internal stakeholders from different backgrounds were included in the interviews might have affected their point of view. However, the different perspectives also resulted in broadening the understanding of selections and actions.

6.2.2 Define

After understanding how the options for acting on selected data are currently presented in The Software, as well as the challenges, motivations and expectations associated with this, the next step focused on defining the problem and user needs. The insights from the Empathize phase were analyzed through an affinity diagram and summarized into five focus areas. The guidelines were revised and a second iteration of guidelines was formulated based on the results.

Analysis of Interviews with Internal Stakeholders

In order to summarize, organize and analyze the insights from the interviews, affinity diagramming was conducted. Data from the transcribed material from the interviews was recorded on sticky notes, and gathered on a digital whiteboard in FigJam. The sticky notes from each interviewee was assigned a different color, and with all six interviews added, the clustering began. The sticky notes were grouped according to relatedness, where similar notes containing similar content were placed together to form a group. The clustering process was iterative, where discussions regarding the formed groups led to regroupings

until each group was fully defined. The final groups were given descriptive titles to indicate the content (Figure 28).

Figure 28. The final groups from the affinity diagram

To define the scope and decide on the areas of focus for the project, a second iteration of the affinity diagram was performed. The aim for the second iteration was to distinguish the most essential problems as well as frequently expressed needs. The notes that were considered most essential were selected and a new clustering was conducted with these. The second iteration resulted in the five final areas of focus: *Non-intrusive*, *Customizability/Scalability*, *Discoverability*, *Exploring data* and *Keep workflow* (Figure 29).

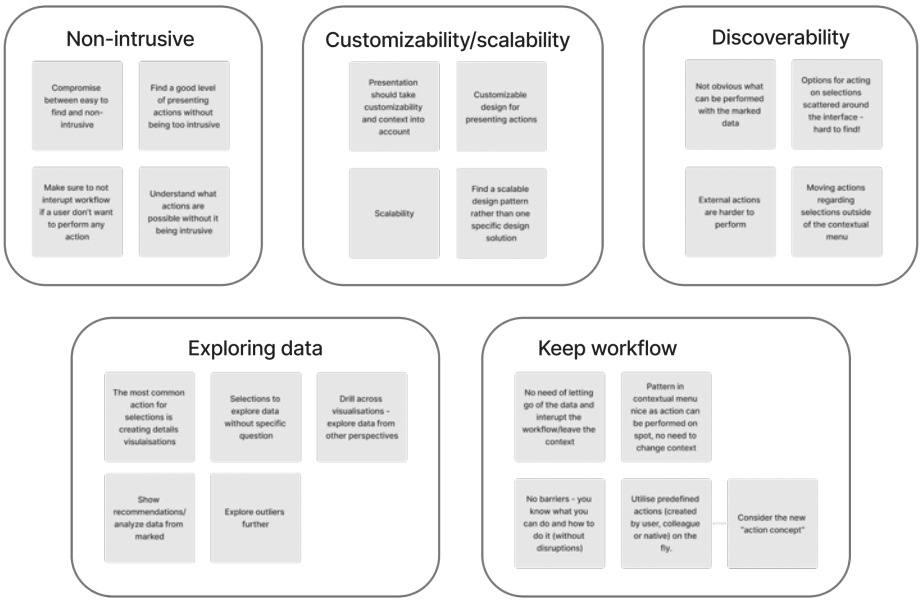


Figure 29. An overview of the final areas of focus

The first focus area, Non-intrusive, emphasized the importance of finding a presentation style where the users understand which actions are available for the selected data without it being intrusive. If a user does not want to perform any action with the selected data, there should not be a pattern that disturbs the user, but rather lets them focus on their workflow. For the second area, Customizability/Scalability, focus was to allow for a scalable design pattern rather than a specific design solution and a pattern that takes customizability and context into account when presenting ways to act on the selected data. The third focus area was Discoverability, an area based on users expressing that it is not obvious which actions are possible to perform with the selection and that actions are scattered around in the interface and sometimes hard to find and perform. Exploring data was the forth area of focus, highlighting the data exploration possibility and the ability to explore data from different perspectives as highly important and valuable features. The fifth and final focus area, Keep workflow, indicates the desire for being able to keep a continuous workflow while performing an action with a data selection. This area emphasizes working on-the-fly and the wish for a workflow where there is no need to let go of the selected data and switch context in order to perform an action. The results from the affinity diagram were used to revise and update the initial guidelines.

Second Iteration of Guidelines

The takeaways from the interviews with the internal stakeholders and the findings from the affinity diagram were used to update the initial guidelines. In the second iteration of guidelines, two guidelines were updated, two were combined and reformulated and three new were added. In addition, some guidelines were strengthened by the results from the internal interviews and kept unaltered. The second iteration of guidelines are presented below.

G1. Consider customizability. It should be possible for each user to customize which actions are presented when selecting data.

G2. Let the user focus on the goal rather than the interaction. The presented actions should not disturb the users workflow and let the user focus on their goal, rather than to direct the focus to the interaction for the desired action.

G3. Limit the number of actions presented simultaneously. Presenting too many actions at the same time can result in unnecessary time being wasted looking for the desired action and the choice of a suboptimal action.

G4. Indicate the access point for the presented actions. The access-point should be discoverable as it should be clear where possible actions for the selected data can be found and how they can be accessed.

G5. Do not hide important information. The presentation of actions must not hide or affect important information in the interface.

G6. Internal consistency should be considered. The presentation of actions should use the same visual style as the rest of the interface, including color, language and sizing.

G7. Limit interruptions of workflow. Utilizing actions should to the greatest extent facilitate a continuous workflow without changing context, in order to support the user's sense of control.

G8. Increase accessibility by allowing keyboard navigation. To support expert users who prefer quick commands, but also people who have certain disabilities and have trouble using the mouse, keyboard navigation should be available to navigate the presentations of actions.

G9. Allow for scalability. The presentation should follow design patterns that are scalable to support the implementation of additional actions, as well as to support a customized set of actions.

G10. Aim for a non-intrusive design. When indicating that the user can perform an action or when presenting available actions, it should be non-intrusive while still being discoverable.

Based on the results from the Empathize and Define phases, G1 and G4 were updated to better create the conditions to meet users' needs. In the new version, G1 focuses on allowing support for customizability, rather than focusing on the most frequently used actions. The interviews revealed that which actions are most commonly used depends both

on the user and on the use case. It is not safe to say that a certain action is the most common, but a specific user can, for example, utilize different actions for different analyzes. Based on these findings, the decision was made to focus on allowing users to choose the desired actions themselves. In addition to G1, G4 was also revised. The updated version of G4 highlights discoverability, which turned out as an area of focus, as well as removes the focus on which users to cover. Since the idea is that the presentation of options to act on selected data should be independent of who the user is, that part seemed redundant.

From the initial guidelines, *G5. Reduce navigational excise* and *G8. Facilitate the workflow for multi-step actions* were combined and modified and resulted in *G7. Limit interruptions of workflow* in the second iteration of guidelines. This merge was done based on the fact that the content was overlapping since both of the guidelines concerned navigation and multi-layered interaction. The resulting guideline, G7, highlights the importance of keeping a continuous workflow, something that was expressed during the interviews and found to be one of the areas of focus from the affinity diagram.

In addition to the guidelines that have been changed in some way, two new guidelines, *G9. Allow for scalability* and *G10. Aim for a non-intrusive design*, were also added. G9 was added as some of the interviewees expressed a desire for a scalable design solution. I2 explained that for some contexts it is desired to only show a few specific actions that are supposed to be performed, whilst in other cases there might be a need for significantly more. Beyond that, G10 was added as a complimentary guideline to *G4. Indicate the access point for the presented actions*. G4 highlights the importance of a discoverable design solution, but from the affinity diagram, one of the focus areas turned out to be related to a non-intrusive design. To create conditions for a balance between being visible but not disturbing, G10 was formulated.

Two of the guidelines were especially strengthened by the interviews. For the second guideline, *G2. Let the user focus on the goal rather than the interaction*, I3 and I4 expressed that in the current way of presenting actions it is not obvious what can be performed with the selected data. In addition, they pointed out that the description of the actions are sometimes hard to understand. Further, I6 described that for a desired solution, there would not be any barriers, but users should know what can be done and how to achieve it. I5 confirmed this by expressing that a dream would be if The Software would propose suitable actions for the selection, instead of having to browse through the contextual menu or use the search bar to find an action. The forth guideline, *G4. Indicate the access point for the presented actions*, was strengthened by I3 and I6 who both expressed that it is important that the user knows how to perform a certain action, and brought up right-click as a bad alternative since not all users are aware of such a hidden access point. I6 also explained that customers of The Software have expressed that some features are slightly hidden in the interface, which I2, I4 and I5 confirmed through pointing out that actions are scattered around the interface. I1 exemplified this by explaining that for example external actions are tricky to perform, and that actions located in other places than in the contextual right-click menu are harder to perform. I4 explained that it is problematic that it is currently not

obvious what the user can do next when they have selected data. Such a problem could be solved by having a discoverable access point for presenting options for acting on selections.

6.2.3 Ideate

Based on the findings from the previous phases, the Ideate phase aimed to generate a variety of ideas to exemplify the updated guidelines. The Ideate phase consisted of different stages of convergence and divergence. In this phase, methods such as Crazy 8's and a combination of braindrawing and brainwriting were used to generate ideas, which were then refined using a Morphological chart. To complement the ideas and concepts that emerged, a workshop was conducted with internal stakeholders at The Company.

Idea Generation

To start generating ideas, the Ideate phase was initiated with a session of Crazy 8's. Eight quick sketches (Figure 30) were developed over an eight minute period and thereafter discussed. The sketches were rough and undetailed, but the results from the method showed a variety of partial solutions.

Figure 30. Overview of the ideas from the Crazy 8's session

Utilizing the sketches from the Crazy 8's session as foundation, a new brainstorming session was performed. The five focus areas for the project, *Non-intrusive*, *Customizability/Scalability*, *Discoverability*, *Exploring data* and *Keep workflow*, were written on a whiteboard and thereafter brainstormed separately. A combination of braindrawing and brainwriting was used, where potential partial solutions for each focus area were explored by extending the ideas from conducting Crazy 8's and discussing the solution space for that particular focus area. The brainstorming session ignored the interplay between the different areas of focus, instead focusing only on all conceivable ways in which the area in question could be fulfilled. Since coming up with a solution that takes all the areas of focus into account is a complex problem, each area was ideated upon separately in order to widen the solution scope and ensure that the ideas were thoroughly explored.

When the solution space for the different focus areas had been explored, the ideas were gathered and combined using a Morphological chart (Figure 31). Based on the five areas of focus, the Morphological chart was divided into seven criterias: *Alert*, *Discoverable*, *Customizable*, *Scalable*, *Non-intrusive*, *Explore data* and *Enhance workflow*. The ideas were distributed into the different sections and thereafter combined to form ten different concepts. Some of the sections had far fewer ideas than others, which affected the formation of concepts. Several of the concepts used the same partial solutions and for some of the concepts a section was skipped, resulting in concepts where not all focus areas were covered.

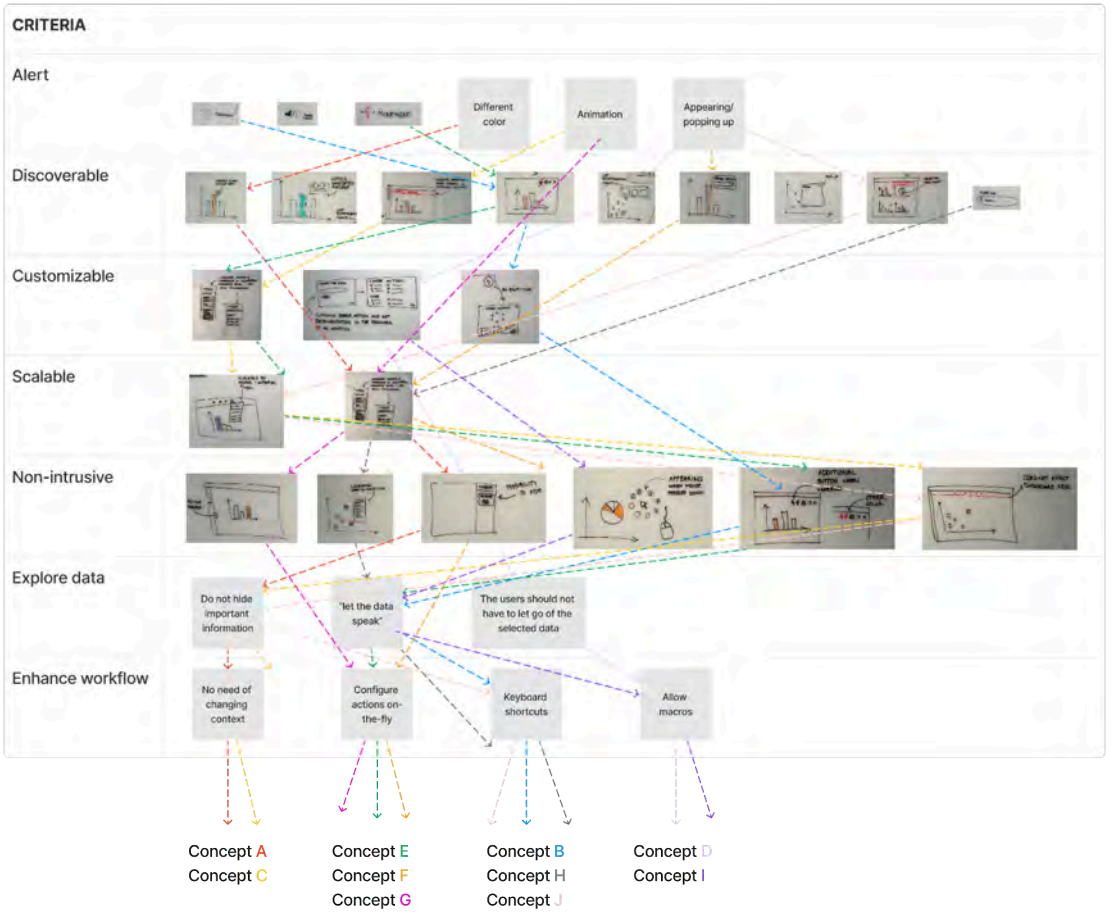


Figure 31. Overview of the Morphological chart

Design Workshop with Internal Stakeholders

To complement the ideas and concepts that emerged during the idea generation, a design workshop was held with internal stakeholders at The Company. The purpose of the workshop was to broaden the solution space, get new perspectives and come up with new ideas. During the workshop, eight different stakeholders from The Company participated, including two developers and six UX-designers. Developers were included to broaden the idea scope, but also in order to consider technical limitations and to keep the ideas feasible to some extent. The design workshop lasted for about 90 minutes and was held on site as it enabled easier collaboration.

The workshop started with a short introduction of the research question along with a presentation of the agenda for the workshop. The workshop then proceeded with a short warm-up exercise. The purpose of this exercise was to get the participants to start thinking about selected data in general and why selections are an important feature of The Software. The task was to write down their thoughts on sticky-notes and place them on a whiteboard with two different questions: "*What can be done with marked data*?" and "*Why is it important to be able to select data in a visualization*?". After the warm-up exercise the project's focus areas were presented to set the scope and explain what has been done in the project so far. The participants were then divided into three different groups and each group got one of three questions to ideate upon for twelve minutes. The questions to ideate upon, were based on the focus areas identified in the Empathize phase:

- *How might we enhance the users understanding of what can be done with their selected data, without being intrusive?*
- *How might we present options for acting on selections in a flexible and personalized way that adapts to individual user preferences and specific use cases?*
- *How might we design the presentations of options for acting on selections in a way that facilitates a streamlined workflow, enabling users to focus on data exploration?*

The first question focused on understanding what can be done with selected data and featured a combination of *Discoverability* and *Non-intrusive* since these two focus areas can be contradictory. The second question focused on *customization* and the third question featured a combination of *Keep Workflow* and *Explore data* since ensuring a streamlined workflow will facilitate data exploration. The questions were not presented during the introduction of the workshop since the participants should focus on one question at a time. No specific ideation method was used during the ideation session since the design challenge requires a lot of focus on details and time for discussions.

After each ideation session, new groups were formed to ensure that no group got stuck on a certain idea as well as to allow new group dynamics and ideas. The new groups were also given a new question to generate ideas around. This resulted in each participant having generated ideas on all three questions during the workshop and being part of three different groups. After the ideation sessions, the remaining time of the workshop focused on presenting and discussing the different ideas. As the ideation sessions took a bit longer than expected, there was not enough time to go through and discuss every idea thoroughly and more time should have been planned for this part of the workshop. The participants should also have been reminded to document the ideas since the different groups had a lot of discussions but ended up not writing or sketching every idea. In addition, it would have been beneficial to listen to each group's discussions to understand the different ideas and thoughts better.

Overall the workshop resulted in a lot of different ideas. However, since the time for each ideation session was kept short, the final ideas were sub-solutions of a relatively low level of abstraction. The ideas also consisted mainly of notes and a few sketches. This low level of abstraction was anticipated based on the short ideation time and setup of the workshop. Since the goal of the workshop was not to get fully developed concepts, the workshop successfully fulfilled its purpose, confirming the already explored solution space while bringing new perspectives. Furthermore, the participants of the workshop expressed that the different ideation questions were hard to understand and different groups had interpreted the questions differently. It also emerged that it would have been better to present and explain the different ideation questions at the beginning so that their meaning and distinction of each question would be clear to everyone. However, the participants were satisfied with the workshop as a whole.

With the input from the workshop, the ten already existing concepts were discussed to see if any of the ideas from the workshop could be incorporated into them. A lot of the ideas from the workshop were similar to the already existing concepts which resulted in three concepts being combined with ideas from the workshop. In addition, three new ideas from the workshop were added, resulting in 13 concepts (Appendix A).

6.2.4 Prototype

The Prototype phase focused on visualizing the concepts generated during the Ideate phase, as well as developing them further. Wireframes were created to communicate the concepts and Six Thinking Hats was conducted to narrow down the concepts. In addition, a design critique was performed with stakeholders at The Company to gather input and to further narrow down the number of concepts. Low-fidelity prototypes of the chosen concepts were then created using Figma.

Concept Refinement

To visualize the 13 concepts formed by the Morphological chart and inputs from the workshop, wireframes were created, see Appendix A. The key features of each concept were highlighted, and the workflow briefly described. Creating wireframes allowed all concepts to be visualized in the same abstraction level, enabling a fair basis for communication and discussion. When all concepts were compiled and visualized in an equivalent way, refinement of the concepts could begin.

The method Six Thinking Hats was used to evaluate and reconsider the concepts (Figure 32). Different perspectives were taken into account when analyzing the concepts, where each sticky note color indicated a new hat, and a new way of approaching a concept. Each concept was analyzed based on facts (white), cautions (black), feelings (red), creativity (green), benefits (yellow) and process (blue). The black hat considered potential issues or challenges with a concept, but also evaluated it against the guidelines and considered whether it would interfere with any guideline. The blue hat summarized the results from the other hats, and based on that decided on future proceedings for the respective concepts.

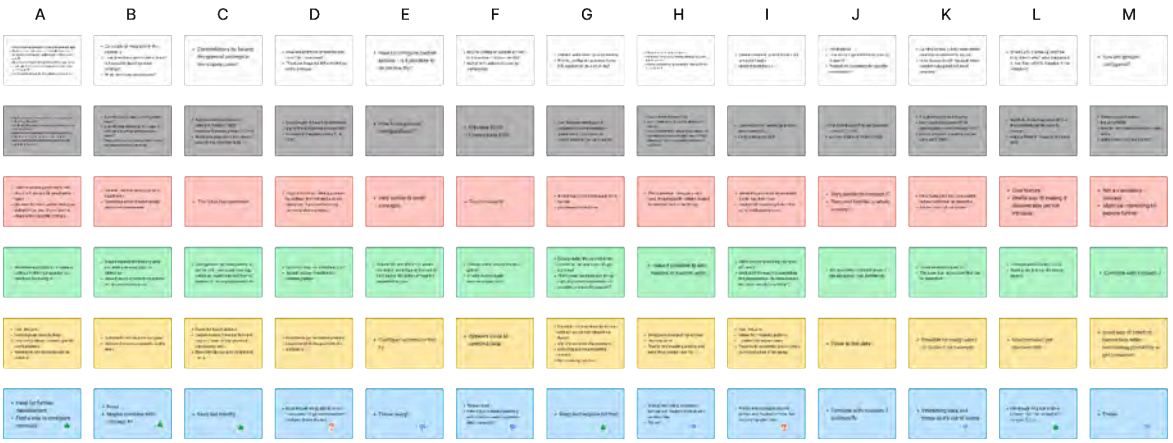


Figure 32. Overview of the result from the method Six Thinking Hats

The Six Thinking Hats session narrowed down the concepts from 13 to eight. Based on the notes from the session, several concepts were dropped, some were combined and kept and some were modified and improved. Some ideas were removed as they were considered out of the scope, while others were removed as they interfered with too many of the guidelines or in ways that did not seem possible to solve in a good way. They were either considered too intrusive or did not support the user in focusing on their goal, but rather demanded lots of focus on the interaction itself. The wireframes were revised to visualize the updated concepts.

Design Critique

To get input on the concepts brought forward from the Six Thinking Hats session, a design critique was conducted. Since the prototypes at this stage were of low fidelity, it was not considered worthwhile to evaluate them with users. Instead, the Head of the UX department and a UX researcher from The Company were invited to attend the design critique since they are involved in The Software and could provide valuable feedback regarding how well the concepts could be applied in The Software. The eight concepts were presented one by one, followed by a discussion. Notes were taken to ensure that no feedback was left behind.

The general attitude towards the concepts was positive, with several ideas considered promising. Through discussions, it emerged that wide horizontal menus should be avoided. Compared to, for example, vertical menus, horizontal menus are not scalable to the same extent unless using hierarchies. It was further expressed that hierarchies can be difficult in The Software because there are no obvious groupings of actions, which would require users to create groups themselves for it to make sense. Another aspect brought up was that it is not desired to require users to decide on a specific use case they want to use The Software for. Since data exploration is an iterative process and users don't always know what to do with their data, users should not be limited from the start but rather be able to start using the tool, to gradually choose how they want to continue their work. In addition, more specific feedback was given about the various concepts. Examples of things that were raised were that a panel would have been better suited to the right of the screen where configurations are already made in panels. It was also expressed that it is advantageous that

an access point for acting on data appears close to the selected data and that there is the possibility to turn it off. In addition, a radial menu was considered interesting, but how different numbers of actions would be presented is important to consider.

From the design critique session, the importance of clarifying the context in which the user acts was also expressed. In The Software there is a concept called *Brushlinking*, which means that the data selected in one visualization is highlighted in all other visualizations where the same marking type is used. This is an effective way to explore data, but also places extra demands on the user to understand which data rows are actually affected when an action on selected data is performed.

The design critique led to five of the concepts being reworked based on the feedback that emerged. Two concepts were dropped, whilst one concept, a contextual right-click menu, was brought back into the loop and further iterated upon. To summarize, six concepts were developed further after the design critique.

Low-fidelity Prototyping

The six refined concepts from the design critique were: Floating access point, Glowing icon, Panel, Radial menu, Toolbar and Right-click menu (Figure 33). The first idea features a floating access point indicated by an icon button, that appears close to the data and presents a customizable list of actions when clicked on. The idea that included a glowing icon and the idea with a panel were ideas based on already existing components in the current interface of The Software, such as a visualization properties panel and a menu bar. The fourth idea featured a radial menu inspired by different CAD-programs. The toolbar concept features a toolbar that appears at the top of the visualization area. The last concept features a divided right-click menu that focuses on the different contexts of The Software.

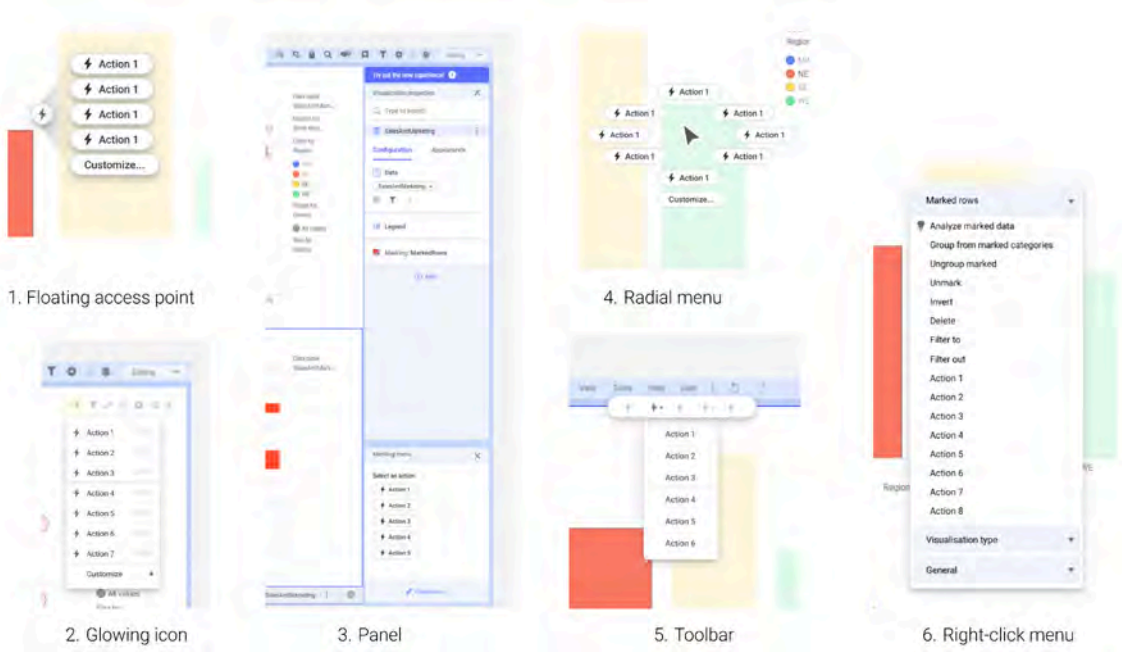


Figure 33. Overview of the six refined concepts

Low-fidelity prototypes of the six concepts were created in Figma (Figure 34). The purpose of these prototypes was not to test the different concepts with users, but rather to use them to communicate the ideas better and use them as support for discussions. As a result, the prototypes were only interactive to some extent and in a specific flow. The purpose of the prototypes was also not to evaluate a specific design, but rather to present the design pattern of how different options for acting on selections could be presented in The Software. While creating the low-fidelity prototypes in Figma, several minor changes were also made to the concepts as new aspects and ideas were discovered. The prototypes were created by taking screenshots of the already existing dashboard of The Software and adding the different design concepts on top. The screenshots were used to make the prototyping process more efficient and to end up with more realistically looking results. Although keeping the prototypes low-fidelity and the details of the different presentations to a minimum, the more realistic look might have contributed to making the ideas look more high-fidelity and thus might have affected the evaluation of them.

Figure 34. Overview of the six concepts as low-fidelity prototypes in Figma

6.2.5 Test

The Test phase aimed to evaluate the prototypes, in order to choose which ones to proceed with. An evaluation session with the UX team of The Company was conducted, where the concepts' presentation styles and trigger types were discussed. Additionally, on suggestion by The Company supervisors, pros and cons were listed for each of the concepts and analyzed based on a specific user role .

Evaluation with Internal Stakeholders

Since the time frame was limited and the low-fidelity prototypes only had limited interactivity, an evaluation session with internal stakeholders at The Company was organized to evaluate the different concepts. This type of evaluation was found more suitable at this stage since evaluations with users would have required more detailed and interactive prototypes of higher fidelity. More extensive evaluations with users were therefore planned and prioritized towards the end of the design process in the second iteration.

The evaluation session was conducted with the UX team at The Company. The participants included five UX designers, two UX researchers, as well as two visual designers and four technical writers. The evaluation session started with a presentation of the research question and a short walkthrough of the low-fidelity prototypes of the six different concepts. It was also explained that the evaluation would focus on the presentation of options for acting on selected data rather than the trigger type since many of the different presentations could be combined with different trigger types and access points. The participants were divided into four different groups to promote discussion and the possibility to share thoughts in smaller groups. The groups were given ten minutes to discuss two different tasks:

- Pick the 2 presentation styles you like the most and motivate why you prefer those.
- Motivate which trigger type you think would be suitable for the 2 presentation styles you chose.

After the discussions in smaller groups, a general 15 minute discussion and presentation of thoughts was held with the whole team. The outcome of the evaluation session with the internal stakeholders resulted in interesting discussions regarding the different concepts. However, there was a large distribution of preferred concepts among the groups. The first concept, *Floating access point*, was considered promising since it takes cursor position into account and that the access point is visible at all times. A disadvantage that was brought up during the discussion was that it is challenging to find a suitable placement for the floating action button in all different visualization types and contexts of The Software. In addition, different suitable triggers were discussed such as hover and mouse click. The second concept, *Glowing icon*, was considered easily accessible and possible to implement in the interface of The Software. However, the fact that the title bar, where the icon button was located, can be switched off was considered challenging. The *Panel* was considered an interesting concept since a panel is a design pattern that is already used within The Software. A disadvantage that was brought up during the evaluation is that using a panel for presenting actions is less suitable for The Software's user group *Consumer*, since they focus on viewing the data and the panel would take up a lot of unnecessary screen real estate. The discussed trigger types for this concept were to have it open on default or including an access point closer to the selected data to open the panel. The *Radial Menu* sparked a lot of discussions since many of the stakeholders found that it was an interesting design pattern since it allows for quick and easy interaction with the selected data. Some concerns were expressed regarding that it would be hard to implement this pattern since it requires the users to learn a new, for many people unfamiliar, pattern. For this concept, a lot of different modifier keys were discussed as triggers. Furthermore, the participants expressed that the *Toolbar* concept was non-intrusive yet discoverable and liked that there is a possibility to categorize and group different actions together. The last concept, *Right-click menu*, *was* not discussed as much during the evaluation since only one group voted for this concept. Nevertheless, it was considered an interesting idea since the concept takes context into account and a right-click menu is a very well-known pattern.

Moreover, the second task of the evaluation, focusing on finding a suitable trigger type for the different presentations, was not discussed as much as the first task regarding the presentation. This could have been due to the time constraints since the participants got ten minutes to discuss both questions and therefore had to distribute the time by themselves. Another possible reason for this could be that the prototypes already included some type of trigger, which could have resulted in the participants seeing it as part of the concepts.

Decision of Concepts
As the evaluation with the UX team gave scattered results regarding which concepts were preferred, difficulties arose in selecting concepts to proceed with. In order to create better conditions for making a decision, a pros and cons discussion was carried out, where the concepts were discussed based on notes from the evaluation with the UX team. Even when pros and cons were written down for all concepts, it was ambiguous, as there were both positive and negative aspects to all concepts. After a new discussion with the supervisor and a UX researcher from The Company, it was decided that a clearer scope would facilitate the proceeding of the project. The Analyst user role was set to be the primary user group. This role can be broadly described as someone who uses The Software to build analysis and then spends hours examining and understanding their data, to predict events or draw conclusions. With this in mind, all concepts were evaluated based on the Analyst user role. Evaluating the concepts from an Analyst, and thus a data discovery perspective, made it easier to narrow down the concepts. For example, discoverability did not become as important a factor as these users spend many hours in The Software and are more willing to learn new interaction patterns and are okay with a learning curve if it will benefit their work in the long run.

Finally, two concepts, the panel and the toolbar, were chosen to proceed with based on pros and cons and on taking the Analyst's perspective. These concepts supported data exploration without disturbing the user by being too intrusive. In addition, they were considered having the potential to be implemented in the existing interface, as well as interesting to develop further, while showing no signs of any major concerns. From the evaluations with the UX team, these concepts were also expressed as interesting and promising.

6.2.6 Reflections

The first iteration resulted, among other things, in five distinct focus areas: *Discoverability*, *Customizability/Scalability*, *Non-intrusive*, *Data exploration* and *Keep workflow*. The focus areas were in line with what The Company had already expressed as important factors to tackle the problem of presenting actions in The Software. However, new more detailed aspects and insights were discovered during the interviews. Based on the findings from iteration 1, it became clear that it was difficult to find a solution that covers all five focus areas. This was due to the fact that especially discoverability and non-intrusiveness to a large extent counteract each other, something that became even more apparent when evaluating the six concepts. Thus, some kind of prioritization of the focus areas was needed

to be able to move forward with any of the concepts. By choosing to focus on the Analyst user role, as suggested by the supervisor from The Company, less emphasis could be placed on the area of discoverability. In hindsight, it would have been beneficial to make this change of scope earlier in the process, right after the focus areas had been formulated. Then the ideas that emerged during the Ideate phase of iteration 1 might have taken a different direction.

During the workshop it became apparent that some of the participants' ideas were influenced by the fact that The Company has briefly tried to solve this problem in the past. Similar ideas as the previous project's concepts emerged during the workshop. However, the participants were still aware that these already existing concepts did not fulfill all the desired criterias. As a result, it became clear that even though the participants to some extent were biased by previous projects, they were open to new suggestions and new ideas were encouraged.

Another reflection from the first iteration is that there was no time to go into the details of every idea due to time constraints. This also contributed to the choice of evaluating the concepts with the UX team at The Company rather than real users which would have been valuable at this stage. However, to be able to test with real users it would have required the prototypes to be more detailed and interactive. As a result, it was decided that the second iteration should focus on testing with users and thus creating more detailed and interactive prototypes.

The insight and decision to focus more on details also led to some adjustments in the time plan for the second iteration. To make sure that there was enough time to focus on details during the second iteration the three phases Ideate, Prototype and Test were extended. As a result, less time was planned for literature studies and the Empathize phase. Apart from the change in time distribution, no major changes were made and the second iteration therefore still follows the design thinking process.

6.3 Iteration 2

The second iteration focused on developing more detailed designs and a high-fidelity prototype. Just like iteration 1, the second iteration followed the five different design thinking phases. Empathize, the first phase, focused on gaining a deeper understanding of the software through discussions with internal stakeholders at The Company. During the Define phase, a persona and scenario were developed and the guidelines were updated and refined. The Ideate phase consisted of further development of the selected concepts and a design critique. From this phase, only one concept was further developed in the Prototype phase and an interactive high-fidelity prototype was built in Figma. The prototype was tested and evaluated both at The Company and through the UserTesting service. The second iteration was completed by analyzing the results, updating the prototype and iterating the final set of guidelines.

6.3.1 Empathize

In order to be able to go into a more detailed level in the second iteration, a better understanding of The Software's functionality was considered essential. Two separate discussion sessions were conducted with two UX designers from The Company's UX team, who did not participate in the previous evaluation session. These discussion sessions also served as a sanity check to verify that the concepts taken forward cover the requirements and user needs, and to investigate possible opportunities and challenges with the selected concepts.

During the discussion session, the feature of Brushlinking was explored and discussed more in detail, resulting in a better understanding of The Software and underlying relationships of data. Going into this kind of functionality also revealed the importance of considering the context in which the user acts and clearly letting the user know what data will be affected by the action they take. It became evident that the interactive data in a visualization is not only a visual object, but that it is connected with underlying rows from the data table that has been uploaded to The Software.

The concepts of the toolbar and the panel were discussed separately and both of them were considered good alternatives with potential. The sessions indicated a promising future for the toolbar as it appears close to the data and can clearly show which context the user is acting on. However, a challenge brought up was regarding the area available and how to present information about the selected data in combination with the available actions in a clear yet non-intrusive way. The panel on the other hand showed promising features in terms of having plenty of space for presentation and interaction, but challenges in terms of context sensitivity.

6.3.2 Define

After gaining a deeper insight into how The Software works and how different functions interact, the Define phase focused on creating a persona and scenario as a basis for the ideation. In addition, the guidelines were updated and a third iteration of guidelines was formulated based on the results from the Empathize phase.

Persona & Scenario

In order to frame the findings from the Empathize phase, a persona and scenario was created (Figure 35). The idea was also to use the persona and scenario as support for the Ideate phase, to generate concrete ideas based on a typical use case. The persona was formulated based on insights from user research made by The Company. It features a data analyst, who uses The Software to create dashboards, as well as to analyze and act on data. Using a data analyst as the persona entailed a certain framing of the scenario, emphasizing the importance of being able to inspect and explore the data, as well as keeping an efficient workflow. The persona is accompanied by a supporting image, which was generated using AI. The scenario covers an imaginary workflow of how such a user can utilize The Software. It includes a variety of different actions that can be performed on selected data, in order to

showcase and ensure a solution that supports simple actions that can be performed in one click, but also more advanced actions that require further steps.

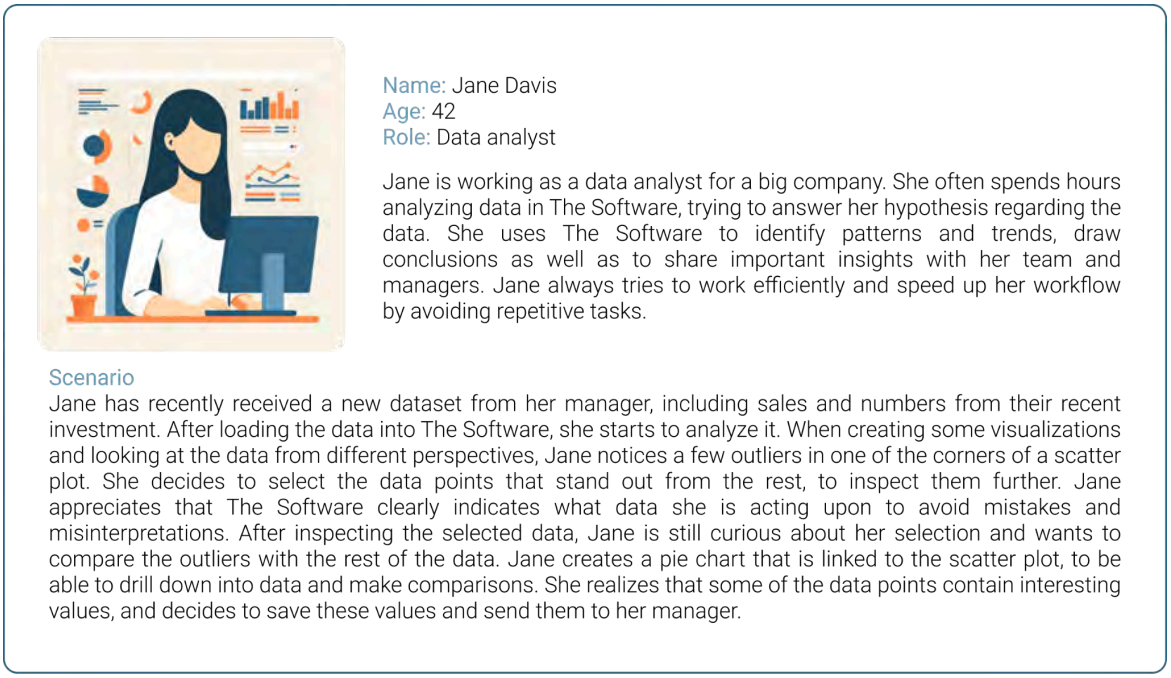


Figure 35. Overview of the persona and scenario

Third Iteration of Guidelines

Based on the findings from iteration 1, as well as the findings from the Empathize and Define phases in iteration 2, the guidelines were refined and updated. In the third iteration of guidelines, two guidelines were clarified, two were modified and updated and one new was added. In this stage, two guidelines were also removed as they were considered too general. The third iteration of guidelines are presented below.

> **G1. Allow for customizability.** It should be possible for each user to customize which actions are available in the presentation for acting on selected data. The iterative nature of visual analytics, combined with the strive for efficiency among data analysts, would benefit from a customizable design solution enabling users to control their interactions.
>
> **G2. Let the user focus on the goal rather than the interaction.** The presented actions should not disturb the users workflow, but should let the user focus on their goal of answering their hypotheses rather than to direct the focus to the interaction for the desired action.
>
> **G3. The actions presented should not overwhelm the user.** The actions included in the presentation should be structured in a clear way that promotes discoverability without overwhelming the user. How the presentation is perceived can be affected by the number of actions included or the level of details but should not overwhelm the user regardless.

G4 (former G5). Avoid hiding important information. Hiding or covering information in visualization areas should, to the greatest extent possible, be avoided. It is important not to intrude on the data exploration by covering interactive data in visualizations or related information in the dashboard area.

G5 (former G7). Limit interruptions of workflow. Utilizing actions should to the greatest extent facilitate a continuous workflow without changing context from one view to another, in order to support the user's sense of control.

G6 (former G9). Allow for scalability. The presentation should follow design patterns that are scalable to support the implementation of additional actions, as well as to support a customized set of actions.

G7 (former G10). Aim for a non-intrusive design. When indicating that a user can perform actions with the selected data, a non-intrusive design that does not disturb data exploration but still is discoverable, should be aimed for.

G8 (new). Indicate the context of what data is acted upon. When selecting an action from the options presented, it should be clear which data is acted upon. The selected data is represented by visual objects in a visualization, but it is the underlying rows in the data table that are actually acted upon.

In the third iteration of the guidelines, emphasis was placed on making the guidelines as easy to understand as possible. To make G1 clearer, the wording was adjusted and updated. G1 was changed from *Consider customizability* to *Allow customizability* as the evaluation in the first iteration showed that customization was an important feature to include. *Allow* was considered to be less vague and therefore a better formulation of the guideline. It was also clarified in the description of G1 that customizability refers to the presentation for acting on selected data and why customizability is important. Another guideline that was clarified was *G2. Let the user focus on the goal rather than the interaction.* To clarify how the guideline is applicable for the field of visual analytics, the description was updated. In addition to clarifying G1 and G2, it also became evident that G4 (former G5) needed to be clarified, as it is not only the presentation of actions that should avoid hiding information. The trigger type and access point should also not hide any information and thus the description of the guideline was reformulated to be more general. Additionally, the description of G4 (former G5) was updated to clarify the meaning of important information. It was also decided to change the wording from *Do not hide important information* to *Avoid hiding important information* since it can depend on the circumstances, but should to the greatest extent be avoided.

Three guidelines from the second iteration of guidelines were changed to better reflect the essence of each guideline. From the evaluations and discussions with internal stakeholders,

it became clear which parts needed to be emphasized, which led to a reformulation of three guidelines from the second iteration. G3 was changed from focusing on limiting the number of actions presented, to rather emphasizing that the presented actions should not overwhelm the user. The fundamentals should be that the presentation, regardless of the number of available actions, should not overwhelm the user. If the presentation would include lots of actions, but still does not overwhelm the user, it won't be an issue. For G5 (*former G7*). *Limit interruptions of workflow*, the description was revised. It was clarified that the change of context concerned not having to switch between one view to another, but that the user should be able to stay in the same view to perform their chosen action. Similarly, the description of G7 (*former G10*). *Aim for a non-intrusive design* was also changed. The description was updated to emphasize that it is the part indicating that there are actions to utilize on the selected data that should not be intrusive. During the design critique in iteration 1, it was clarified that it is mainly until the point where the user has actively decided that they want to perform an action with the selected data, that data can not be covered or intrude on the data exploration. When the user has taken the choice to perform an action, it is okay if data is covered.

In addition to the guidelines that were reformulated and changed in some way, a new guideline, G8. *Indicate the context of what data is acted upon*, was added. The new guideline was added since it became evident during both the design critique and during the discussions with the UX designers that it is important for users to know which data is acted upon and thus also the context. In addition, the persona and scenario also strengthen the importance of knowing the context when inspecting and exploring data. Furthermore, three guidelines were removed during the third iteration of guidelines. Those were G4. *Indicate the access point for the presented actions*, G6. *Internal consistency should be considered* and G8. *Increase accessibility by allowing keyboard navigation.* G4 was removed since focusing on the Analyst user role put less emphasis on the area of discoverability. The reason why G6 and G8 were chosen to be excluded was that they were considered too general and similar to other already established guidelines. Internal consistency and keyboard accessibility are important considerations that always should be kept in mind regardless of the software or interface designed for.

6.3.3 Ideate

Based on the persona and scenario as well as the third iteration of guidelines, the Ideate phase consisted of iterating and developing the remaining two concepts, the toolbar and the panel, more in detail. A design critique was held with internal stakeholders at The Company where it was decided to only move forward with one of the concepts. An additional ideation session was conducted, where the selected concept was ideated upon more in detail.

Idea Generation

The Ideate phase started with an unstructured literature review to gain a better understanding of the chosen design patterns. The review focused on design principles related to panel and toolbar, as well as important considerations regarding customizability and scalability. The aim was to gather information about the different design patterns, their

variations, and usage. Several books and articles were read, and notes were captured in a FigJam board. In addition to the literature, images of various panels, toolbars, hover tools, and popup menus were also collected on the Figjam board to inspire the Ideate phase.

Crazy 8s was used as a method to generate quick ideas and solutions for the panel and toolbar based on the created persona and scenario as well as the gathered information and inspiration from the literature review. The persona and scenario as well as the discussion around those, highlighted the importance of inspecting and exploring the data as an interesting feature to include when generating ideas. Furthermore, Crazy 8s was an effective method for the toolbar, a smaller and less detailed design pattern, resulting in numerous solutions. However, for the panel, a more complex and detailed pattern, it was challenging to generate a variety of solutions in a short amount of time. The ideas that emerged from Crazy 8s were generally similar with minor variations (Figure 36).

Figure 36. Overview of the result of the method Crazy 8s

After conducting Crazy 8s, the challenges and opportunities for each design pattern were discussed. One new idea emerged for both the panel and the toolbar during the discussion. The total number of ideas was narrowed down, and three different ideas for the toolbar and two for the panel were chosen to be developed further. The three toolbars presented different designs for inspecting and taking actions on selected data. The first toolbar had a segmented and expandable button, while the second toolbar had an always-open inspect section and a floating access button that expanded a list of actions. The last toolbar also had an inspect section, but included separate icon buttons for each action. For the first panel, a static inspect card and icon buttons for actions were chosen. If an action requires more steps, a modal dialog pops up where the action is performed upon clicking the action button. Another idea for the panel was to implement cards with multi-step actions and perform them directly in the panel.

To enhance communication of the ideas, simple wireframes of the five concepts were created using FigJam. During the wireframe creation process, an additional idea that combines a simple toolbar with a floating action button and a panel emerged.

Design Critique

The refined wireframes of the toolbar and panels were brought forward to a design critique, where two UX designers from The Company attended for an hour and a half. The initial idea with conducting a design critique was to gain feedback on the ideas, to evolve them further and potentially generate new ideas. The ideas were presented one by one, and notes were taken as each idea was discussed. The setup of the design critique led to a lot of time being spent discussing the existing ideas, rather than coming up with new ones. Many new thoughts and insights emerged, which meant that a change in the setup during the course of the session did not feel justified. Despite the lack of new sketches, valuable suggestions of modifications emerged throughout the design critique.

Generally, there was a more positive attitude towards the toolbars than towards the panels. A combination of a toolbar and panel was considered redundant, since it would be more beneficial to perform everything in a toolbar close to the selected data. The toolbars were expressed as promising thanks to their proximity to the selected data, as well as their discoverability. Regarding the appearance, it was appreciated with a section where the user could inspect their data. This type of inspect section was considered to have the potential to evolve to allow new ways of exploring its data, where content could be changed based on visualization type. However, it was expressed that it is not necessarily important to display that type of information as soon as the user selects the data, but that instead it can be placed in a section that is opened upon interest. To use icons with tooltips for the available actions was considered suitable since this type of pattern is frequently used among softwares. Additionally, actions can be presented in a compact way using icons, as well as enabling an immediate overview of the actions.

A panel was considered to take up a lot of screen real estate. According to the UX designers, a panel is powerful in that it allows a lot of interaction and configuration, but for this purpose it was not considered to bring enough added value to be justified. Since most of the actions in The Software are performed with a few clicks and not through lots of configurations, the value of performing the action near the selected data, achieved through a toolbar, was considered more important. However, what was expressed as an advantage of the panel compared to a toolbar was that a panel would make it clear which data the user is acting on, because it is clear which visualization is active and thus which selection will be affected. This would remove the concern with Brushlinking, which was expressed as an important aspect to solve for the toolbar ideas.

Details Ideation

Based on the feedback and opinions that emerged during the design critique, a decision was made to go ahead with the third version of the toolbar, consisting of an inspect part along with action icon buttons. A new brainstorming iteration was conducted to delve into details for the toolbar. During the brainstorming, ideas were generated around different aspects of the toolbar, and these were sketched on a whiteboard (Figure 37). Ideas concerning the general appearance of the toolbar as well as its size, location and number of actions to include for default were iterated upon. Scalability and how the toolbar should behave for different sizes of visualization surface, including a section for additional actions, what such a

section can contain and how an icon for such a section can look like were also sketched upon. Finally, it was discussed whether to include visualization-specific actions in the toolbar and what a division between different kinds of actions might look like, as well as how the toolbar would behave for brushlinked visualizations.

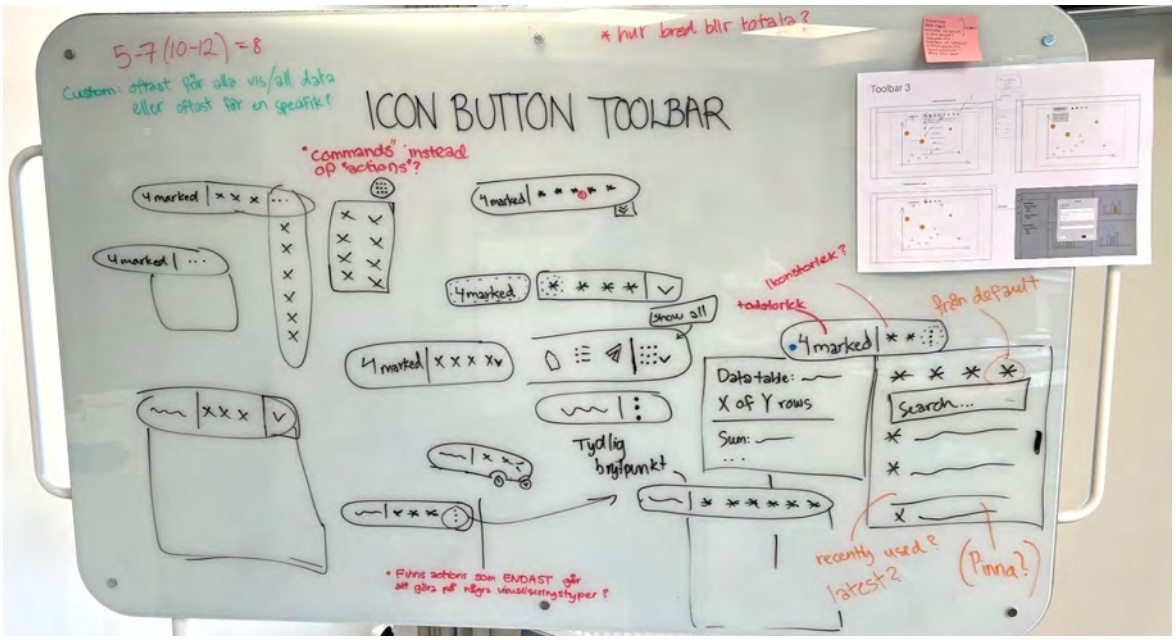


Figure 37. Overview of sketched ideas of the toolbar

6.3.4 Prototype

Decisions about the final appearance and behavior of the toolbar were difficult to make in the Ideate phase of the project, as the low fidelity made it difficult to estimate whether different proposals would behave and fit into The Software. The ideas were thus taken on to this phase, where they were prototyped in higher fidelity. In addition, an interactive flow was prototyped in order to showcase a conceptual workflow of utilizing the toolbar, to evaluate the toolbar and how well it exemplified the guidelines.

High-fidelity Prototypes

High-fidelity prototypes were created both in order to be able to decide on appearance and interaction, but also to serve as means for evaluating the guidelines. Using Figma, different high-fidelity versions of the toolbar were created (Appendix B). Components were used where different variations were created and positioned on screenshots of different dashboards in The Software, in order to compare and conclude on an appearance that would fit. Different roundings, strokes and shadow effects were tried, as well as whether to have a two-sectioned toolbar where the inspect part would be separated from the actions.

Beyond the general appearance for the toolbar, different variants were also crafted for the inspect popup and the popup showing more actions. The inspect popup turned out to be a challenge in terms of what content to include, in order to bring value and support the understanding of the context of what data is being manipulated. Repeated discussions were

held with the supervisor from The Company and one of their UX researchers, where new insights were revealed. Different variants of the inspect popup were created (Figure 38) with only static information, with details visualizations and with interactive elements. Suggestions of different content depending on the type of data selected were also prototyped. After several iterations, it was decided to use dynamic popups that would adapt to the selected data, without any visualizations but containing an interactive element where users could inspect the data from different perspectives (Figure 39).

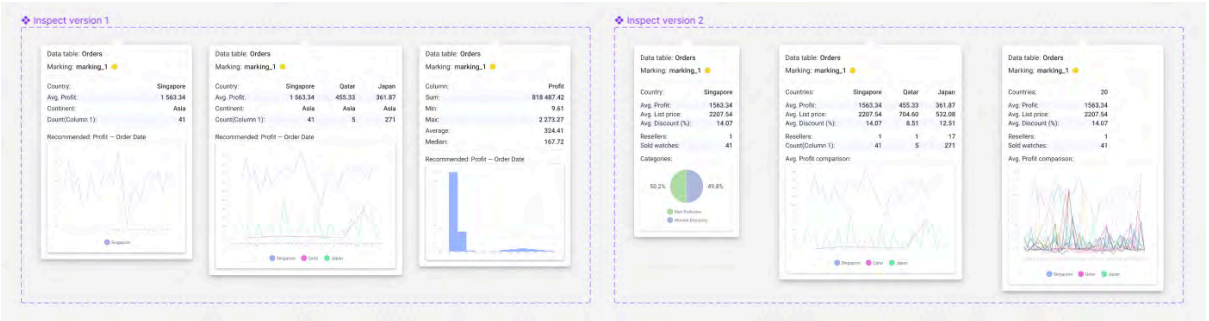


Figure 38. Overview of the different variants for the inspect popup

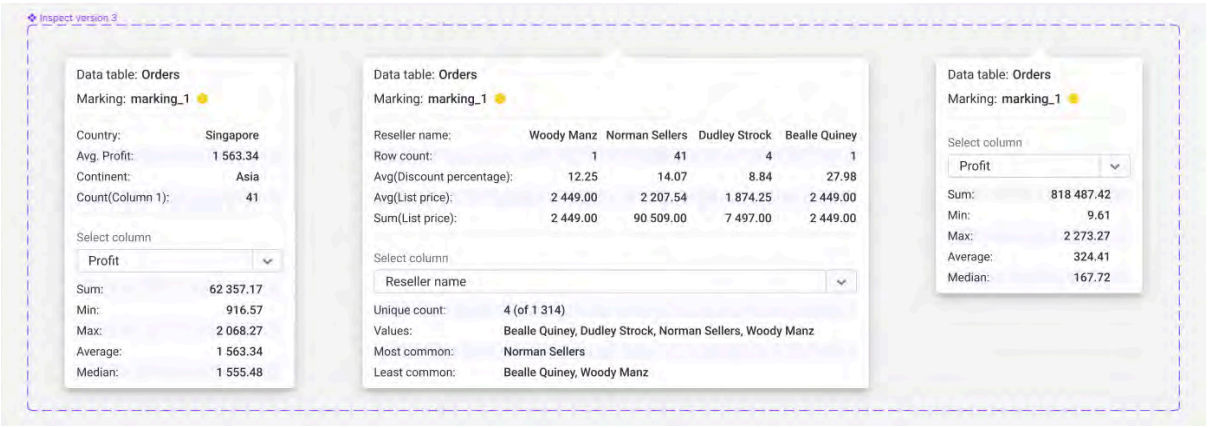


Figure 39. Overview of the final version of the inspect popup without visualizations

Once the appearance was decided, an interactive flow of exemplified use cases were prototyped in Figma. Screenshots of dashboards in The Software were used to showcase how the toolbar would appear in context. Creating an interactive flow was done with the intention to enable users to interact with the toolbar, to get an idea of what it would be like to use the toolbar as a means of analyzing data.

6.3.5 Test

This chapter will describe the final phase of the design process, where the high-fidelity prototype was evaluated with users. Two different formative evaluations of the high-fidelity prototype were conducted with five participants each. One of the evaluations was unmoderated by using the service UserTesting while the other evaluation was moderated and held with Internal stakeholders at The Company. The tests were analyzed with affinity diagrams and the insights formed the basis for the final refinements of the prototype and guidelines.

Unmoderated Tests using UserTesting

The first test (Appendix C) was conducted with external participants from the UserTesting service. To get only the most relevant participants for the evaluations, a number of requirements were set when recruiting the participants from UserTesting. These requirements were set to match The Company's usual requirements when conducting tests. One specific screen was that participants were frequent users of visual analytics platforms such as Power BI, Qlik, and Tableau. Furthermore, the tests at UserTesting were unmoderated and the participants were given different questions and tasks to complete using the interactive prototype. A pilot test was conducted to ensure that the prototype worked as intended, that the questions were clear and that the time for completing the test was reasonable. After the pilot test, a few changes were made to the test such as excluding a question that was considered redundant or adjusting the wording of some questions. In addition, a minor bug with the prototype was also adjusted.

The purpose of this test was to evaluate how well the prototype exemplified the guidelines, as well as to evaluate the usability and overall design of the prototype. Since the test was unmoderated, the tasks given to the participants were very specific and the prototype's interactivity was thereby limited. The tests were video and audio recorded, and an example of one of the test results from UserTesting is shown in Figure 40.

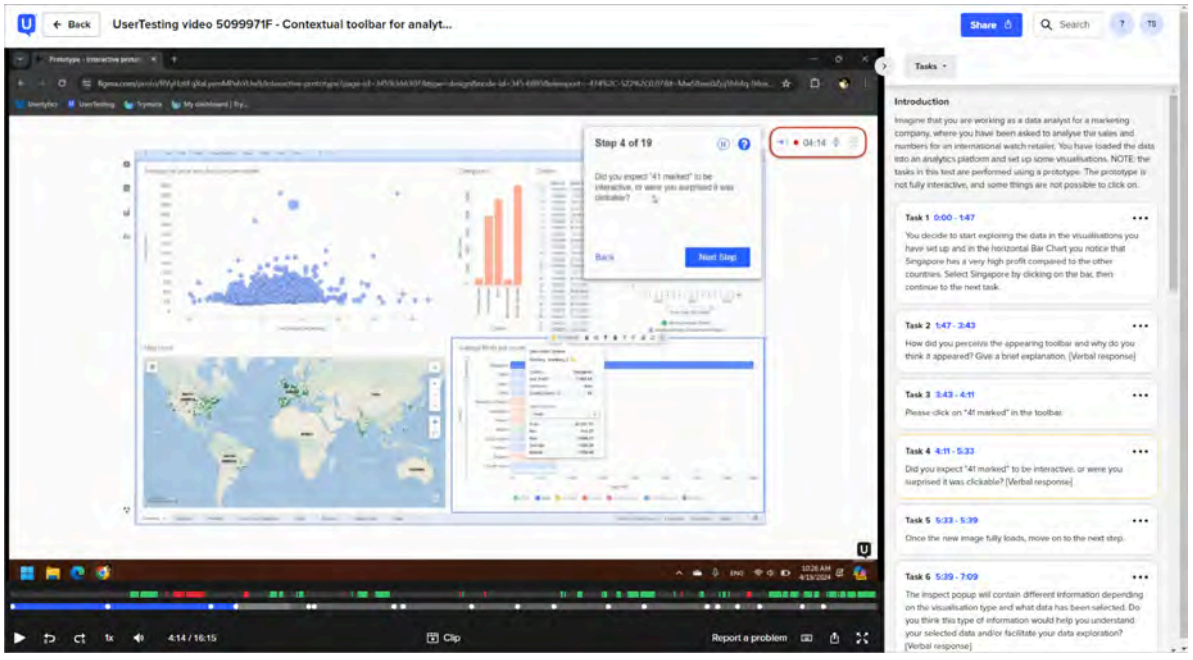


Figure 40. Screenshot of one of the users' video recordings on UserTesting

The video recordings were analyzed using affinity diagramming, where notes for each test were collected and clustered on a digital whiteboard in FigJam (Figure 41). Overall, the UserTesting participants expressed positive attitudes towards the toolbar, finding it intuitive, simple and easy to interact with. They also expressed that customizing the toolbar was a valuable feature. In addition, participants expressed that the toolbar was very relevant to the data and found it helpful to have additional information in the inspect popup. However, only two out of five participants expected the inspection part of the toolbar to be

interactive. In addition, it was difficult to assess the value of the inspect popup as participants were only shown a picture of different versions of the popup and were not familiar with the dataset used.

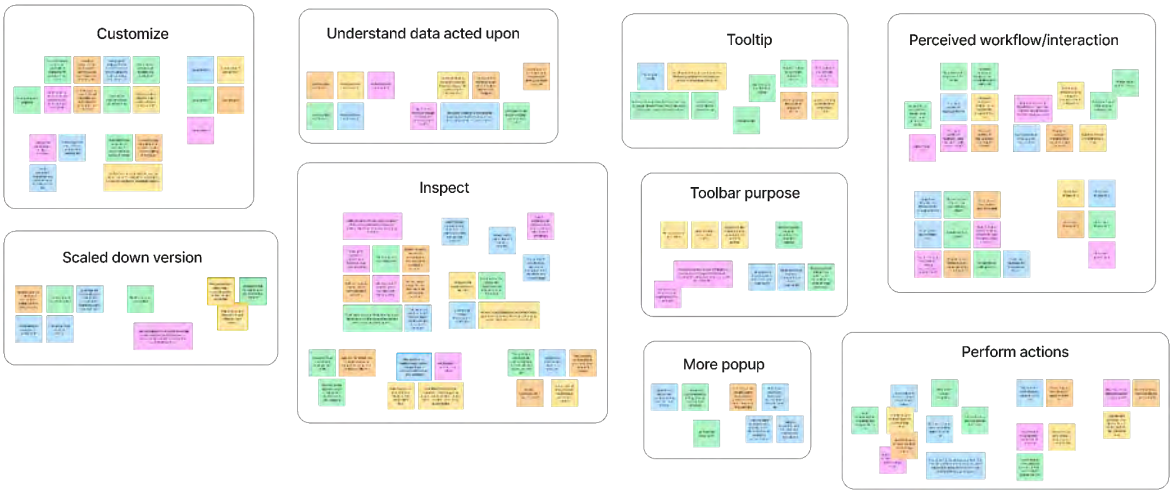


Figure 41. Overview of the result from the affinity diagram of the unmoderated evaluations

Moderated Tests with Internal Stakeholders at The Company

In addition to the unmoderated tests, five moderated tests (Appendix D) were conducted with internal stakeholders at The Company. The purpose of this test was to evaluate the guidelines and usability, but also how well the toolbar would fit in with The Software and its already existing features. The participants from The Company were all experienced users of The Software and had different roles within The Company to include different views and perspectives. Similar to the tests conducted at UserTesting, the participants from The Company were asked to complete a series of tasks using the prototype and answering questions. The test at The Company had a similar setup to the tests conducted on UserTesting. However, after conducting a pilot test it became clear that the questions asked needed some adjustments to fit in a moderated session. By having moderate tests, the ability to probe and ask follow up questions was very valuable to understand the participants thoughts further. In addition, the evaluations at The Company became more of a discussion session about the prototype since the participants had a lot of questions in regards to the toolbar. However, this was considered valuable as it helped to understand how the toolbar could be incorporated in the existing interface of The Software.

Like the previous test at UserTesting, the result was analyzed using an affinity diagram and Figjam (Figure 42). Overall, the participants from The Company had a positive attitude towards the toolbar and pointed out that it improved how options for acting on selected data are presented in The Software compared to today. They found the interaction with the toolbar to be minimalistic, non-intrusive and intuitive. Similar to the first test, The Company participants pointed out that customization was a valuable feature and was almost expected as The Software allows customization for many other features. Furthermore, a majority of the participants pointed out that it was difficult to see the exact value of the inspect popup as they were unfamiliar with the data and it was slightly overwhelming. However, some participants also expressed that additional information about the data could help them

explore it. In regards to the scaled down version of the toolbar, some participants questioned whether it was needed, and suggested being able to collapse or hide it instead. In addition, the participants gave many suggestions for improvement regarding the wording, the icons, the workflow of tagging data using the toolbar, and how the prototype handled brushlinked visualizations.

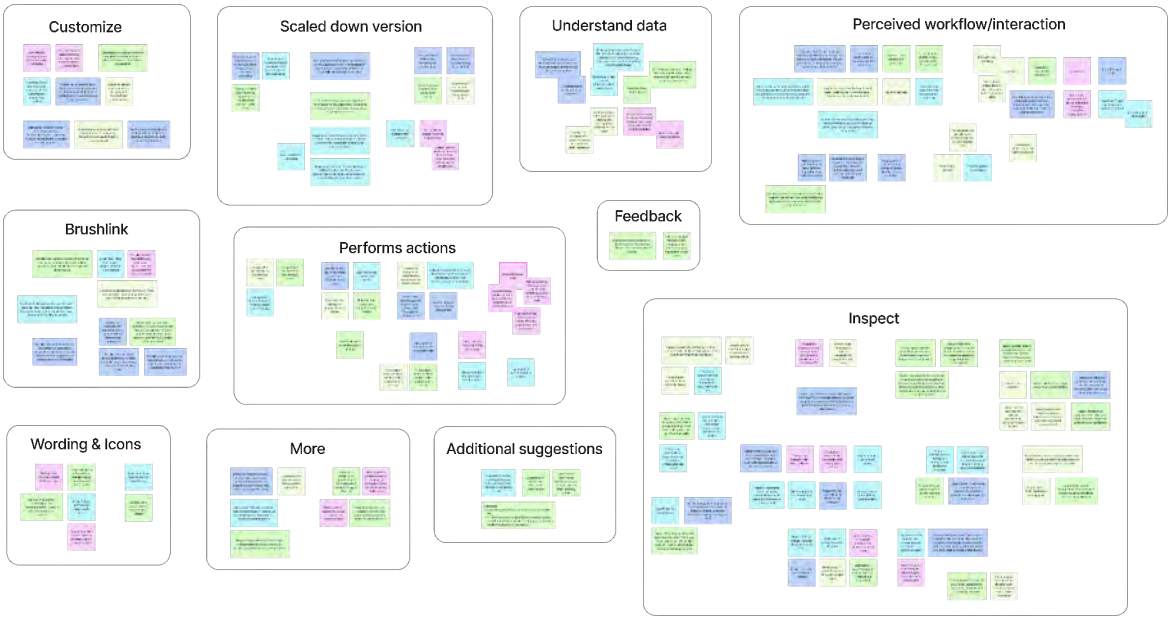


Figure 42. Overview of the result from the affinity diagram of the moderated evaluations

Final Refinements

From the analysis of the user tests, performed through affinity diagramming, some final refinements to the high-fidelity prototype were made. Some of the changes were considered small and therefore implemented directly. These minor updates to the prototype were:

- Reduced the delay for the tooltip to appear as this was something that was specifically mentioned during the unmoderated tests.
- Added an arrow next to the information on selected rows to clarify that it is interactive as uncertainty was expressed about this during the evaluations.
- Added information about which data table the selected data belongs to when adding a new tag to increase the clarity.
- Included the option to add a tag to an already existing tag collection since it is also a common action connected to tagging data.
- Added the possibility to add selected data to an already existing tag collection using the toolbar, as this is another common use case for tagging data that emerged during the moderated evaluations.
- Clarified the label for changing color of the selected data as it was mentioned during the moderated evaluations.
- Added feedback for deleting selected data to simulate how The Software works today.

Other outcomes of the evaluations were considered more complex and therefore required additional ideation and prototyping in order to refine the prototype. Two additional ideation sessions were therefore held with internal stakeholders at The Company. One session was conducted with two UX designers and the other with a developer. In addition, prototyping in Figma was done to update the design of the improved features. The improvements made focused on:

- Scaled down and revised the content of the inspect popup as it became clear during the evaluation that it was perceived as overwhelming and that the value was difficult to determine.
- Implemented a solution to be able to expand the list of actions in the more popup. It emerged during the evaluations that such a feature would facilitate the workflow and increase discoverability since it is difficult for users to search for an action that they do not know exists.
- Refined the visual appearance of the toolbar and how it appears when visualizations are brushlinked. Due to the complex nature of The Software and the concept of Brushlinking, along with feedback from the evaluations, it was considered important to improve and develop further.

Furthermore, the set of guidelines has been iterated upon continuously throughout the whole process but after the evaluations some final changes were made. To better suit the context of this project and to indicate that the guidelines are suggestions, the titles of the guidelines were modified and updated. Formulations such as “Allow…” were changed to “Consider..” to indicate that the guidelines are suggestions. Additionally, the structure and order of the guidelines was changed to place related guidelines together and increase the readability. The final set of guidelines are described more in detail in chapter 7.2. However, another change in the guidelines was that *G2. Let the user focus on the goal rather than the interaction* and *G5 (former G7). Limit interruptions of workflow* were combined. The reason for this was that they both addressed the importance of keeping a good workflow when exploring data. The new combined guideline is described below:

> **Let the user focus on the data exploration workflow.** In order to support the user’s sense of control, utilizing actions should to the greatest extent facilitate a continuous workflow. The presented actions should not disturb the users workflow, but should let the user focus on their goal of answering their hypotheses rather than to direct the focus to the interaction for the desired action.

After the final evaluations, it became evident that it is important to provide an overview of the available actions for the selected data. Two participants of the moderated evaluations also expressed it to be very valuable to be able to see all available actions at the same time in order to get an overview of what you can do with the selected data. Another participant also pointed out that users might not know which actions are available or what to search for and thus would benefit from having an overview. Therefore, a new guideline was added which is described below:

Provide an overview of all available actions for the selected data. To support data exploration, it is important that the user is aware of which actions are available for the selected data. The presentation should therefore provide an overview of all actions that are available to perform.

6.3.6 Reflections

The second iteration resulted in a lot of insights that made the project progress. During the Ideate phase of this iteration, there was a strong focus on understanding the complexity of The Software rather than generating a lot of new ideas. Thus, a lot of discussions were held with different stakeholders at The Company in order to go more into detail on the different features for the presentation of actions. These discussions turned out to be very valuable in order to further develop the already existing concepts and focus on the details. Furthermore, the goal of the second iteration was to be able to go into more detail of the chosen concepts. The fact that it was decided to focus on only the toolbar during the Ideate phase, made it possible to focus more on the details. Thus a lot of time was spent prototyping in Figma which was very valuable at this stage of the project. However, the time plan for the second iteration was still followed to a great extent.

The decision to test the final prototype by using the service UserTesting was made early in the early process of iteration 2. This decision facilitated the development of the prototype because the different user flows were already determined. In addition, the purpose of the tests was kept in mind in order to make a prototype that could be evaluated online. However, having unmoderated tests also came with challenges. One specific challenge was that it was difficult to know how the questions were perceived by the participants. It was therefore important to formulate the tasks in a way that the participants understood what was expected of them and that there was no right or wrong answer. To have this in mind was important since it is not possible to ask any additional questions during the tests.

Furthermore, during the moderated evaluations at The Company it was possible to ask additional questions. As a result, the tasks needed to be reformulated in order to suit the setting of these tests better. Another takeaway from the moderated tests was that since it was possible to ask follow up questions, the evaluation sessions ended up being more of a discussion where the participants asked a lot of questions. One possible reason for this could be that the participants of the moderated test were experienced users of The Software and thus had a better understanding of how it could be implemented. Another contributing factor could be that the prototype followed a certain user flow and had limited interaction. If the prototype would have been more interactive, the participants could have explored the prototype better without the need of asking a lot of questions.

Another challenge connected to both of the evaluations was that it was hard to evaluate how valuable the information in the inspect popup would be for the data exploration. One possible reason for this may have been that participants did not have any prior knowledge of the data set and the visualizations in the dashboard had already been configured. In particular, participants in the moderated test expressed that it was difficult to comment on

the actual value or what other information would help them to understand the selected data better.

7
RESULTS

The following chapter presents the results of the thesis project. Firstly, the final design is presented and described. Secondly, the guidelines are described and motivated.

7.1 Final Design

The final design is a toolbar that aims to gather all actions that can be performed on selected data. By creating a common access point and giving users an overview of the available actions, the goal is to support data exploration and the search for answers to hypotheses, as well as to reduce the focus required to interact with The Software. By providing quick access to options for acting on selected data close to the selection, the toolbar aims to contribute to an enhanced user experience and a more efficient workflow. The possibility to choose the number and type of actions to have close at hand also creates flexibility for users and aims to increase the usability of the toolbar.

As a result of the iterative execution described in chapter 6, the design has finally been realized in the prototyping tool Figma. The different parts of the design are described in detail in the sections below.

7.1.1 Placement and Appearance of the Toolbar

The toolbar appears as soon as data has been selected in a visualization (Figure 43). Furthermore, it is available as long as the user hovers over the visualization area. In order not to intrude on data exploration, the toolbar disappears again when the mouse pointer is moved from the visualization area where the data has been marked, to another area of the dashboard.

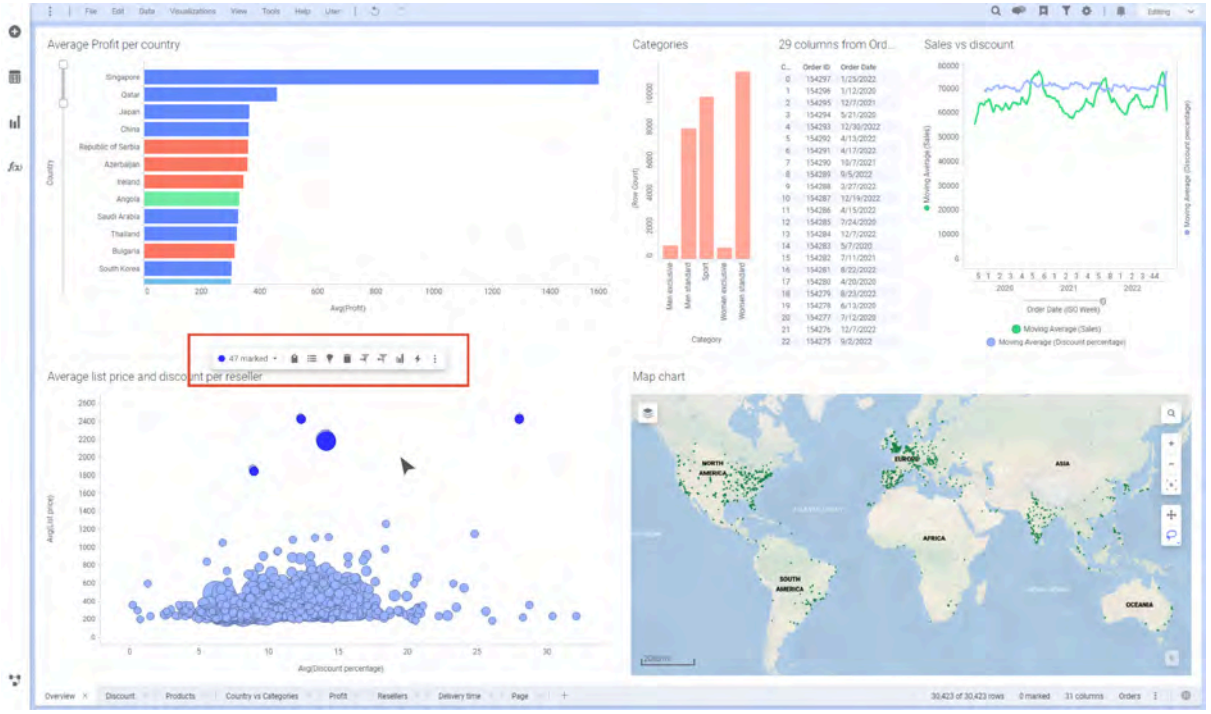


Figure 43. The toolbar appears when data is selected in the scatter plot and is visible while hovering upon the visualization area

The toolbar has a consistent placement, centered on the upper edge of the visualization area. In this way, the toolbar does not cover any data and users can be sure of the placement of the toolbar for a certain plot. Having a toolbar that always appears in one and the same place, and stays there as long as the user hovers over the visualization area, creates a stable impression as that the toolbar does not move around or change position. If the user chooses to redo their selection or wants to select more data points, this interaction model will provide a seamless experience and not risk the toolbar constantly appearing and disappearing.

7.1.2 Interaction with the Toolbar

As mentioned, the toolbar appears when data has been selected in a visualization and is present as long as the visualization area is hovered upon. As soon as the user hovers over the toolbar itself, a thin blue stroke appears around the visualization where the selection was made to indicate the context of which plot the toolbar is connected to (Figure 44). When hovering upon the different icons in the toolbar, each icon gets a darker background to indicate that it is clickable (Figure 45). Using dynamic hinting in this way reduces visual clutter while indicating that the icons have the behaviors of buttons. Along with the change of background color, a tooltip is shown for each icon to provide a modeless interactive help. The tooltips have a short delay to quickly inform the mean of the icon, without disturbing users who know which action to perform.

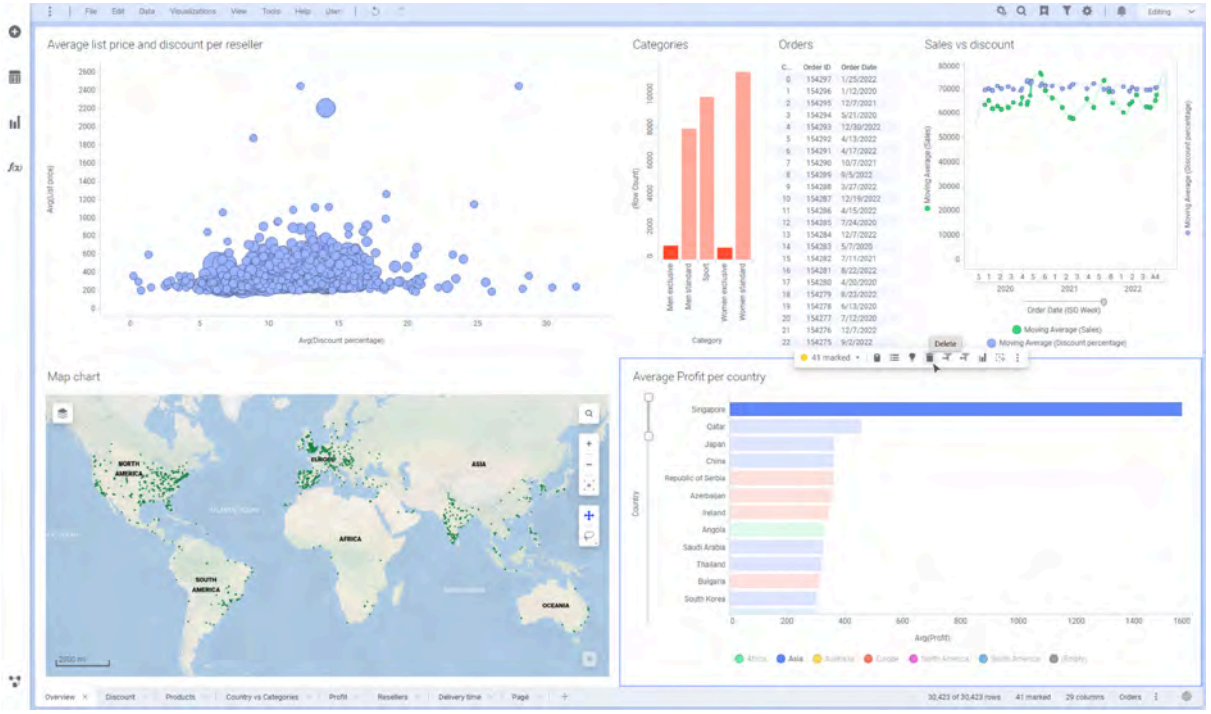


Figure 44. When hovering upon the toolbar, a thin blue stroke appears around the visualization to indicate the context of which plot the toolbar is connected to

Figure 45. A close-up of the toolbar with dynamic hinting and tooltip while hovering

7.1.3 Indication of Selected Data

When acting on a selection in analytics softwares, it is crucial that users understand the context of what data they act upon. In the toolbar, the first part is reserved to be able to understand the selected data. This is indicated directly with a color that corresponds to which marking color is used in the visualization, as well as an indication of how many rows have been marked. Doing so facilitates the understanding of which rows in the data table will be affected by the action performed. The tooltip for this part, *Inspect*, along with the dynamic hinting on hover indicates its clickability (Figure 46). When clicked upon, a popup appears (Figure 47), where users instantly can receive additional information about the selection. Within the inspect popup, it is possible to look at the selected data from different perspectives, by swapping between different columns of the data table to view information of interest. It is also possible to copy the different values displayed, to extract important information to a note or an email, or to facilitate the data exploration workflow by for example using the copied values as input for a new visualization or for a filter. An icon for copying the values appears on hover.

To close the popup, the user can either click on the same area that opened it, or anywhere outside of the popup. If clicking in the visualization area outside the popup, it will close but the data will remain selected.

Figure 46. The inspect part of the toolbar, along with the dynamic hinting on hover

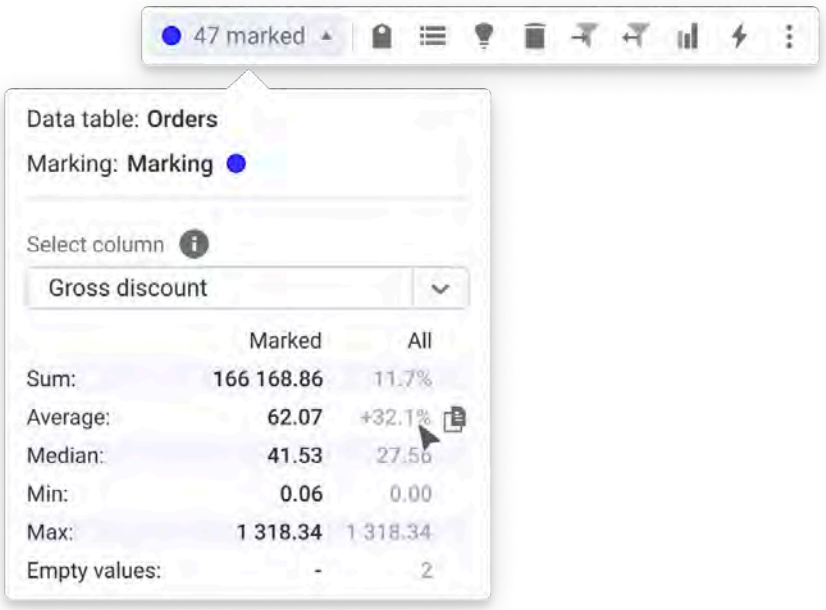


Figure 47. The inspect popup with additional information about the selected data and possibility to copy values of interest

When data is selected in a visualization, the same data is also marked in all other visualizations that are brushlinked and thus use the same marking. For visualizations that are using the same marking color, it should therefore be possible also to take action from the brushlinked visualizations. The toolbar will thereby appear when hovering upon the brushlinked visualizations, as data indirectly is selected in them as well (Figure 48). By displaying the marking color along with the number of marked rows, which will be the same as where the selection is originally made, the toolbar intends to clarify what data will be affected by the performed action.

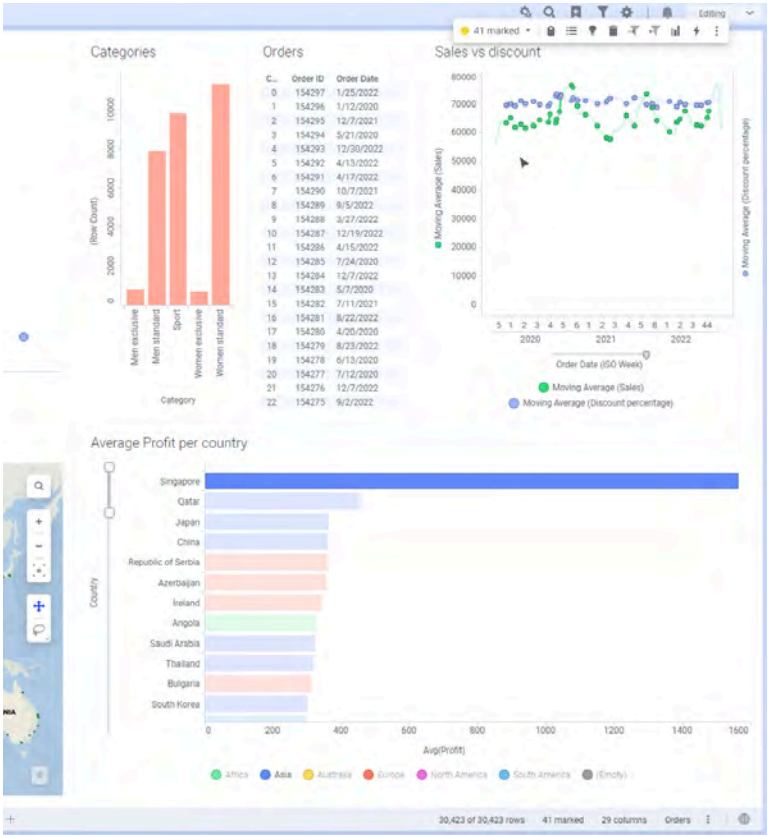


Figure 48. The toolbar appears when hovering upon the brushlinked line chart visualization, even though the selection has been made in the horizontal bar chart

7.1.4 Presenting Options for Acting on Selections

The different actions users can perform with the selected data is represented as icon buttons in the toolbar (Figure 49). Using icons facilitates a compact way of providing many actions, without taking up much screen real estate. The default toolbar presents eight different options for acting on selected data.

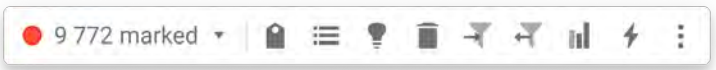


Figure 49. The toolbar with the different actions represented as icon buttons

The icon buttons serve as shortcuts to access desired actions. Some actions are single click actions, which are performed immediately upon click. Others however, require more interaction and more steps. The design of the toolbar facilitates a more efficient workflow of performing multi-step actions as the selection itself provides information to The Software. An example of such a multi-step action is *Tag* (Figure 50). When a selection is made and the user decides to tag the selected data using the toolbar, data table information is already filled out since the selected rows belong to a specific data table. The user only has to choose a tag collection and a tag, or create new ones, and once clicking the OK button, the tag is immediately applied to the selection (Figure 51).

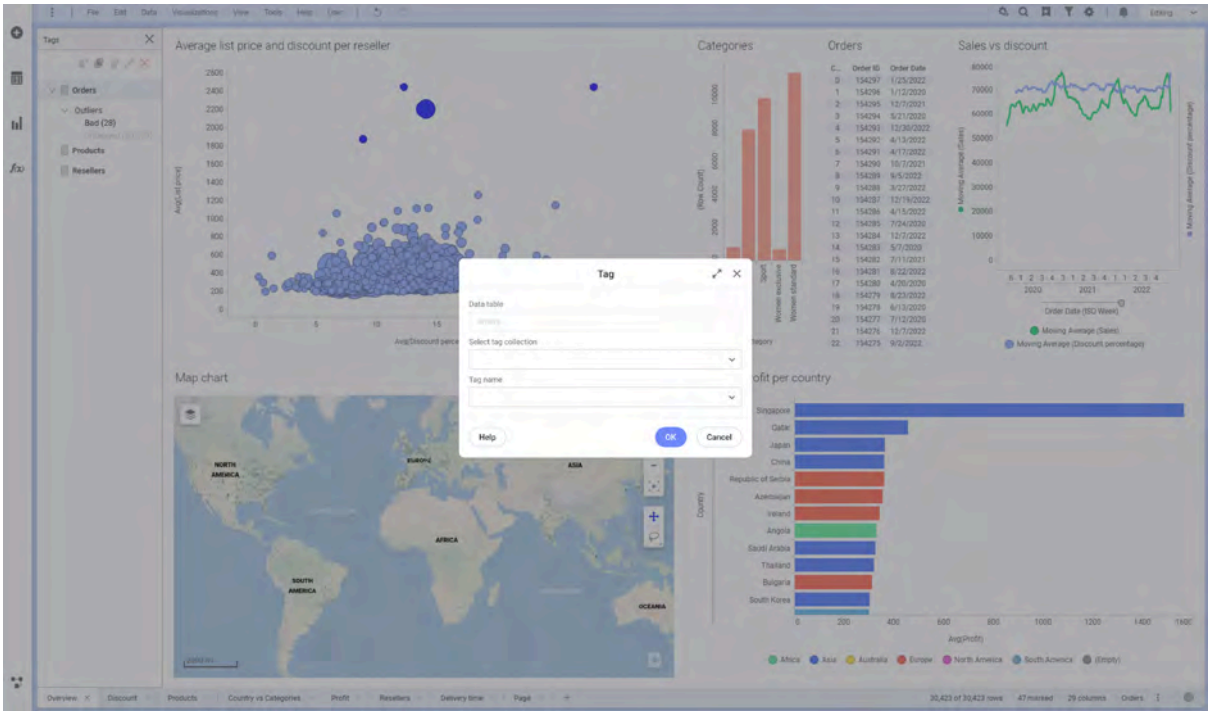


Figure 50. The tag dialog appears when the action for tagging is clicked

Figure 51. The workflow of tagging data with possibility to use an already existing tag or create a new one

7.1.5 Finding Additional Actions

In addition to the actions that are represented as icon buttons in the toolbar, the toolbar also provides the opportunity to access any action that can be performed for selected data. Through the icon button on the far right, *More*, all available actions can be found. When clicked upon, a popup appears (Figure 52). The more popup shows a search field, where a desired action can be searched for. Below are recommendations based on the data that has been selected and the visualization type in which the selection has been made. In the more popup, there is also a scrollable list of all available actions for the selected data.

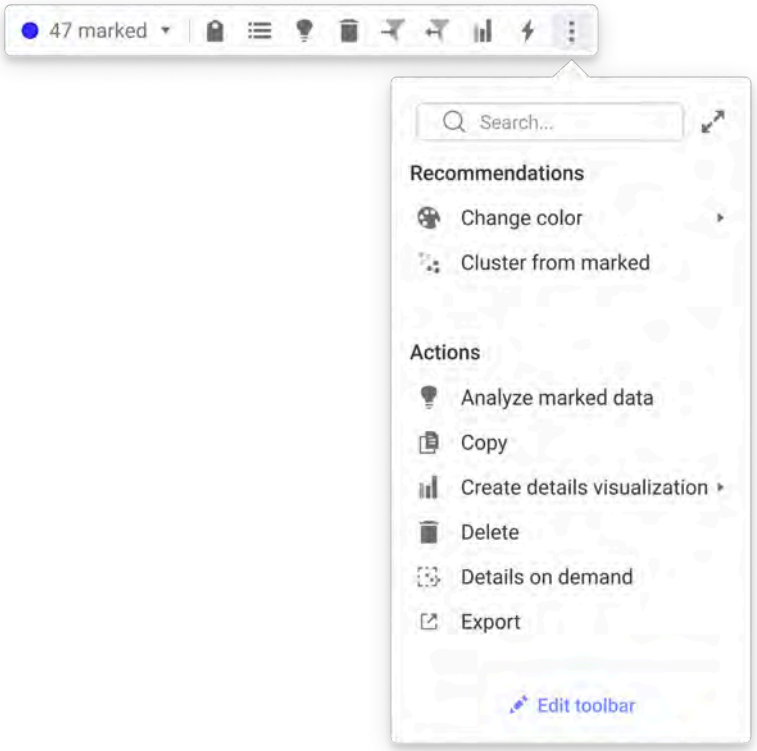


Figure 52. More popup with scatter plot suitable recommendations such as changing color of the selected data points, along with a scrollable list of available actions

If a user is uncertain of the name of an action they want to use, or if they do not know which actions are available for the selection, it is possible to expand the popup using the expand icon to the right side of the search field. In the expanded popup (Figure 53), all available actions are presented simultaneously, removing the need for a long scroll in order to find a suitable option for acting on the data.

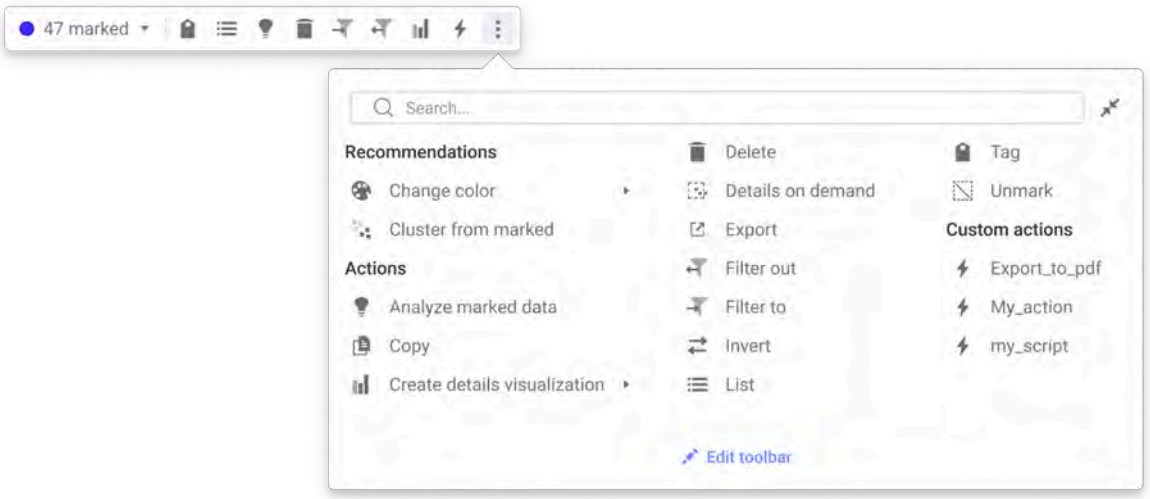


Figure 53. Expanded popup, where all available actions are presented simultaneously to give an overview

7.1.6 Customizability

Another important aspect of the toolbar is that it can be customized. The feature of having a customizable toolbar is based on the fact that different users have different use cases. By opening the more popup and clicking on edit toolbar (Figure 54), users can easily customize and choose actions to have close at hand in the toolbar. These actions include all available actions from The Software, external actions, as well as their own custom actions.

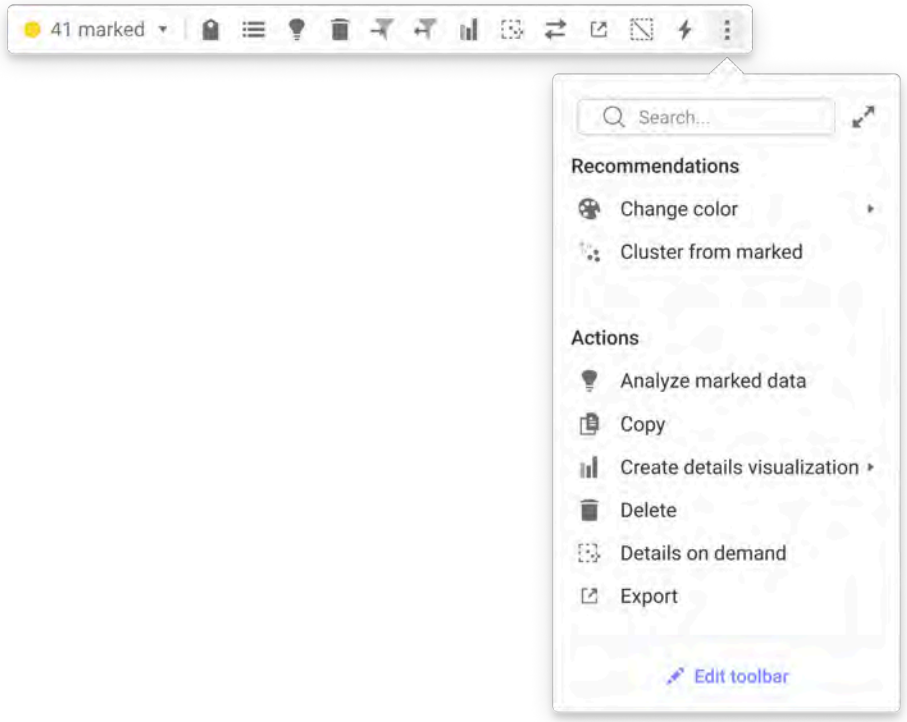


Figure 54. Using the edit button in the more popup the toolbar has been customized to include more than the eighth default actions

7.1.7 Scalability

In addition to being customizable, the toolbar is scalable. This means that the number of actions included in the toolbar can easily be adjusted to the desired number. The number of actions can vary between just a few or more and there is no limit to how many actions can be added. However, if the visualization area where the user has marked data is too small to fit the entire toolbar and its actions, a scaled-down version is displayed instead (Figure 55). The reason for scaling down the toolbar is so that it does not cover information in the dashboard and thus does not risk interfering with data exploration. Furthermore, the scaled-down version contains only the inspect part and the icon button for finding more actions. In order to still keep the selected actions close at hand, they are placed at the top of the more popup in the scaled-down version (Figure 56). This way no functionality is lost, it only takes one more click to utilize an action.

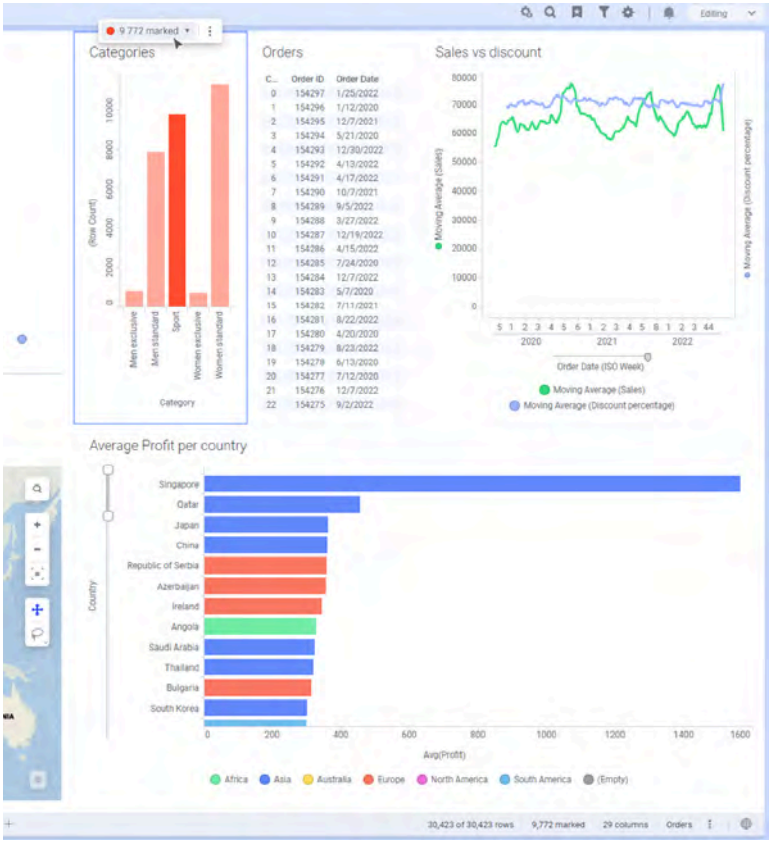


Figure 55. The toolbar is scaled-down when it does not fit in the visualization area

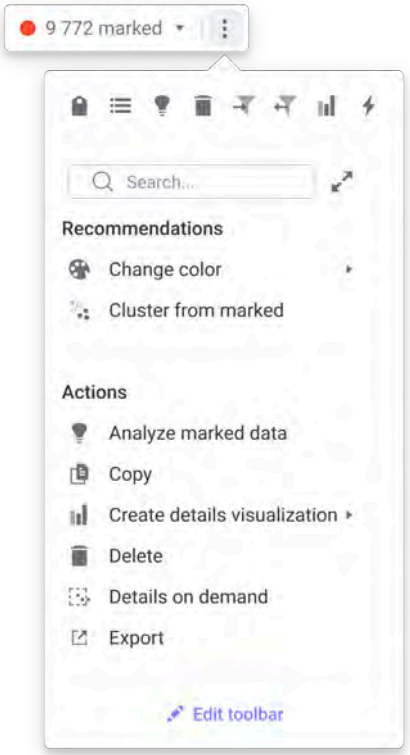


Figure 56. The more popup for the scaled down version of the toolbar, with the icon buttons positioned at the top of the popup

7.2 Final Guidelines

In the following chapter the final guidelines are presented. The guidelines are based on the process of this master thesis and were iterated upon throughout the whole project. The final set of guidelines is influenced by all sub-results from the execution, and is among other things based on the five focus areas identified during the project: *Non-intrusive*, *Customizability/Scalability*, *Discoverability*, *Exploring data* and *Keep workflow*. These are described more in detail in section 6.2.2.

The guidelines were designed to answer the research question of the thesis. The guidelines are based on other common design principles and heuristics within interaction design such as Nielsen's 10 Usability Heuristics for User Interface Design (Nielsen, 2020) and the book About face written by Cooper et al. (2014). The guidelines are intended to extend already existing guidelines and assume that the most common design principles already are taken into account. However, the guidelines have been modified and iterated upon in the context of visual analytics. In order to explain the guidelines better and strengthen their credibility, each guideline is represented with a title, a short description, a motivation and an exemplification. The final set of guidelines is presented below:

G1. Indicate the context of what data is acted upon
G2. Aim for a non-intrusive presentation of actions
G3. Let the user focus on the data exploration workflow
G4. The actions presented should not overwhelm the user
G5. Provide an overview of all available actions for the selected data
G6. Consider a customizable set of actions
G7. Consider a scalable presentation of actions
G8. Avoid hiding information in the dashboard

G1. Indicate the context of what data is acted upon
When selecting an action from the options presented, it should be clear which data is acted upon. The selected data is represented by visual objects in a visualization, but it is the underlying rows in the data table that are actually acted upon.

When performing an action, it is important that it is easy to understand what data is being acted upon. Keim et al. (2008) explain that visual analytics aids decision-making by allowing direct interaction with information and that it is essential that relevant information is being extracted. Further, the fourth and final step of their visual analytics mantra highlights the importance of the data providing insightful details on demand (Keim et al., 2008). Since the interactive data in visualizations are not simply visual objects, but representations of underlying rows from a data table, the discussions with UX designers in iteration 2 (section 6.3.1) revealed the importance of informing users about what data will be affected by their action. Additionally, the importance of clarifying the context in which the user acts was expressed in the first design critique (section 6.2.4), where it was clarified that the selected data can be acted upon from several visualizations.

An example of how the context can be indicated when presenting options for acting on data is by clearly stating how many rows have been marked. In the final toolbar (Figure 57), it is indicated on the far left how many rows the selected visual objects represent, to give the user a first indication of the data on which the action will be performed. When clicked, a popup opens that provides additional information about the selection such as which data table the data belongs to and which marking is used. There, the user has the opportunity to inspect the selected data further, to be sure that the correct data has been marked before an action is performed. To further indicate the context of what data will be acted upon, a thin blue stroke appears around the visualization area in which the selection has been made.

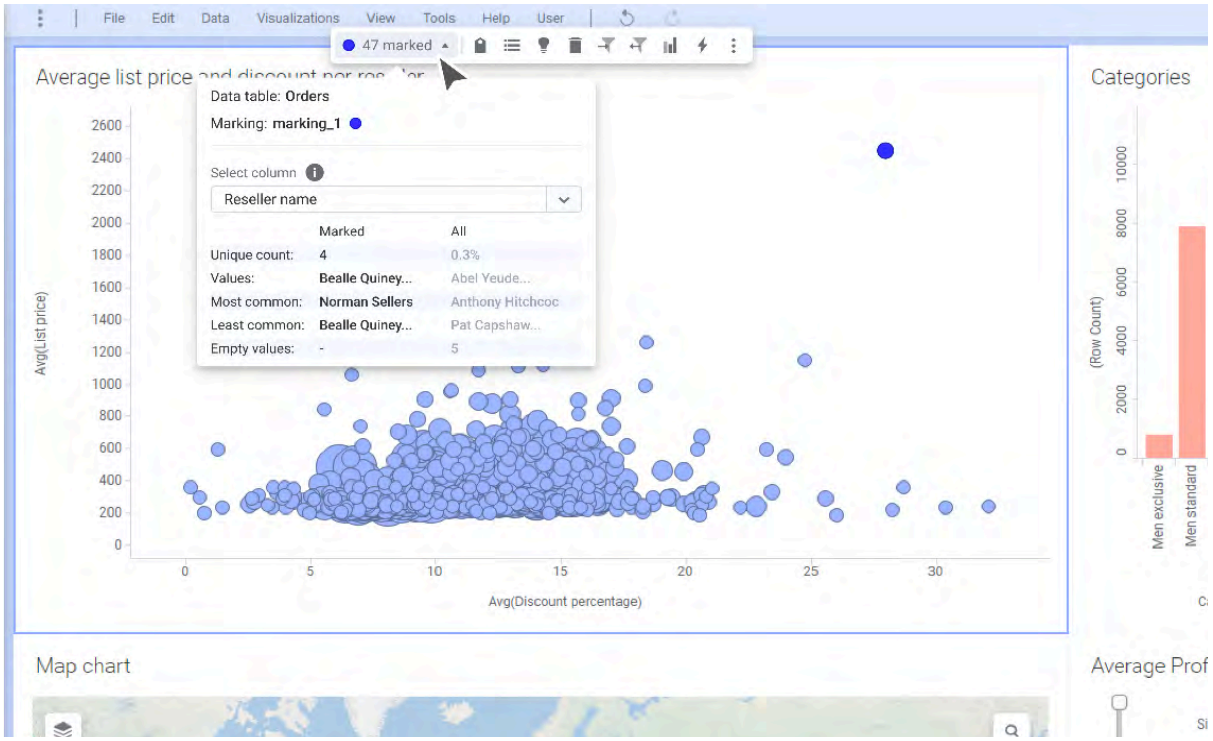


Figure 57. Example of indicating the context using an inspect popup showing the number of selected rows along with additional information

G2. Aim for a non-intrusive presentation of actions

When indicating that a user can perform actions on selected data, a non-intrusive design that does not disturb data exploration but still is discoverable, should be aimed for.

When presenting options for acting on selected data, the presentation should be non-intrusive in order not to disturb the data exploration. Sharp et al. (2019) explain that user experience is about people's feelings and emotions when interacting with a product. As a result, it is essential to consider feelings and emotional appeals to create the conditions for a good user experience. Furthermore, Hassenzahl (2004) states that UX is subjective and that experiences depend on the situation and the person interacting with the product. Interviews with internal stakeholders (I3 & I4) at The Company highlighted that balancing the discoverability of actions with non-intrusiveness is a critical design consideration. Analyzing all of the interviews using an affinity diagram (section 6.2.2) further emphasized the importance of users understanding the actions available for selected data without disrupting

their data exploration. In addition, it became clear from the interviews (section 6.2.1) that the presentation of actions should remain non-intrusive if users choose not to act on the selected data.

Finding the balance between the two focus areas *Non-intrusive* and *Discoverability* (section 6.2.2) is challenging and can be done differently. An example of a design that aims to be non-intrusive can be seen in the final toolbar. The toolbar appears when data has been selected in a visualization and while hovering over that specific visualization area (Figure 58). If the visualization area is not hovered upon, the toolbar will not appear (Figure 59). This way, the toolbar does not interfere with the data exploration if the user does not wish to act on the selected data. Another feature that facilitates a non-intrusive design is that the toolbar always appears in the same position in a visualization, located in the top of the visualization area. The final toolbar is therefore consistent in its placement, does not cover any data and is easy to discover while not distracting when it appears.

Figure 58. Example of a non-intrusive way of presenting options for acting on selected data

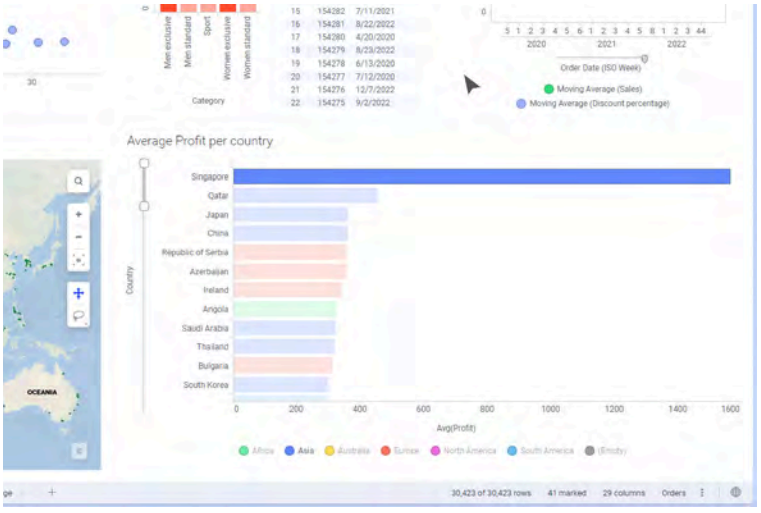


Figure 59. Example of a way of not intruding on data exploration using a hover effect

G3. Let the user focus on the data exploration workflow
In order to support the user's sense of control, utilizing actions should to the greatest extent facilitate a continuous workflow. The presented actions should not disturb the user's workflow, but should let the user focus on their goal of answering their hypotheses rather than to direct the focus to the interaction for the desired action.

When analyzing data, focusing on the data exploration rather than the interaction is essential to answering hypotheses regarding the data. Flow is described as the phenomenon of people being involved in an activity to the extent that they forget about their surroundings and feel like nothing else matters (Csikszentmihalyi, 2008). Cooper et al. (2014) explain that designing for an enhanced flow, as well as making sure the flow is not interrupted, should be aimed for since users who reach this state can be highly productive. If users need to focus on the interaction of finding a suitable action and how to perform it, that interaction will interfere with their data exploration and goal of finding an answer to their hypotheses. This can in turn result in a bad user experience and low user satisfaction.

The need for a guideline highlighting the importance of a continuous workflow was expressed already in the beginning of this project, where the supervisor expressed that acting on selected data is currently something that The Company believes disrupts the user's workflow. It became even more evident during the interviews (section 6.2.1), where two participants (I3 & I4) expressed that in The Software, it is currently not obvious what options there are for acting on selected data, since the available actions are scattered around the interface. Furthermore, an uninterrupted workflow was frequently expressed as a future desired scenario for The Software and *Exploring data* was one of the identified areas of focus (section 6.2.2).

An example of a design where this guideline has been considered is when changing color of a selection in a scatter plot visualization, using the toolbar (Figure 60). The user can access the action from the toolbar, and all steps of the process are performed within the toolbar. Requiring only a few clicks, this design facilitates an efficient workflow without the need of changing context.

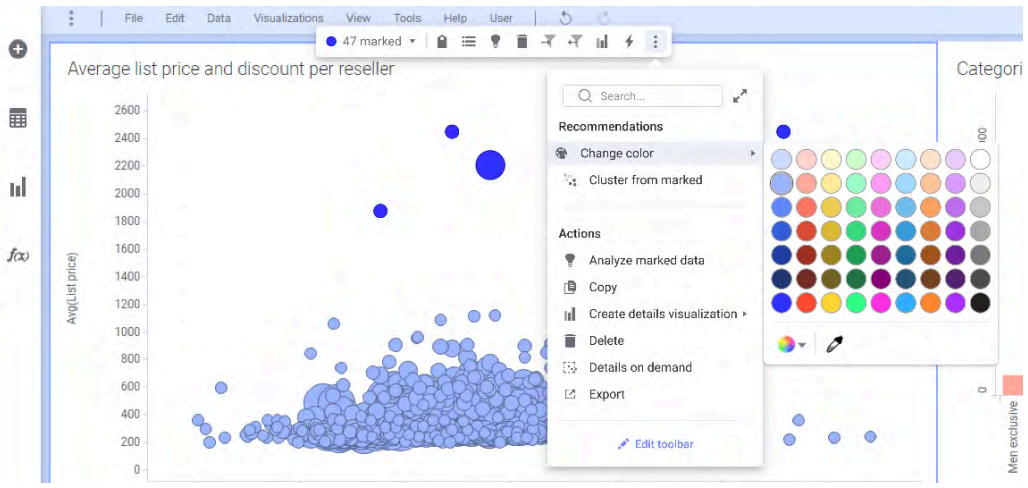


Figure 60. Example of a continuous workflow of changing color of a selection in a scatter plot visualization

G4. The actions presented should not overwhelm the user
The actions included in the presentation should be structured in a clear way that promotes discoverability without overwhelming the user. How the presentation is perceived can be affected by the number of actions included or the level of details but should not overwhelm the user regardless.

Human perception is an important factor that affects user experience. Sharp et al. (2019) explain that vision often is the most dominant sense and in regards to interaction design it is important to consider how information is presented. Ware (2021) confirms this and states that the visual sense efficiently can acquire a lot of information. Consequently, the actions for selected data should be structured in a clear way to help human perception so that it is easy to discover actions without feeling overwhelmed.

During the design critique (section 6.3.3) conducted in the second iteration, it became evident that using icons together with tooltips is a design pattern that is frequently used in softwares. In addition, actions can be presented in a compact and structured way when using icons as well as enable an immediate overview of all the actions. An example of how tooltips can be used in combination with icons in a toolbar can be seen in Figure 61. A finding from the final evaluation (section 6.3.5) was that a long scrollable list of actions can be overwhelming since the user has to scroll and search through a long list to get an overview. This highlights the importance of structuring actions in a clear way without overwhelming the users. Furthermore, a risk when not taking this guideline into consideration is that it may result in difficulties in perceiving the available actions for the selected data.

Figure 61. Example of using icons along with tooltips to present options for selected data in a compact and structured way

G5. Provide an overview of all available actions for the selected data
To support data exploration, it is important that the user is aware of which actions are available for the selected data. The presentation should therefore provide an overview of all actions that are available to perform.

Knowing which actions are available to perform with the selected data is therefore essential for data exploration. Heer and Shneiderman (2012) explain that being able to select data in a visualization and take actions upon that data is crucial to understand the data better. To perform a suitable action, it is important that the users understand all available actions. This was further validated during the final evaluations (section 6.3.5), where one participant explained data exploration as consisting of two different use cases. Either the users know what they want to do and then they need to be able to perform that action quickly, or they don't know how they want to proceed and then they need to be able to see what options are available.

According to the sixth of Nielsen's ten Usability Heuristics, *Recognition Rather than Recall*, providing an overview of all available actions and making the options visible will minimize the user's memory load (Nielsen, 2020). Further, it highlights that *see-and-point* should be used rather than *remember-and-type*. The value of providing an overview of available actions was strengthened during the interviews (section 6.2.1), where three interviewees (I2, I4, and I5) mentioned that actions that are scattered around the interface can be hard to find. Furthermore, another interviewee (I1) expressed that it is challenging to perform external actions as these require even deeper navigation in the interface.

One way of enabling users to find a suitable action is through a scrollable list of all the actions, accompanied by a search bar where the users can quickly find a desired action (Figure 62). This is a convenient and space-efficient way of presenting all actions, however it can be problematic if the list of actions is long. Either this requires the user to know which action they want to use and the name of it, or if they do not know which action they want to use, it requires a long scroll to look through the various options for acting on the data. A better example of a design for implementing the guideline is through an expandable section where all actions can be seen simultaneously. In the final design, an expandable popup is used (Figure 63). This enables a clear picture of what options are available without the need for scrolling, where the different options can be compared and a suitable action selected.

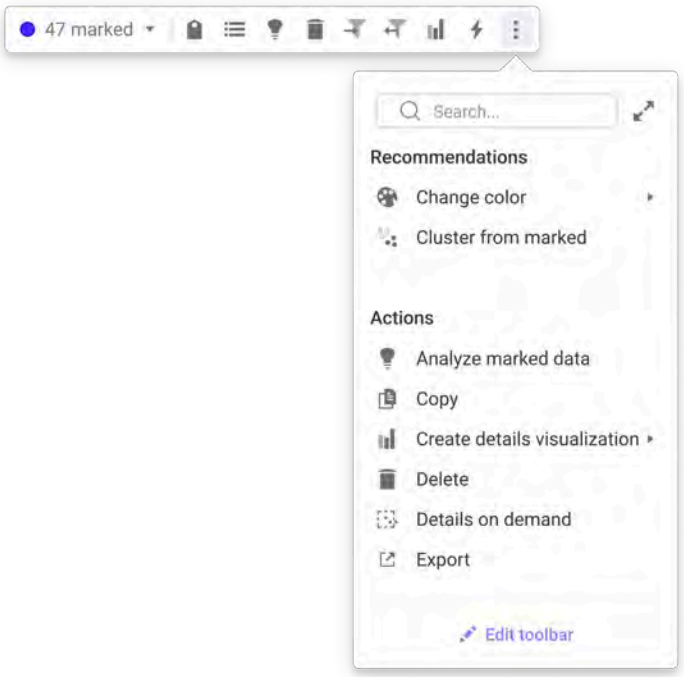


Figure 62. Example of a way to enable users to find suitable actions through a popup containing a scrollable list and a search bar

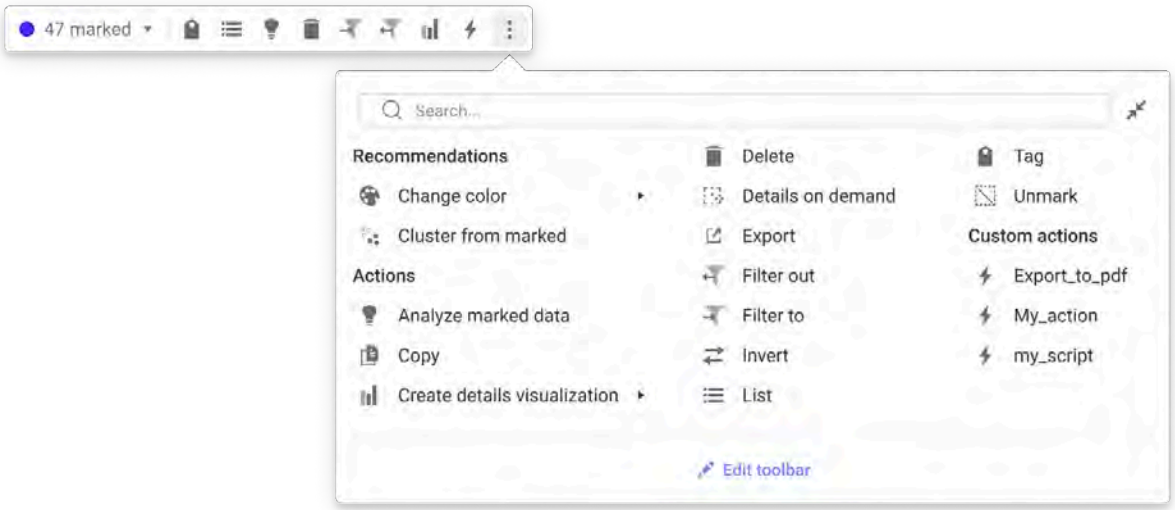


Figure 63. Example of a way to provide an overview of the available actions for the selected data, through an expandable section

G6. Consider a customizable set of actions

It should be possible for each user to customize which actions are available in the presentation for acting on selected data. The iterative nature of visual analytics, combined with the strive for efficiency among data analysts, would benefit from a customizable design solution enabling users to control their interactions.

Information gathering, data preprocessing, knowledge representation, and decision-making are parts of the iterative process of visual analytics (Keim et al., 2008). This iterative process can be carried out in different ways, and the interviews (section 6.2.1) revealed that the actions most commonly used vary a lot, and that it is therefore difficult to choose a unique set of actions that is always useful for everyone. Apart from the fact that it varies because different users work in different ways, two interviewees (I2 & I5) also expressed that which actions are used may depend on the use case or on the type of data being analyzed. This can, for example, be influenced by the industry you work in, as different workflows may be appropriate. By conducting interviews with several different types of users, with different roles and relationship to The Software, it became clear that different users make use of different actions, which supports the importance of considering *Customizability*, one of the five focus areas (section 6.2.2).

The seventh of Nilsen's usability heuristics, *Flexibility and Efficiency of Use*, strengthens this guideline by claiming that users should have the opportunity to tailor frequent actions (Nielsen, 2020). Additionally, Nilsens guideline describes customization as a way of giving users the ability to decide on how they want a product to work by making selections. Providing the opportunity to customize which actions to have close at hand creates freedom and flexibility, and allows users to speed up their work.

An example of a design where customization is available is in the final design, where the user can edit the toolbar (Figure 64). Users can choose which actions to have close at hand, including all available actions from The Software, external actions, as well as their own custom actions.

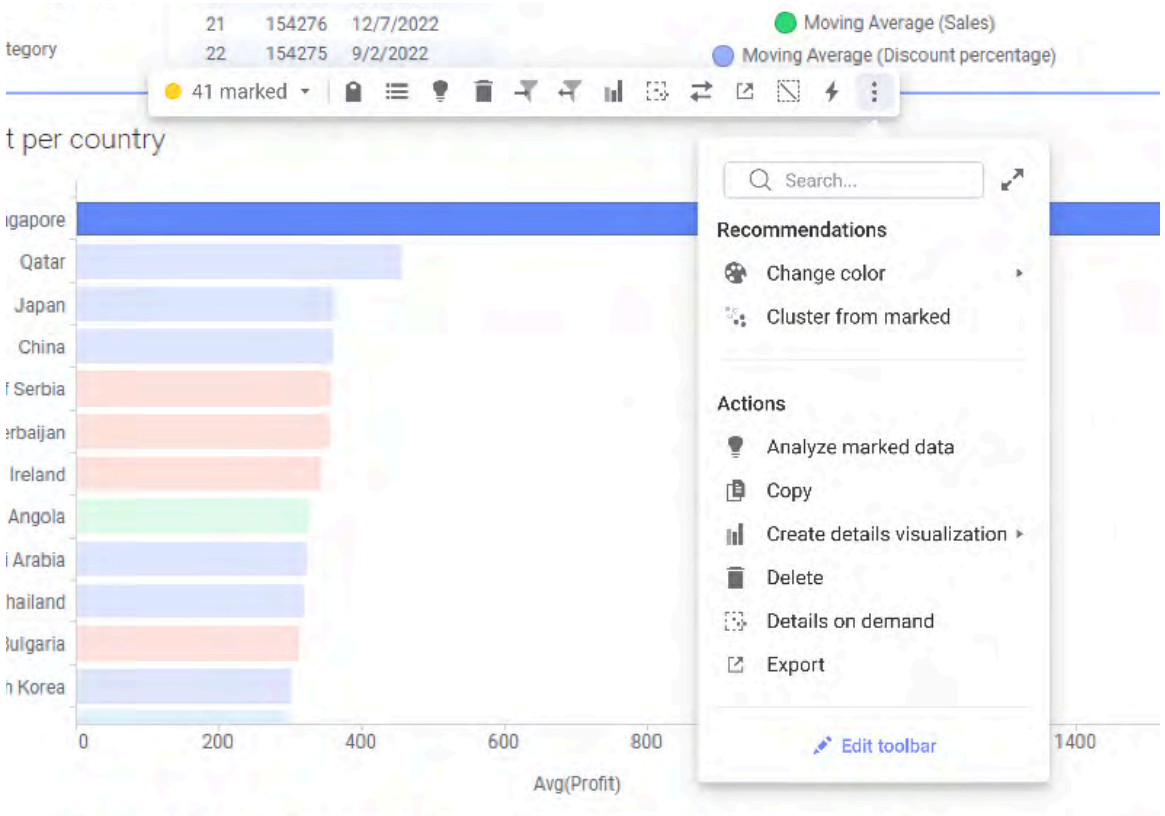


Figure 64. Example of a customizable toolbar where the user can include preferred actions

G7. Consider a scalable presentation of actions

The presentation should follow design patterns that are scalable to support flexibility in the number of actions to include. If the user decides to include more actions than the default set, the presentation should scale accordingly.

In accordance with Nielsen's eighth heuristic, Aesthetic and Minimalist design, interfaces should only contain relevant and necessary information (Nielsen, 2020). Additionally, the heuristic states that the user's primary objective should be supported by the visual elements of the interface. Consequently, it is also important to support flexibility when presenting options for acting on select data, as some users may prefer having a multitude of actions at their disposal (Figure 64). During the initial interviews (section 6.2.1) in the first iteration, I2 and I4 expressed a desire for a scalable design solution for acting on selected data. I2 noted that in certain contexts, it is preferable to only display a few specific actions, while in other contexts, a more extensive set of actions may be required. This need for scalability was also highlighted during the evaluations of the high-fidelity prototype (section 6.3.5). One participant proposed the possibility of including an unlimited number of actions, without being constrained by a specific limit.

A lot of different design patterns can be scalable. An example of a scalable design pattern can be seen in Figure 65 and Figure 66. The toolbar provides quick access to frequently used actions and the number of icon buttons included can easily be adjusted to the desired number. For instance, the toolbar can contain only a few or numerous actions. As the toolbar also features a search option for all the available actions, no functionality is lost when choosing a scaled-down version. Furthermore, scalability and customization are interrelated and part of the same focus area, *Customizability/Scalability* (section 6.2.2). Consequently, the guideline *G6. Consider a customizable set of actions* and *G7. Consider a scalable presentation of actions*, overlap to some extent and a combination of these features should be aimed for.

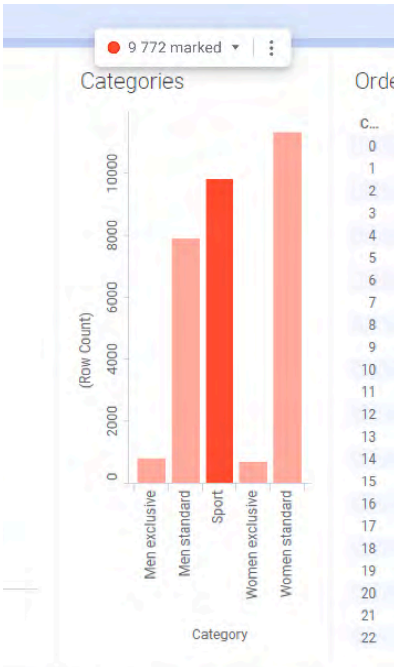


Figure 65. Overview of the scaled-down version of the final toolbar

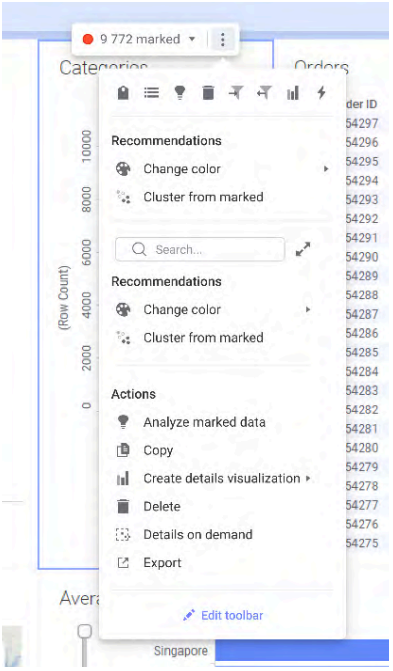


Figure 66. Overview of the more popup in the scaled-down toolbar, where the icon buttons are positioned on top

G8. Avoid hiding information in the dashboard

Hiding or covering information in visualization areas should, to the greatest extent possible, be avoided. It is important not to intrude on the data exploration by covering interactive data in visualizations or related information in the dashboard area.

Ware (2021) explains that visualizations are valuable tools for perceiving a large amount of data since the visual sense efficiently can acquire a lot of information. The author also states that a well structured visualization can help to find patterns. Thus, it is of great importance to avoid hiding information or covering interactive data in visualizations in order to not hinder data exploration and pattern recognition. This was also highlighted as two areas of focus for the project, *Keep workflow* and *Exploring Data* (section 6.2.2). In the final evaluations of the prototype (section 6.3.5), two participants voiced concerns regarding the popups associated with the toolbar, noting that they disrupted their data exploration process. Despite the popups only appearing when explicitly opened by the user, participants

found them to be disturbing even after making the decision to engage with them. This feedback underscores the critical need to ensure that no elements obstruct the view of data unless users have actively chosen to interact with them.

Designing a presentation of options for acting on selected data that does not hide data or intrude on the visualization can be done differently. One example can be seen in the final design, where a small toolbar is centered at the top of the visualization. By placing it at the top it does not cover any data or other information when appearing. In addition, the toolbar is scalable to also fit in smaller visualization areas. However, when interacting with the popups associated with the toolbar it covers parts of the visualization. Thus, an even better way to exemplify this guideline is presenting the options for acting on selected data in a panel (Figure 67). A panel creates a distinct area within the interface where actions for selected data can be displayed without covering or obstructing the data in the visualizations. More specifically, a panel compresses the visualization area instead of covering it. Users can also choose when to open or close the panel, allowing them to access supplementary information or perform specific actions without obscuring the main visualization. The panel was one of the ideas developed during the first iteration (section 6.2.4) but later in the process it was decided not to move forward with it in order to be able to go more into depth with the toolbar.

Figure 67. Example of a presentation for acting on selected data that does not, at any time, hide information or intrude on the dashboard area

8
DISCUSSION

This chapter will discuss the execution of the process as well as the final result consisting of guidelines and a final design. In addition, the validity and generalization of the result, as well as potential ethical issues will also be discussed. Lastly, suggested future work will be reflected upon.

8.1 Execution Discussion

The goal of the process was to answer the following research question:

> *In analytics softwares, what should be considered when designing how to present relevant options for acting on selected data in visualizations?*

To achieve this, the process started with a prestudy where time was spent understanding and exploring The Software. Understanding The Software and how users work to analyze data using a visual analytics tool proved to be very important throughout the whole project. It was especially important to understand different use cases in order to know what to consider when designing a presentation for acting on selected data. Therefore, a combination of an interview and a demo with an internal stakeholder at The Company was conducted during the prestudy. This interview provided a slightly better understanding of how to explore data using The Software. However, more interviews could have been conducted in order to gain an even better understanding. Another method that would have been valuable in the initial part of the process would have been to conduct contextual inquiry or observations of real users of The Software. Being able to observe users in action would ensure a more profound understanding of the process of analyzing data, as well as the nature of real use cases.

After the prestudy, the first iteration began. Additional interviews were held with internal stakeholders at The Company to gain insights about potential challenges connected to acting on selected data using The Software. This part of the process was vital for understanding that users work very differently and see different actions as the most important when exploring data. Moreover, when analyzing the interviews, five different focus areas were found. These were: *Non-intrusive*, *Customizability/Scalability*, *Discoverability*, *Exploring data* and *Keep workflow*. Some of these focus areas such as *Non-intrusive* and *Discoverability* are conflicting with each other. As a result, using the

focus areas as a basis to generate ideas proved to be difficult as no solution met all of the areas of focus. During the evaluation of the first iteration, it was therefore necessary to adjust the scope of the project to be able to decide on which concepts to move forward with. The change of scope resulted in looking at it from the perspective of a Data Analyst as the main target audience and therefore less focus could be put on the focus area regarding discoverability. Nevertheless, it would have been beneficial to change the scope earlier in the process, before the actual idea generation, since other more relevant ideas might have emerged then. Due to the fact that the scope was changed towards the end of the first iteration, there was not enough time to generate new ideas focusing mainly on the Data Analyst. Consequently, among the generated concepts, those most suitable for the Data Analyst were chosen for further iteration, resulting in other potentially more suitable ideas not being explored. However, it would have been difficult to make this change of scope in an earlier stage and it was still valuable to try to come up with a solution that fully covered all of the focus areas.

Furthermore, the process was following Design Thinking and was divided into the five different phases: Empathize, Define, Ideate, Prototype and Test. As Design Thinking is an iterative process, the different phases intertwine which became very apparent in the process as it was difficult to maintain a coherent and chronological structure in the report. Another insight from using the Design Thinking process was that the Test phase was quite closely related to Empathize. This fact made it even more difficult to divide and adapt the process into these different phases. Additionally, the time plan also needed to be adjusted slightly after the first iteration as more time was needed for the Prototype phase. This allowed more focus on details and to create interactive prototypes, something that turned out to be necessary for being able to evaluate the prototype thoroughly. If the project would have been redone, a different, more fluid division of the process would have been beneficial. However, following the Design Thinking and dividing the report after its five phases ensured an easy-to-follow structure and an iterative design process.

8.2 Results Discussion

In the following section, the results of the project will be discussed and reflected upon. To start with, the final design will be discussed, followed by a discussion of the developed guidelines. Finally, the validity and generalization of the results will be reflected upon.

8.2.1 Final Design

The aim for this thesis project was to understand what to consider when presenting options for acting on selected data in visualizations, in analytics softwares. As part of the project, it has thereby been important to create prototypes and evaluate these to explore important factors and answer the research question. Due to limited knowledge of data analysis, combined with the difficulty of finding a good and easy-to-understand dataset, it was hard to showcase a credible use case. In addition, the complex nature of visual analytics tools, combined with the limited time frame, made it hard to develop a fully interactive prototype. The lack of a fully interactive prototype resulted in a highly guided flow of an exemplified

use case, and thus it was difficult to evaluate the real value of the final design, the toolbar, and especially the inspect popup. During the evaluations, the scores of how well the toolbar helped with understanding the selected data got a relatively high score, 4.6/5. However, several users expressed that their ratings were based on their assumptions and that a more real setting with data they are familiar with would be needed to know the value for certain. Based on the feedback received, it would have been valuable to test the final toolbar in a less guided and more interactive setting, where a realistic hypothesis about the data could be set. Trying to find an answer to a realistic hypothesis and thus performing an exploratory workflow could have strengthened the evaluations of the toolbar and better understand the value and usability of the final design.

Additional feedback expressed during the evaluations was concerning the scaled down version of the toolbar, which appears when the visualization area is too small to fit the default size of the toolbar. There was a wide spread of feedback regarding the scaled down version. Some participants expressed that it was good that it was scaled down so as not to intrude on any of the other visualizations in the dashboard, while others expressed it as disturbing that the actions ended up hidden one click away. It was decided not to explore this any further, due to time constraints and the fact of it being a question of implementation. However, it would have been interesting to explore and evaluate this further to understand whether the solution of a scaled down version is the better solution.

The final design considered the concept of Brushlinking to some extent. Since Brushlinking is a concept specific to The Software and not a concept that goes across all visual analytics platforms, it was hard to know how much to consider it in the final design and whether it would affect the answer to the research question or not. After the final evaluations of the toolbar, a new design iteration was performed concerning how the toolbar would appear for brushlinked visualizations. Since the final decision was taken without the possibility to evaluate it, it would be interesting to examine this further.

To conclude, the final design is conceptual and developed as a means for developing and evaluating the guidelines. To be able to implement the final design in The Software, further exploration of technical features, as well as compatibility with other aspects of The Software, would be required.

8.2.2 Guidelines

The final set of guidelines included eight guidelines, developed as means for answering the research question. Throughout the project, the guidelines have been iterated upon continuously based on insights revealed. They are based on theory, where the first iteration of the guidelines was derived from the results of the literature study. Throughout the process, the guidelines have been revised and built upon based on the results from, for example, interviews and evaluations. However, carrying out additional literature studies during the process would potentially have been valuable in further developing and substantiating the guidelines, and making them even more robust. Furthermore, some of the guidelines are similar and have some overlapping content. *G2. Aim for a non-intrusive*

presentation of actions, *G3. Let the user focus on the data exploration workflow* and *G4. The actions presented should not overwhelm the user* are related and contain similar aspects. The same applies to *G6. Consider a customizable set of actions* and *G7. Consider a scalable presentation of actions*. By incorporating more theory and extending these guidelines, they could have been further differentiated.

Since the guidelines and the prototype were iterated upon alternately, the final design has strongly been influenced by the guidelines. However, the decision to only move forward and develop one concept more in detail may have impacted how well the guidelines were exemplified. Creating several designs could have potentially made some of the guidelines better exemplified, but at the expense of the fidelity of the designs. However, the decision to only move forward with one design enabled the possibility of delving into details and developing a more extensive design to exemplify the guidelines.

In conclusion, the final set of guidelines have been iterated continuously and have been strengthened from both theory, user research and evaluations. Extensive work has been carried out to end up with the final guidelines, but in order to be able to say with certainty that these guidelines fulfill the answer to the research question in the best way possible, summative evaluations would have been required. The final guidelines are quite broad, and could have been applicable also to tools outside the field of visual analytics, such as within computer aided design (CAD) programs, word processing tools or other design tools, to name a few.

8.2.3 Validity and Generalization of the Result

This thesis project has focused on solving a wicked problem using research through design and an iterative design process. Rittel and Weber (1973) state that there is no guarantee that the solution for a wicked problem is good since there is no way of knowing when a solution is final. Due to the nature of a wicked problem, the general validity of the results of this thesis are uncertain. However, taking the final guidelines into consideration when designing presentations for acting on selected data provides a good basis. In addition, there is a relatively low risk of errors when considering the guidelines, since they build upon an interactive design process where evaluations have been carried out and new knowledge has been acquired alternately, which is a good way of tackling wicked problems.

The project has been based on internal stakeholders' ways of using and working with The Software, as well as their interpretation of customers' needs for acting on selected data. The fact that there has been no access to real end-users during the process might thus have affected the validity of the results. Including mainly internal stakeholders in the interviews and evaluations, might have resulted in not discovering important factors that could have influenced the project. It would have been valuable to actually see how end-users of The Software work to understand how they access actions for selected data today and what challenges they face. However, conducting evaluations with experienced analytics users of other tools as well as with internal stakeholders, and not customers of The Company, still fulfilled its purpose of evaluating the usability of the design.

Another factor that has influenced the validity of the project, is how the prototype of the final design was built and evaluated. During the project a great challenge was understanding how data exploration was carried out and what different use cases could look like, as well as which actions users are interested in taking upon selected data. As a result, it was difficult to build credible flows for the evaluations and thus it makes it difficult to know how credible the results are. Furthermore, during the final evaluations at The Company several of the participants expressed that it was difficult to know how helpful the toolbar would have been. A contributing factor to this might have been that the participants had no prior knowledge of the data and that the use case was imaginary. A similar challenge was found during the unmoderated tests using the service UserTesting since it was difficult to make the prototype fully interactive and the evaluations were based on a strictly guided flow.

The overall process and journey towards the results and answering the posed research question of this thesis, can be generalized and applied to similar projects in the future. However, the fact that this thesis has been carried out in collaboration with The Company, might have affected the process and thus also the generalization of the results of the final design and guidelines. This can be considered positive as it is a visual analytics company and the work has been based on their visual analytics tool. However, working with only one company can also be considered negative for the generalization of the result. Thus, it might have been beneficial to work with other companies to evaluate the validity and generalization further.

8.3 Ethical Issues

As within any project, there have been ethical aspects to consider. During the startup of this thesis project, potential ethical considerations were explored (section 1.4) and the privacy of the users, the risk of excluding certain user groups, as well as the risk of misleading users into making certain choices were brought up. During the entire project, user privacy has been considered. The process has been transparent where it has been clarified what information will be saved, for how long, and for what purpose. In the case of recorded parts, approval has also been given before recording.

To avoid ethical concerns related to exclusion of certain user groups, focus has been on creating conditions for all user groups, regardless of experience with analytics tools and The Software, to be able to use the tool to find a desired action. When conducting interviews and collecting feedback, to the extent possible, internal stakeholders at The Company with different roles, genders and experience from analyzing data using The Software have been recruited. In this way, as similar a representation of the user group as possible could be included, to take into account all the different needs and opinions. One guideline, *G5. Provide an overview of all available actions for the selected data*, was developed especially with this in mind. The guideline is exemplified in the final design with the more popup, where all available actions a user can perform with the selected data are gathered. By providing a search option, but also an expandable list of the available action with accompanying titles, the needs for both experienced users and inexperienced users are catered for. Additionally, positioning the list of all actions one click away ensures that the

workflow is not disturbed for those who have customized their toolbar and want to work quickly through the icon action buttons.

To include a default and to provide recommendations of actions might potentially mislead the user and create an assumption about which actions are most important or most appropriate for the situation, assumptions that may not be true. In order for this not to become an issue, a solution that can be customized was developed. Two guidelines are primarily referring to this, *G6. Consider a customizable set of actions* and *G7. Consider a scalable presentation of actions*. These guidelines were developed with the intention of allowing users to choose the actions that suit their needs and include the number that best facilitates their workflow, since it became apparent that people analyze data very differently. It is when users customize their toolbar that it becomes most effective and provides the most value. However, there is a risk that users do not choose to customize the toolbar according to their needs, but use the default. For that scenario, the risk remains that users will be misled about which action is appropriate to take. This could potentially ultimately result in incorrect or less appropriate decisions being made or important patterns from the data not being discovered.

8.4 Future Work

The final design and the guidelines were developed in parallel and therefore many other suitable concepts for presenting options for acting on selected data were identified during the project. Due to time constraints, these other concepts have not been investigated in further detail. However, it is important to keep these concepts in mind since they are also relevant when designing presentations for acting on selected data in the future.

One interesting aspect that was discussed during the process but that was not covered to a great extent in this thesis due to time constraints, was the potential value of providing recommendations for appropriate actions. For example, it would have been interesting to investigate more in depth how AI can be used to provide recommendations for actions on selected data. The recommendations could depend on the selection, the type of visualization or the use case for the data exploration. The area of AI is highly relevant and investigating how it could be used to optimize acting on selected data would have been interesting.

The final evaluations conducted in this thesis were formative in order to understand which aspects of the design function effectively and which ones need improvements. To carry out summative evaluations in the future would therefore be valuable in order to understand the overall experience of using the toolbar and identifying how well the design performs. Furthermore, in general, more evaluations of the design should be conducted in the future since conclusions cannot be drawn with confidence from the number of evaluations and usability tests conducted in this thesis. An evaluation of the guidelines could also have been relevant to ensure that they are perceived as clear and present the intended purpose. Additionally, The Software is complex and there are many different ways of acting upon selected data, which is why a prototype that is interactive to a greater extent would be

beneficial. In order to conduct valuable summative evaluations, developing a more interactive prototype would be required.

The guidelines and final design have been developed with the primary user group in mind, who analyze the data using the desktop version and use data at rest. In the future, it would also be important to consider the tablet and mobile versions, as well as ensuring that the results also are applicable for other contexts of use such as real-time data and time-critical decisions.

9
CONCLUSION

This thesis project was conducted in collaboration with The Company. The purpose of the project was to explore how different options for taking actions on data that has been selected in a visualization can be presented in analytics softwares. The project aimed to answer the following research question:

> *In analytics softwares, what should be considered when designing how to present relevant options for acting on selected data in visualizations?*

To answer the research question and tackle the wicked problem it presents, the iterative process Design Thinking was followed. The project was initiated by a prestudy, consisting of a literature review, a benchmarking and spending time understanding The Software. The findings from the prestudy were summarized and used as the basis for an initial set of guidelines. Subsequently, two design iterations were conducted that followed the five different phases of Design Thinking: Empathize, Define, Ideate, Prototype and Test. During the iterations, user needs were analyzed and defined, ideas were developed and prototyped, to finally be evaluated. Over the course of the project, guidelines were developed and a final design was prototyped in order to exemplify the guidelines and answer the research question. The final set of guidelines is summarized in the list below:

G1. Indicate the context of what data is acted upon
G2. Aim for a non-intrusive presentation of actions
G3. Let the user focus on the data exploration workflow
G4. The actions presented should not overwhelm the user
G5. Provide an overview of all available actions for the selected data
G6. Consider a customizable set of actions
G7. Consider a scalable presentation of actions
G8. Avoid hiding information in the dashboard

For future work, more and richer evaluations would need to be carried out. The evaluations conducted throughout the project were formative, where users generally expressed a positive attitude towards the final design. To fully be able to understand the value of the design, summative evaluations would be needed. To conduct such evaluations, it requires a prototype that to a greater extent is interactive and a credible context where the user has a hypothesis they want to answer.

In addition, more research would be needed to consider all different concepts specific to The Software. However, The Company expressed gratitude towards the project and satisfaction with the outcome and design achieved. The final design was considered an improvement compared to the current workflow of acting on selected data. The Company also expressed a belief that the final design could act as a foundation and inspiration for future implementation in The Software.

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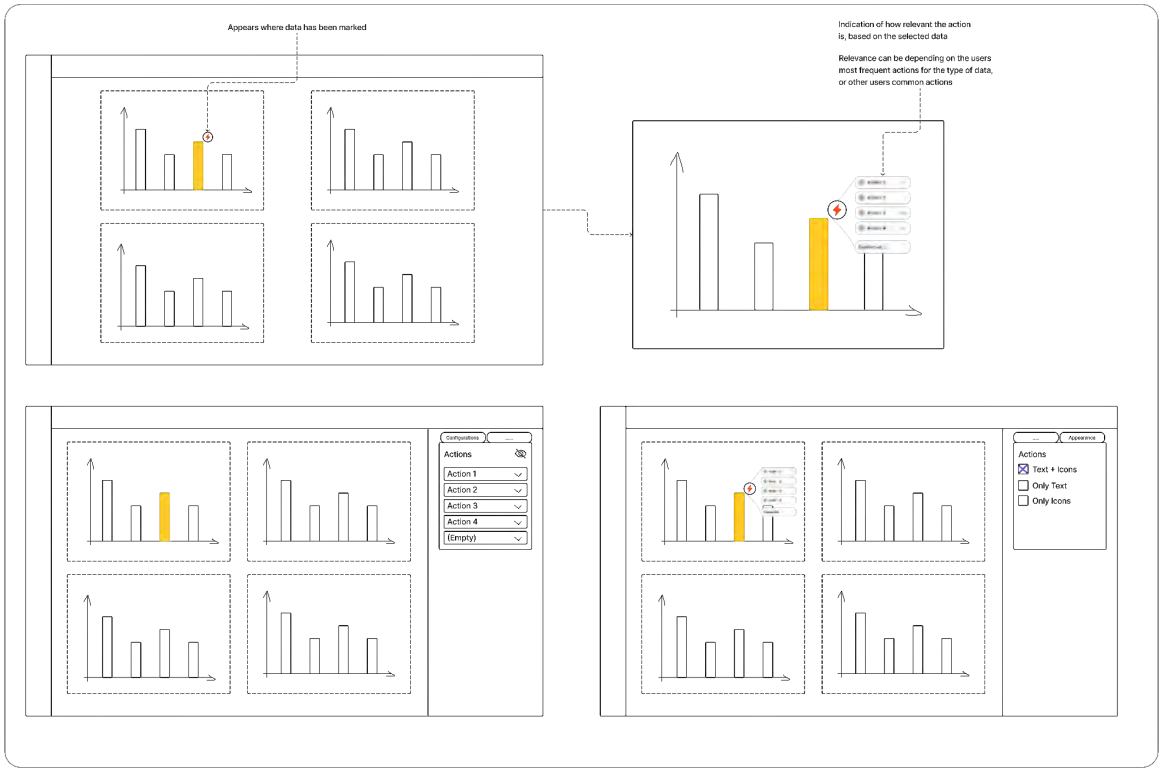
APPENDICES

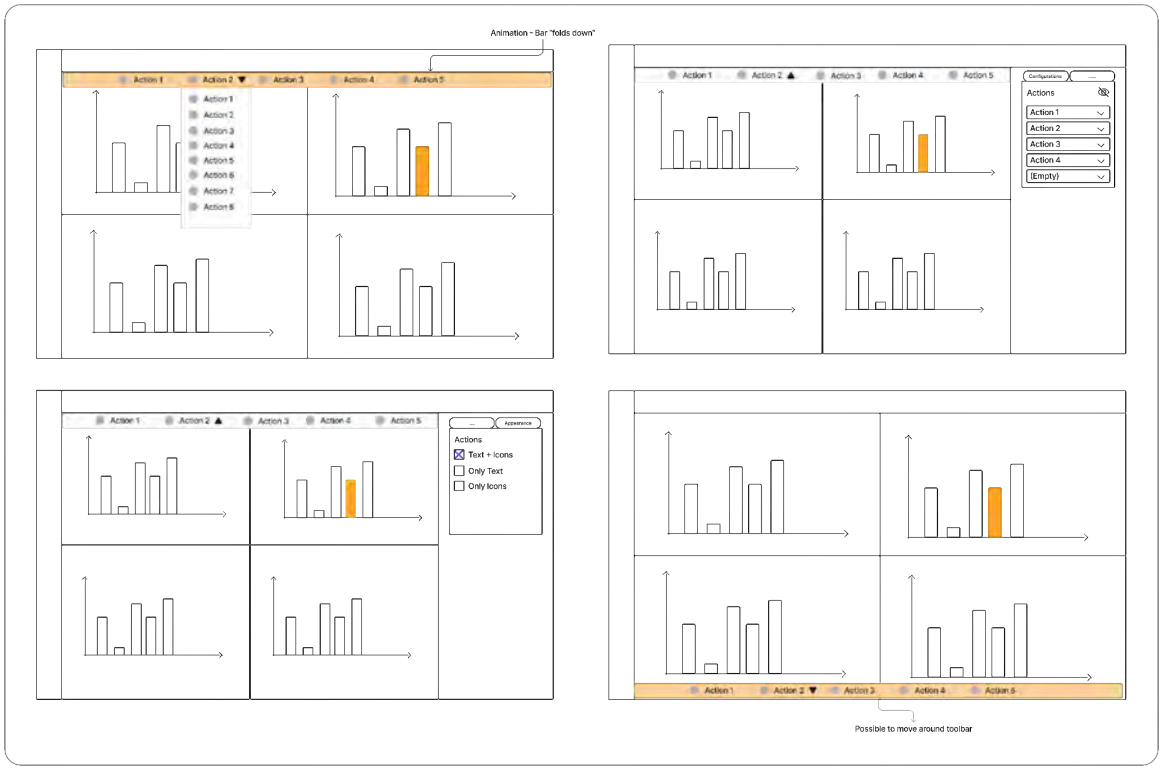
Appendix A - Wireframes of the 13 Concepts

Concept A



Concept B

Concept C

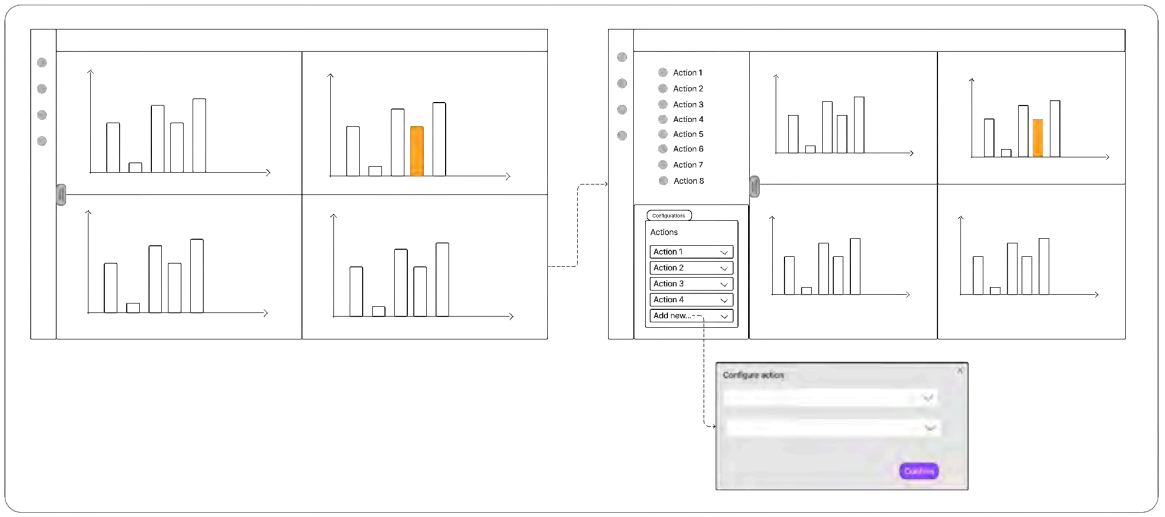


Concept D

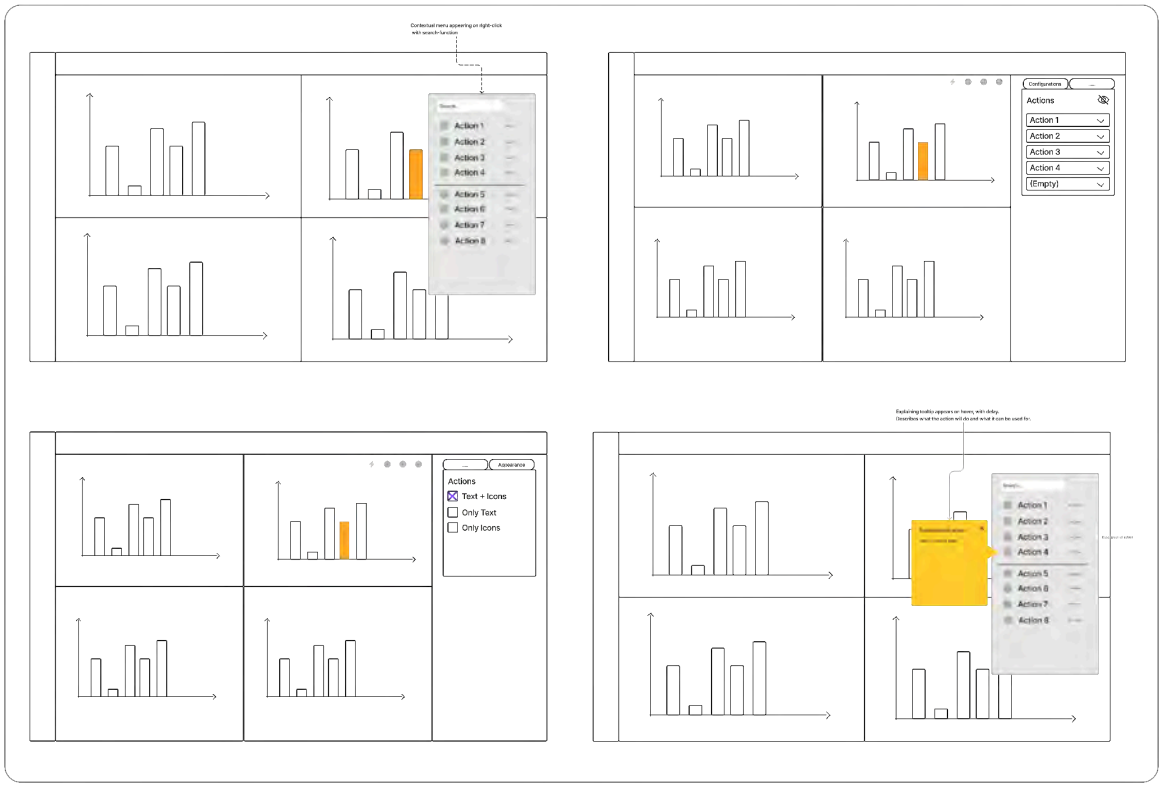
Concept E

Concept F

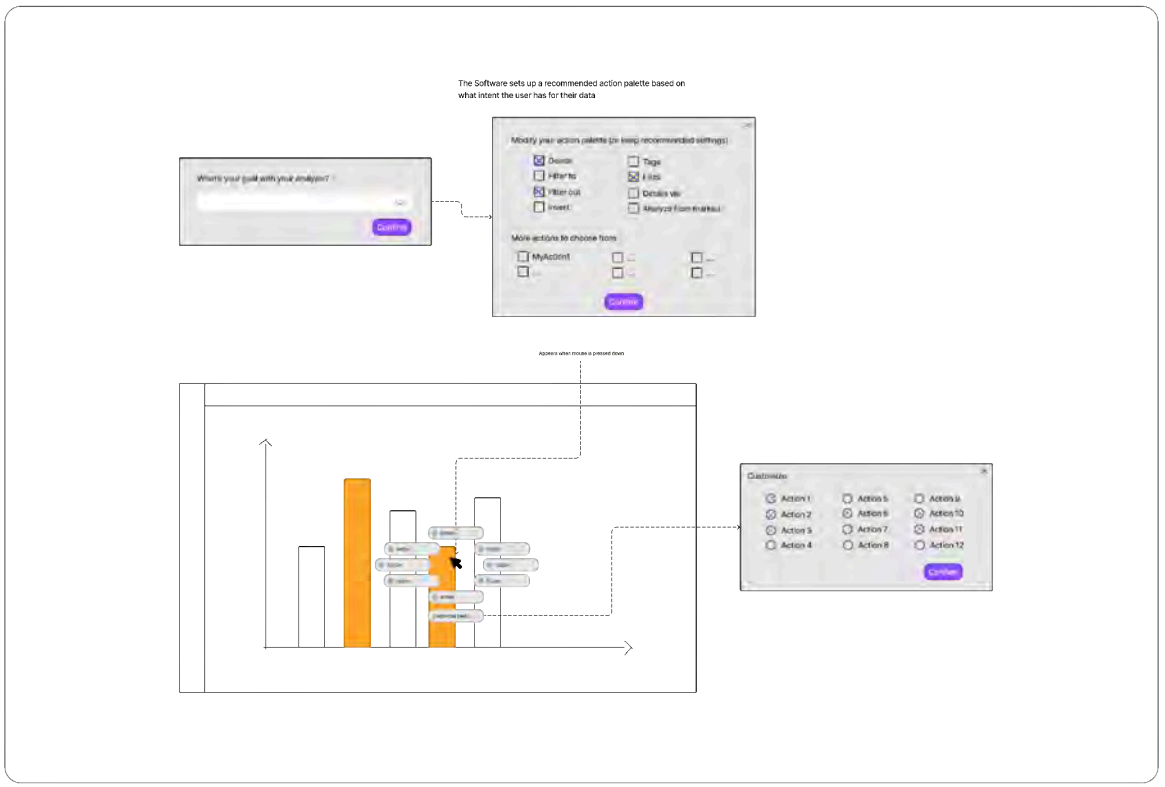
Concept G



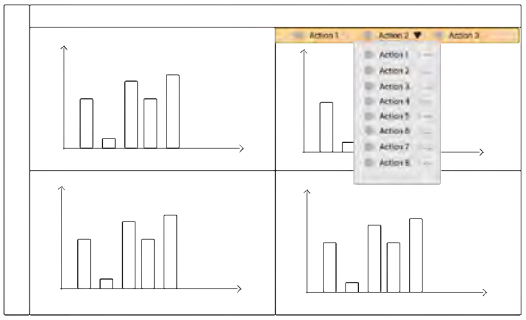
Concept H



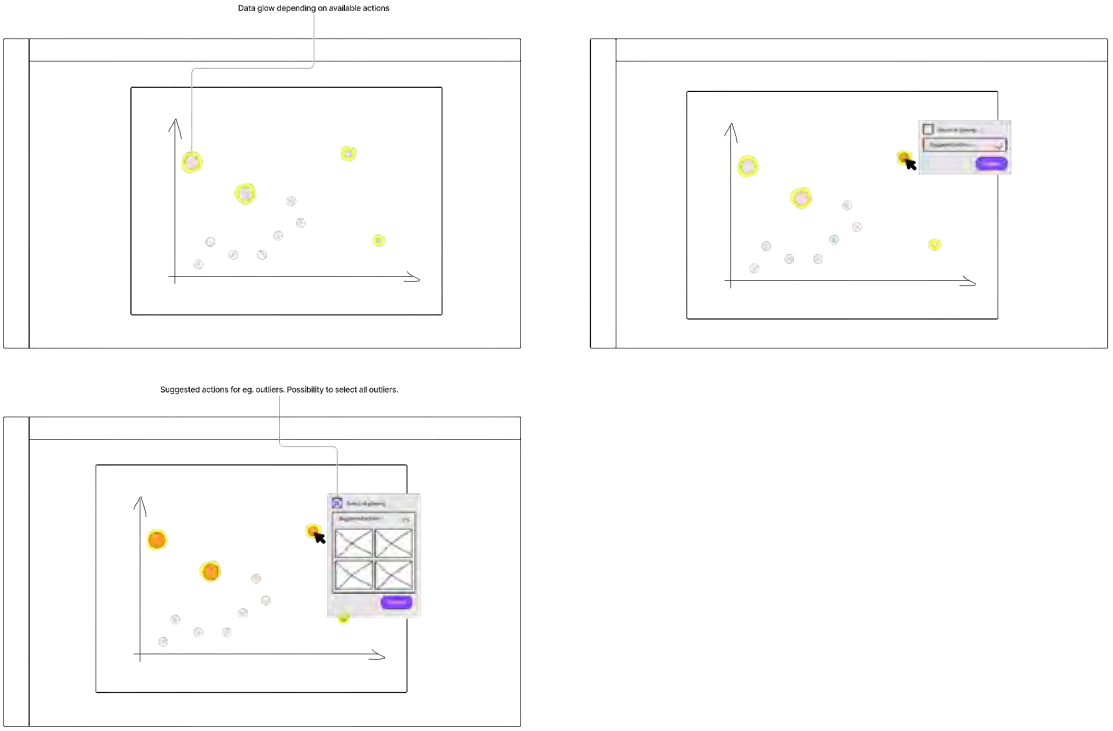
Concept I



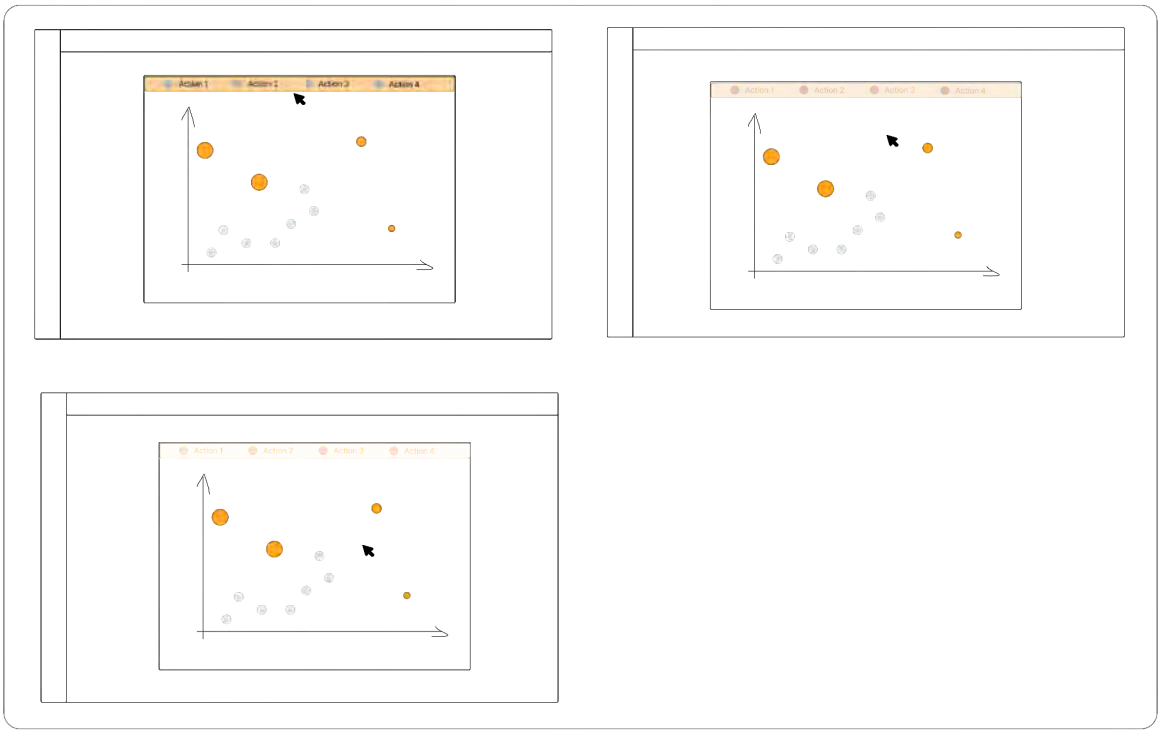
Concept J



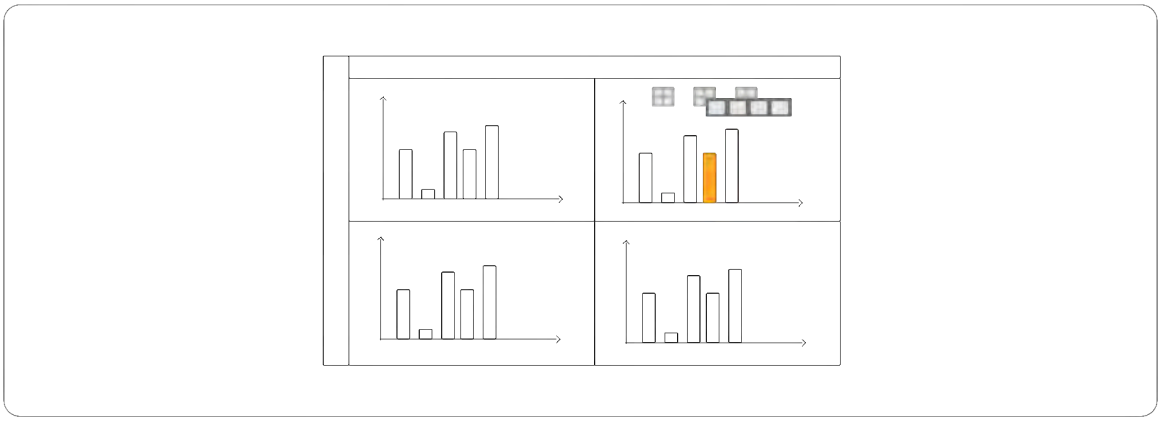
Concept K



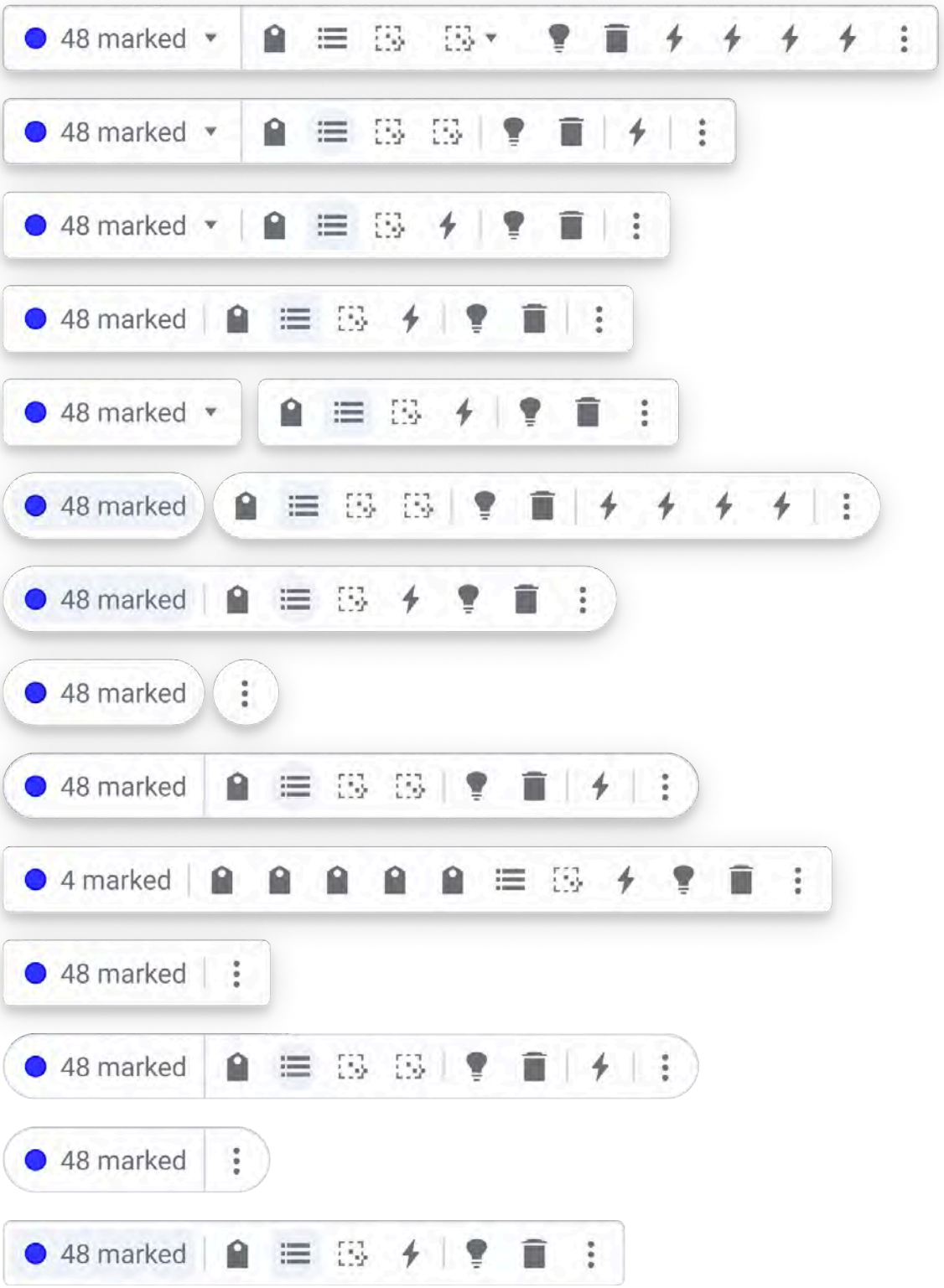
Concept L



Concept M



Appendix B - Different Versions of Toolbar



Appendix C - Final Test: UserTesting

Screener

1. Which of the following analytics tools do you use on at least a weekly basis?
    - Tableau, Qlik, PowerBI, Looker [Accept]
    - Google Analytics [Reject]
    - SAS, Matlab, Alteryx [Accept]
    - Python, R, other open source [Reject]
    - None of the above [Reject]

Scenario: Imagine that you are working as a data analyst for a marketing company, where you have been asked to analyze the sales and numbers for an international watch retailer. You have loaded the data into an analytics platform and set up some visualizations.

Note: the tasks in this test are performed using a prototype. The prototype is not fully interactive, and some things are not possible to click on.

Task: You decide to start exploring the data in the visualizations you have set up and in the horizontal Bar Chart you notice that Singapore has a very high profit compared to the other countries. Select Singapore by clicking on the bar, then continue to the next task.

Verbal response: How did you perceive the appearing toolbar and why do you think it appeared? Give a brief explanation.

Task: Please click on “41 marked” in the toolbar.

Verbal response: Did you expect ”41 marked” to be interactive, or were you surprised it was clickable?

Verbal response: The inspect popup will contain different information depending on the visualization type and what data has been selected. Do you think this type of information would help you understand your selected data and/or facilitate your data exploration?

Task: You notice 4 outliers in the scatter plot that have an average list price ABOVE 1800. Select these four by clicking on them, then continue to the next task.

Verbal response: Describe which actions can you perform using the toolbar.

Task: If you didn’t notice, the last icon in the toolbar is a “more” option. Change the color of the four selected outliers to red, using the “more” icon in the toolbar. When you are done, continue to the next task.

Verbal response: How did you perceive the workflow of finding an action in the “more” popup? If you did not manage to change the color, what was challenging?

Rating scale: How valuable do you think it would be to be able to customize which actions to include in the toolbar? [5-point Rating scale: Not at all valuable to Very valuable]

Task: Using the toolbar, create a new tag for the currently selected data in the scatter plot and name it "Good". Add it to the existing tag collection "Outliers". When you are done, move on to the next task.

Task: The new tag appeared in the panel on the left side of the screen. Close the panel by clicking the "X" button.

Verbal response: How did you perceive the process of tagging data?

Task: In the Category bar chart with five red bars, select "Sport" and delete it.

Verbal response: How do you perceive the scaled down version of the toolbar (presented when the visualizations are downsized in order not to cover any of the other visualizations)?

Rating scale 1-5: Overall, how well did the toolbar help you understand what data you acted upon? [5-point Rating scale: Not at all helpful to Very helpful]

Rating scale 1-5: Overall, what is your impression of interacting with the toolbar? Please give a brief motivation for your answer. [5-point Rating scale: Poor to Excellent]

Question: If you had a magic wand, what would you change about this solution?
Question: Do you have any other comments you'd like to share with us?

Appendix D - Final Test: The Company

Scenario: Imagine that you are working as a data analyst for a marketing company, where you have been asked to analyze the sales and numbers for an international watch retailer. You have loaded the data into an analytics platform and set up some visualizations.

Task: You decide to start exploring the data in the visualizations you have set up and in the horizontal Bar Chart you notice that Singapore has a very high profit compared to the other countries. Select Singapore by clicking on the bar.

Verbal response: How did you perceive the appearing toolbar?

Verbal response: Why do you think it says “41 marked” in the toolbar?

Task: Please click on “41 marked” in the toolbar.

Verbal response: Did you expect this part to be interactive or clickable? Why?

Verbal response: In the inspect popup, you can inspect the data you have selected and you can also toggle between different columns to compare the data and look at it from different perspectives. In what way do you think this might, or might not, help you understand your selected data and/or facilitate your data exploration?

Task: In this dashboard, the horizontal bar chart and the line chart are using the same marking, and since the visualizations are brushlinked data is also highlighted in the line chart when you select Singapore. Hover over the line chart, and then over some of the other visualizations that are not brushlinked.

Verbal response: How did you experience this feature of the toolbar appearing for brushlinked visualizations? Do you have any improvements or other suggestions for how to solve this?

Task: You notice 4 outliers in the scatter plot that have an average list price ABOVE 1800. Select these four by clicking on them.

Task: You are curious about these outliers so you click on “47 marked” to inspect them further.

Verbal response: How do you experience this version of the inspect popup? Would this information help you compare the different data points?

Verbal response: The idea is also to be able to copy the different values listed if you hover on a row. What do you think about this feature? Would you find it valuable?

Task: Change the color of the four selected outliers to red, using the toolbar.

Verbal response: How did you perceive the workflow of changing color? If you did not manage to change the color, what was challenging?

Verbal response: Now we have some questions about this more popup. This popup gives you recommendations based on your selected data and the visualization type and it allows you to search among all available actions. Do you find the more-popup intuitive or would you want the information to be presented in another way?

Verbal response: The idea is that you can customize the toolbar and that you can add any action as a shortcut in the toolbar. This can even be an external action or a custom action. What do you think about being able to customize and edit the toolbar?

Task: Using the toolbar, create a new tag for the currently selected data in the scatter plot and name it "Good". Add it to the existing tag collection "Outliers".

Task: Close the panel by clicking the "X" button.

Verbal response: How did you perceive the process of tagging data? Why?

Task: In the Category bar chart with five red bars, select "Sport" and delete it.

Verbal response: How did you perceive the scaled down version of the toolbar (presented when the visualizations are downsized in order not to cover any of the other visualizations)?

Rating scale 1-5: Overall, how well did the toolbar help you understand what data you acted upon? 1-5? (Not at all helpful to Very helpful)

Rating scale 1-5: Overall, what is your impression of interacting with the toolbar? 1-5? (Poor to Excellent)

Question: If you had a magic wand, what would you change about this solution?
Question: Do you have any other comments you'd like to share with us?