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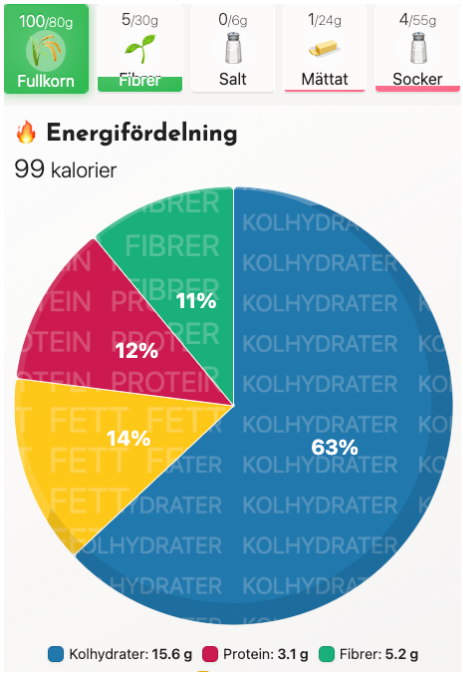




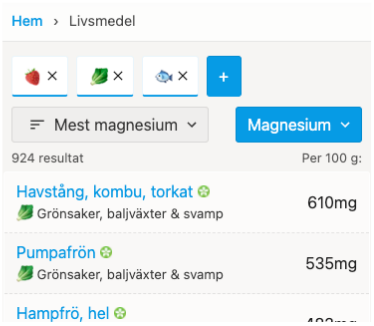


# Facilitating Engagement in Data-Driven Web Interfaces

An Exploratory Study on How to Balance Presentation and Interaction to Facilitate Engagement With Important Data

Master's thesis in Computer science and engineering

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Gothenburg, Sweden 2021

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Master's Thesis 2021
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## Abstract

Our data-driven society could benefit from more research focusing on making important information more engaging and accessible to more people. Both presentation and interactivity can be helpful in this regard, but it is not obvious how to balance the two. Furthermore, interactions today depend very much on technologies which continuously change and evolve, making it hard for designers to keep up. Responding to these challenges, a research-through-design process was conducted and a functioning web interface was developed. Relevant theory from various disciplines, such as information visualization and interface design, was considered and contextualized. Along with a functioning web interface, the outcome of this project includes important considerations and techniques helpful for future practitioners. In summary, facilitating engagement in data-driven web interfaces can benefit from considerations of: *technology*, *an iterative workflow*; and utilization of techniques involving: *dynamic queries*, *direct manipulation*, *entry points*, and *visual narratives*.

Keywords: Information visualization, interaction design, data-driven storytelling, interactive visualizations, data literacy, web interfaces, web technology

## Acknowledgements

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Oskar Lyrstrand, Gothenburg, June 2021

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# Glossary

**CSR** Client-Side Rendering. 18
**CSS** Cascading Style Sheets. 15, 17, 32, 53, 74

**D3** Data-Driven Documents. 18, 19, 32, 41, 53, 72, 74
**DOM** Document Object Model. 17

**FHM** Folkhälsomyndigheten. xiii, 5, 6, 33

**GBD** Global Burden of Disease. 33

**HTML** HyperText Markup Language. 17, 32, 53, 74

**LIVS** Livsmedelsverket. xiii, 5, 6, 7, 33
**LIVS-DB** Livsmedelsdatabasen. 33, 34, 39

**SSG** Static Site Generation. 18, 49, 66
**SSR** Server-Side Rendering. 18, 49

# 1
# Introduction

The enormous amount of data and information available today introduces new challenges in terms of interpretation. Visualizations pose great benefits in this regard, since they utilize the parallel powers of the visual cortex (Ware 2021, preface). Furthermore, complementing visualizations with interactions can significantly increase enjoyment, positive attitudes, and desirable behavioral intentions (Kirk et al. 2016, p.146; Yang & Shen 2018; Elmqvist et al., 2011). One challenge, in regards to visualizations, revolve around keeping our knowledge of best technological and theoretical practices up-to-date. Another challenge revolve around creating visualizations that accommodate for a broader audience (Lee et al. 2020).

Interactive visualizations are not effective and efficient in and of themselves. They can often be deceiving and, in our data-driven society, there is a tendency to privilege objectivity and rationality; often resulting in misinterpretation and exclusiveness of knowledge (Cairo 2019; Kennedy & Hill 2018). Instead, visualizers should focus more on inclusiveness and facilitating engagement. With data-driven storytelling, organizations and industries have started to take steps in this direction (Feigenbaum & Alamalhodaei 2020; Riche et al. 2018; Dykes 2019). Data-driven storytelling has the potential to connect to peoples experiences, and communicate data more effectively and efficiently. One main challenge in data-driven storytelling revolves around the balancing act of exploration and explanation.

Information about dietary habits is one area that could benefit from more authoritative information being made more accessible and engaging. In Sweden, unhealthy eating habits are one of the biggest risk factors for premature death and disease. At the same time, there is an increasing amount of information available on the topic, possibly causing confusion and leading to misinformed decisions. In fact, it has been indicated that health information of lower quality is often preferred over higher quality just because of it being easier to understand and more engaging; even when people know that the lower quality source is less reputable (Swire-Thompson & Lazer 2020). Clearly, this is an indication that we need to explore new ways of making high quality information more engaging and understandable to more people.

## 1.1 Aim and Research Question

The initial goal was to provide considerations of the balancing act of explanation and exploration in data-driven storytelling. However, data-driven storytelling is not the only technique with a potential to engage, and when building web interfaces specifically it can be beneficial to consider other things too. Interface design and web technology are two such examples that broadened the scope. Additionally, nudging and misinformation in

visualization were considered helpful in regard to ethical considerations.

In this project, explanation and exploration are synonymous with presentation and interactivity. Although the former combination of words is often used in data-driven storytelling, the latter combination of words might give a more clear indication of what the project is about. What is meant by *data-driven* in this project is explained in Section 1.1.3.

With the adjustment in scope, the goal became to better understand how elements of presentation and interaction, in general, can be combined to ethically accommodate a broader audience to engage with important data. The outcome of the project is a functioning web interface along with some gathered insights. More specifically, the goal became to contextualize and propose some theoretical and technical considerations, ultimately providing a toolbox for future practitioners:

## Research Question:

*What are some useful techniques and important considerations when balancing the act of presentation and interaction in data-driven web interfaces?*

### 1.1.1 Limitations

The design choice is never void of personal preference, and in this project both suggested considerations and techniques depend on them. However, any suggestions will be backed by theory and are based on takeaways from the process.

### 1.1.2 Delimitations

The project delimits itself to nutrition and a Swedish target audience (see Section 1.1.4). Furthermore, the project delimits itself to theory relating to information visualization, data-driven storytelling, web interfaces, nudging, and web technology. Generilizability of the results will be discussed in Chapter 9.

### 1.1.3 Data-Driven

The word *data-driven* can mean two things in this project: something based on data represented by numbers in large databases or tables, or something based on well-accepted research. For example, nutritional databases and guidelines will be utilized, providing either (close to raw) composition data or information based on scientific evidence. Data-driven is thus used to emphasize that the web interface is driven either by large databases, or authoritative information. Just to clarify, statistics and information from authoritative sources is not seen as data, but can still be seen as data-driven since they are based on data interpreted and analyzed by professionals. Any data or information (authoritative or not) must of course still be used with caution and carefulness (see Section 6.1).

### 1.1.4 Target Audience

The project attempts to make nutritional information more available and accessible to Swedish people in general. The target audience are Swedes because nutritional information differs between countries and the author is Swedish. *General people* refers to non-expert users, meaning people that are less knowledgeable than for example nutritionists and

health experts. The research community tends to focus on creating visualizations for expert users, whilst new insight and benefits could be gained from focusing on a broader audience (Lee et al. 2020). Making more people knowledgeable about authoritative and science-backed information (in this project specifically relating to food and health) can clearly be beneficial. Furthermore, this target audience is easier to come by and will make the user research more manageable. Ethical concerns regarding not including minorities as a consequence on a generalized audience will be discussed in Section 6.2.

## 1.2 Stakeholders

Making important data more available, accessible and engaging facilitates welfare and equality; and the hope is that the website can inspire Swedish citizens to explore and better understand information relating to dietary habits. Furthermore, the goal is to inspire more researchers to explore novel ways of making important data more available, accessible and engaging. Specifically, with the results of this thesis, developers and designers might gain a better overview of what to consider when trying to engage the user with important data in web interfaces. Ethical considerations and concerns will be discussed in Chapter 6 and Section 9.3.

## 1.3 Relevance to Interaction Design

In a way, this thesis argues that a deeper understanding of possible interactions can only be achieved through interaction with technology. In interface design, technology is what opens up for dynamic behaviours, and by interacting directly with these behaviours we can understand them in a way that we cannot when solely working with lower fidelities. We must, however, understand these things to know our possibilities and limitations.

It can be challenging to navigate the large landscape of technology. The hope is that this project can help in this regard. With a broad scope, insights can be helpful for interaction designers who want work more multidisciplinary. Or it can be helpful for interdisciplinary teams to understand the potentials and limitations within the team. Interaction designers can learn not only from working closer with technology, but also from borrowing techniques from other disciplines such as the data-journalism community or the InfoVis (Information Visualization) community.

# 2
# Background

In Sweden, unhealthy eating habits are one of the biggest risk factors for premature death and disease; and the covid-19 pandemic has made it clear how important it is to both prevent and promote healthier habits.[1] Surprisingly, there is limited efforts in educating the general public regarding some specific dietary risk factors that have been strongly linked with both death and disease. For instance, there is strong scientific evidence that fibre-rich foods decrease the risk of cardiovascular diseases, type-2 diabetes, and cancer; and there is strong evidence that high consumption of processed meat has the opposite effect (NNR 2014, p.21-22).

Rather than exploring ways of informing the public on these important topics (as a prevantative measure), most governmental responses focuses on policies, regulations, and qualified counselling to people who are already in risk groups.[2] Clearly, dietary habits are important and great benefits could come from a more well-informed society. Information about health should be accessible, clear, and usable for all; but extra focus should be put on "reaching and engaging the population groups disproportionately affected by low health literacy" (Nutbeam & Lloyd 2021). In other words, we need to explore ways of making more people (especially the less knowledgeable) engage with important health data.

When more efforts on educating the population are necessary, it seems questionable that so little focus is put on autonomy and allowing people to explore and educate themselves. Especially since there are great societal benefits to be gained from incorporating practical suggestions. As an example, if Swedish people adhered to the Nordic Nutritional Recommendations, a considerable number of lives could be prevented or delayed (Saha et al. 2019). By utilizing modern technology and novel visualization techniques that accommodate for a broader audience we can provide great practical impacts on peoples everyday lives (Lee et al. 2020). Furthermore, with techniques such as storytelling and interactive visualizations we have the potential to humanize information by making it more relatable, accessible and engaging (Alamalhodaei et al. (2020); Riche et al. 2018, p.260).

## 2.1 Official Information

Apart from in school, and in terms of counselling to people already in risk groups, there are limited preventative measures in terms of educating the public regarding dietary choices. Both FHM and LIVS have websites with dietary suggestions, but the information needs to be actively seeked out within their large websites. On top of this, the information provided

[1] https://www.regeringen.se/pressmeddelanden/2021/04/regeringsuppdrag-for-en-hallbar-och-halsosam-livsmedelskonsumtion

[2] https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/nationella-riktlinjer/2021-3-7328.pdf, 9

is arguably not that engaging (see Figure 2.1). LIVS also provide a nutritional database where users can access and search nutritional values for specific foods (see Figure 2.2). This information is probably not that useful for people who are not actively seeking out specific nutritional details, and there is very little focus on presentation.

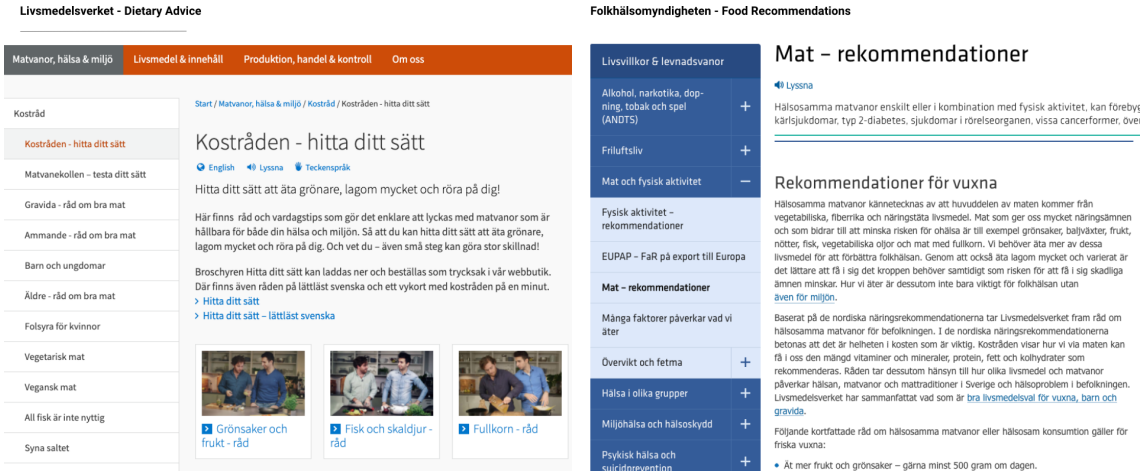


**Figure 2.1:** LIVS and FHM publish articles with dietary recommendations.

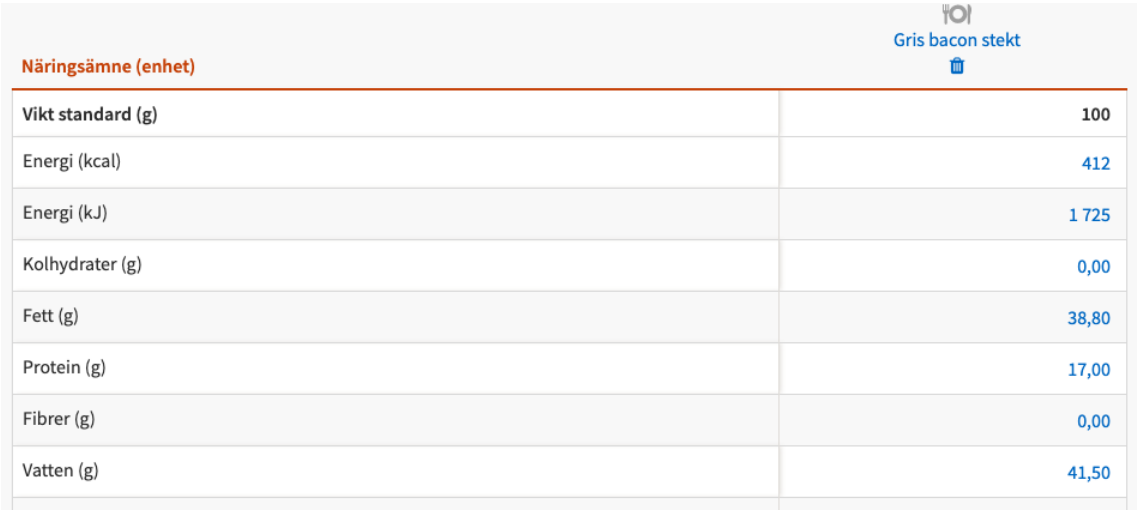


**Figure 2.2:** LIVS provide a nutritional food database, where nutritional information for specific foods can be explored.

Maybe most promisingly, LIVS provides an interactive tool called Matkollen where users can evaluate their dietary habits and get suggestions based on official dietary recommendations. The most recent version of the tool was released in 2019.[3] The tool is mobile-friendly and presents recommendations in a more attractive format. However, although it may seem as content depends on user input, a surprisingly small amount of the information is not personalized. Both the text displayed directly after user input, and the texts at the end of the interactive parts of the interface are mostly standardized. Furthermore,

[3]https://www.livsmedelsverket.se/matvanor-halsa--miljo/kostrad/mat-och-naring/matvanekollen-testa-ditt-satt-ett-smart-verktyg-i-halso-och-sjukvarden

the result always suggests: "Maybe you eat healthy, maybe you don't", and always links to the same articles with more textual information. In this instance, more exploration and interactivity could allow for more autonomy and playfulness; and ultimately increase the probability of longer engagement. Consequently, this could make people reflect more, have more to explore, and ultimately become more well-informed.

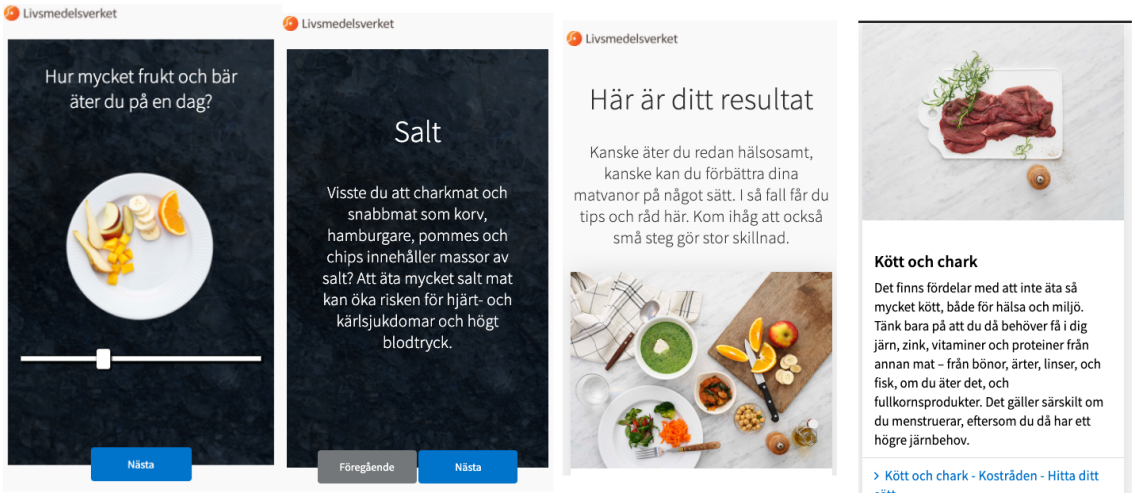


**Figure 2.3:** Matkollen (2019) is an interactive tool by Livsmedelsverket where users can explore what aspects of their diet is healthy or unhealthy.

## 2.2 Unofficial Information

If a Swedish person Googles "hälsosam mat" ("healthy foods"), they will probably be suggested articles or blog posts with information or recipes. Googling for nutritional recommendations will likely lead to a long article post with textual and tabular information on LIVS website. To explore nutrition related information in more depth, many people might also visit popular websites like Fatsecret or Matkalkyl (see Figure 2.4). Fatsecret provide a helpful tool for people who want to track their macro- and micronutritional intake, but (as the name clumsily suggests) they cater for people who want to loose weight. Matkalkyl similarly presents a lot of detailed information and numbers about nutritional composition. The disadvantage with Matkalkyl is that it focuses very little on both presentation and interactivity. It is simply an accummulation of all available information, without any filters, which is probably not relevant or interesting to most people.

Fatsecret caters mostly to people who want to loose weight and the information on Matkalkyl might be too detailed for most people to care about. Matkalkyl is one such example where developments in technology have been underutilized. It uses old visualizations that might resembles a PowerPoint presentation; a lot of blue text, which might confuse the user as to what is clickable; and it presents most information in tabular form. The only visual cues, indicating what is "good" or "bad", are red and green text colors. Furthermore, the website does not provide a mobile-version and mobile users have to use things like zooming and pinching to find what they are looking for.

There are some more modern mobile applications that also serve information about nutrition (see Figure 2.5). Most of these are similar to Fatsecret, since they focus on fitness and

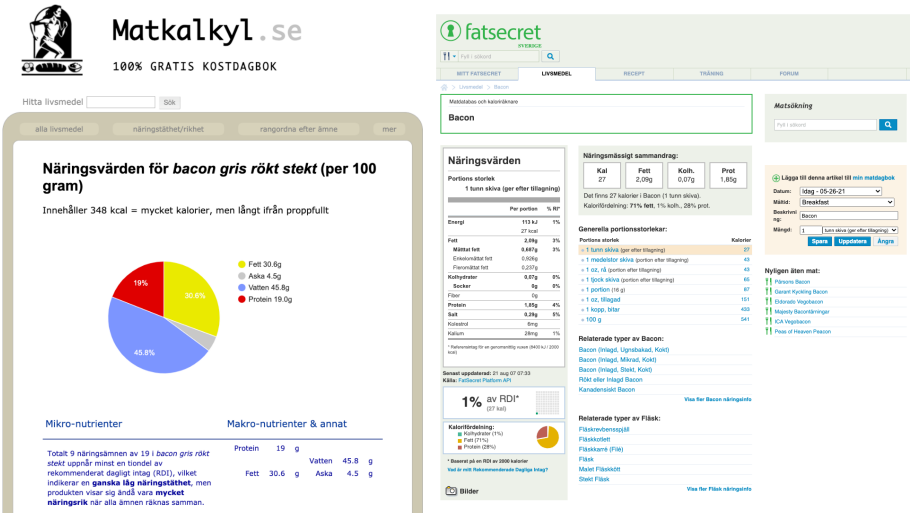


**Figure 2.4:** Matkalkyl and Fatsecret are two websites where users can explore nutritional values for different foods.

losing weight (rather than solely on nutrition). These apps are more expressive through utilization of colors, icons, and by way of structuring things. On their home page, they often present summaries of information that is relevant to the user. Additionally, they use progress-bars, emojis, and animated feedback; making the experience more enjoyable and making it feel more like playing a game. For two out of three of these apps you have to pay to get information about nutritional content, and in all apps the nutrients are seemingly not filtered out given any scientific research regarding recommended intake. For instance, the right most app in Figure 2.5 presents 77 nutrients, while NNR (2014) suggests that there are only around 20 nutritional recommendations that have relevance (enough backing) according to current scientific research.

All in all, current solutions either do not utilize important aspects of presentation and interaction, show too much irrelevant information, or they do not cater to a broader audience.

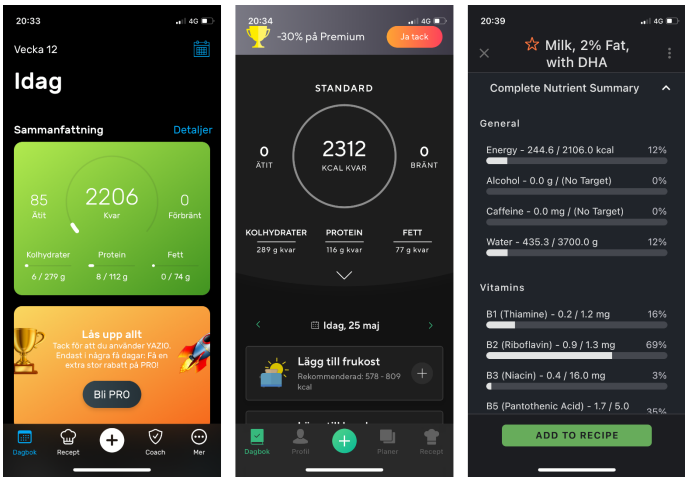


**Figure 2.5:** Three different mobile apps with nutritional information. Emphasis is often on caloric intake.

# 3
# Theory

Below theory relevant to this project will presented. All different aspects will be utilized in the later project in some shape or form. This chapter can therefore be thought of as a toolbox of useful techniques.

## 3.1 Information Visualization

Information visualization is an interdisciplinary study merging knowledge from many different fields including human-computer interaction, computer graphics, and psychology. The study relates to how the human cognitive capabilities can be utilized when visualising information. Visualizations can be helpful in comprehension of abstract or complex data, in the identification of patterns or emergent properties, and it allows us to utilize cognitive parallel processes of "enormous power" (Ware 2021, preface). Information visualizations can therefore be powerful for data analysts, to explore and discover new things, but they can also be useful when trying to present and communicate knowledge to a broader audience.

There are more qualities to visualizations than allowing for quicker processing. Tufte (1983) coined the term *Graphical Excellence*, Cairo (2012) talk about the *Functional Art*, and similarly Kirk (2016) talk about *Elegant Design*. In general, the consensus seems to be that a visualization should be precise, clear, and aesthetically pleasing while also being meaningful and purposeful to the observer. Below are some techniques that can help achieve these things, section 3.2 will further explore aspects of meaning and purpose.

### 3.1.1 Visual Attributes

Humans give different meanings to things based on how they look. As visualizers, we utilize visuals to communicate data properties or, in reverse, we *encode* data properties through visual representations. The ability to both create and consume visualizations is often referred to as *data literacy* (Kirk 2016, p.385). There are some common techniques, regarding both perception and psychology, that we can utilize in order to optimize data literacy.

For example, we can take advantage of gestalt laws (see Figure 3.1). Gestalt laws are concerned with how humans perceive visual patterns (Ware 2021, p.185-203). They present principles that are helpful for creating intuitive visualizations (and interfaces in general), helping the audience to efficiently and effectively get an understanding at a glance. For instance, *similarity* in shape and size, or if there are *connections* and *closures*, help the observer group and distinguish objects in a visualization.

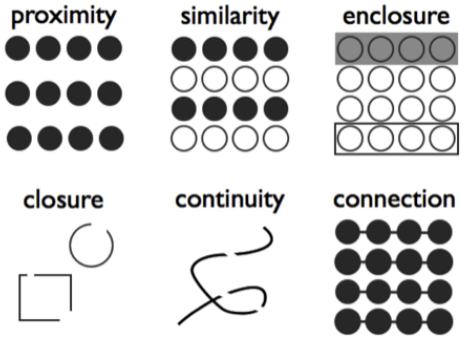


**Figure 3.1:** Gestalt laws concerns itself with how humans humans interpret patterns.

In addition to gestalt laws, there are other types of *visual encodings* worth considering. For instance, size, position, or color are all different means of communicating the properties of data. A large size circle can indicate a large number, and the positions of dots on a scatter plot can represent their different values. Furthermore, color-codings are often utilized on choropleth maps to communicate the relevant percentages of each region. Characteristics such as colors can also make visuals more emotionally loaded, this will be covered further in Section 3.2.3.

### 3.1.2 Charts

Charts are graphical presentations of data that often utilize a combination of visual attributes to convey something meaningful. For example, we might use lines, bars, or dots to represent trends, relationships, and characteristics of data. Charts are especially powerful in regard to big data, as they can convert thousands of rows of a table to one comprehensible representation. To help guide what charts might best suit our (and our audience) needs, we can take advantage of Andy Kirk's CHRTS taxonomy (see Figure 3.2). For instance, hierarchical data might be represented with a pie chart while a bubble chart might be better for presenting categorical data.

Most people learn to interpret some common charts like bar charts, line charts, and pie charts early in life. Still, they are often misinterpreted or misused (Cairo 2019, p.8-26). There are some suggested principles that we should be guided by when designing charts, not to risk misconstruing the representation of the underlying data. One rule is that bar charts should always start at zero, so that the length and height can be proportional to the underlying number (Cairo 2019, p.20). Another rule is not to use 3D pie charts (because they can be deceptive), and 2D pie charts should always sum to 100% (Kirk 2016, p.51).

**Summary:** Because most people understand them and they are often easy to implement, simple charts like pie, bar and line charts can be valuable. To pick the one that suits our needs we must consider what we try to convey. Furthermore, we should make sure that we do not create a false image.

### 3.1.3 Annotations

Text such as titles, labels, and descriptions are examples of *annotations* that compose a *scaffolding* for visualizations; providing context and clarity (Cairo (2019) 2019, p.35;

| Understanding Andy Kirk's CHRT(S) | | |
|---|---|---|
| **Type of Chart** | **What is it For?** | **Common Examples** |
| Categorical | Comparing categories and distributions of quantitative values | Bar chart, clustered bar chart, pictogram, bubble chart, spider diagram, polar chart, word cloud |
| Hierarchical | Revealing part-to-whole relationships and hierarchies | Pie chart, waffle chart, stacked bar chart, tree map, Venn diagram, dendogram, sunburst, |
| Relational | Exploring correlations and connections | Matrix chart, network diagram, Sankey diagram |
| Temporal | Plotting trends and intervals over time | Line chart, slope graph chart, area chart, horizon chart, GANTT chart |
| Spatial | Mapping spatial patterns through overlays and distortions | Heat map, proportional symbol map, dot map, flow map, area cartogram |

**Figure 3.2:** CHRTS provide a taxonomy, helping designers in determine what type of chart is best for their data. Image courtesy of Feigenbaum & Alamalhodaei (2020)

Kirk et al. 2016, p.123). Without annotations, the observer might not be able to fully comprehend a visualization and the likelihood for misinterpretations increase. Sometimes text can be a even more efficient way of communicating than visuals. For instance, the logical structure of natural language are built upon words like *if*, *else*, *probably*, and *unlikely*. Interpretation of such logic are often naturally deduced through speech and written language; while having to infer such logic through, for example, a flowchart will require more cognitive work (Ware 2021, p.334-336).

Annotations are a way to take care of our audience by guiding and assisting them through their journey (Kirk et al. 2016, p.123). When we use annotations, we should carefully consider what part of the interface is in need of additional explanation, and we make sure to be clear and concise in our descriptions. Especially on mobile, too much text can clutter up screen space, cause frustration, and throw people of; while a small amount of carefully crafted text can facilitate for effortless understanding (Krug 2014, p.38-39).

**In summary:** Text can complement visuals and give clarity and context, they should be used to guide and assist. Titles and names should be well-chosen and descriptions well-crafted.

### 3.1.4 Interaction

Interactive visualizations can empower people to explore and engage with data in a way that static images cannot. Thoughtfully conceived interactivity do not only broaden the depth of the visualization, but can also create a sense of fun and playfulness (Kirk 2016, p.277). Interaction combined with animation can facilitate similar experiences as of games. However, interaction should be meaningful not to cause confusion or frustration, and it is important that we do not "succumb" to the belief that the visualization is a chance to "showcase" our "technical competence" (Kirk et al. 2016, p.20). Interactive features should always have clear purposes, and help users achieve their goals.

Two examples of useful interactions, according to Ware (2021), are *drill down* and *dynamic*

*queries*. Drill down actions allow users to explore nodes of an interface, to expand and reveal more information. These interactions should be implemented with as much *information scent* as possible, meaning they should communicate the outcome of interaction. Any extra step in navigation to reach the end goal is a direct *cost of knowledge*. Dynamic queries are useful for multidimensional datasets and can help users filter and sort out the range of what is being displayed. To facilitate the users cognitive abilities we must strive to create quick and responsive interfaces.

Furthermore we should try to be inclusive and create accessible tools, independent of expertize. One suggested way to do this is by utilizing *fluid interactions* (Elmqvist et al. 2011). Fluidity refers to smooth and seamless, but powerful and responsive. Fluid interaction lets the user feel like one with the system and promotes the psychological concept of "flow". A fluid interface can promote flow by, for example, having "balance of challenge", be "intrinsically rewarding" to use, and immediately "prompt feedback" (Elmqvist et al. 2011). Secondly, the interface can be fluid using *direct manipulation* through immediate, incremental, reversible actions. Lastly, fluid interfaces should try to "minimize the gulfs of action" by matching the systems state and action with the users perception and intention.

## 3.2 Data-Driven Storytelling

Storytelling in information visualization became a topic of research not long after it was popularized by news media outlets. Combined with the technological evolution, storytelling had the potential to ”reveal information as effectively and intuitively as if the viewer were watching a movie” (Gershon & Page 2001). In general, data-driven storytelling is an attempt to create meaningful visualizations by utilizing a combination of the ancient art of storytelling with the powers of modern technologies.

In the wild, data-driven storytelling is a practice "highly interdisciplinary and collaborative" (Riche et al. 2018, p.185-209). In an optimal scenario, a team of data analysists, designers, developers, and publishers come together to create important visualizations. However, teams often become cross-disciplinary since there are tight relationships between, for instance, technology and design. Hence, knowledge from various disciplines is necessary in order to create data-driven stories, and teams must work closely and in a tight dialogue to achieve optimal outcome.

### 3.2.1 Story Structure

There are many popular structures that can help us understand how a story can be composed. Aristotle's *tragedy structure* suggests that stories should have a beginning, middle, and end and that an introduced complication is followed by unraveling (Dykes 2019, p.187). *Freytag's pyramid* (or *the narrative arc*) builds upon the tragedy structure and suggests that tension is slowly built up until a point of climax where tension is then slowly decreasing (see Figure 3.3). These are two of the most common structures that are abstracted enough to fit most story structures, but there are other popular ones such as the *the hero's journey* where more emphasis is on a main characters.

### 3.2.2 Narrative Patterns

Stories in visualizations might not look exactly like the conventional stories. Segel & Heer (2010) carried out a rigorous case study to analyze and identify the characteristics of 58

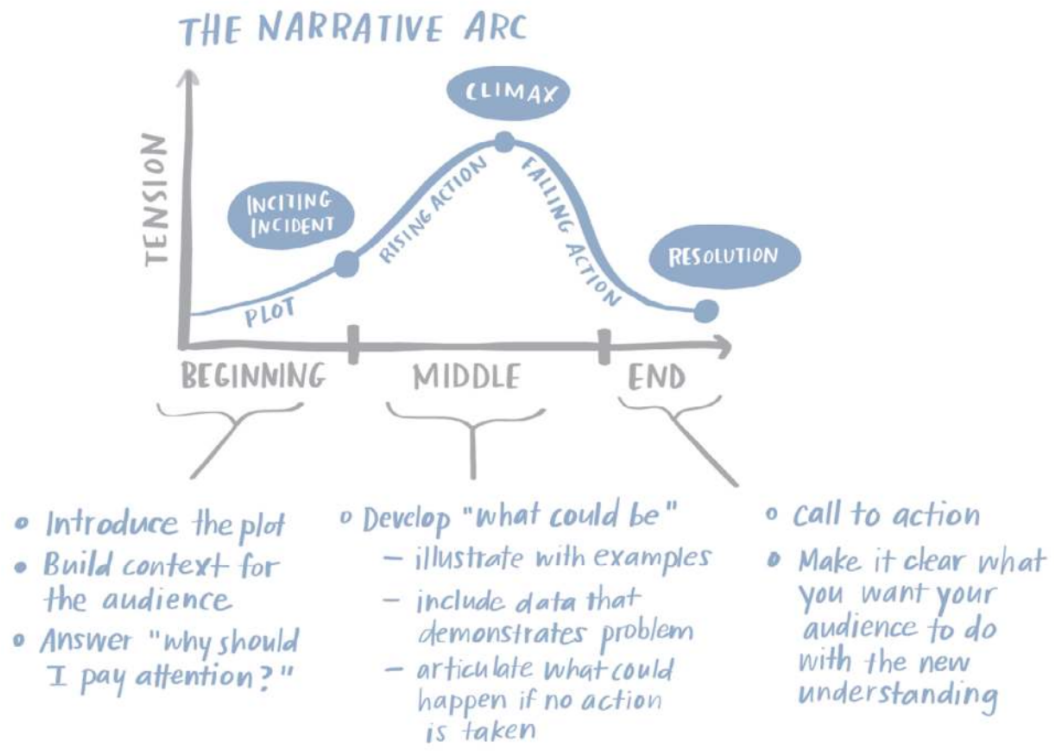


**Figure 3.3:** A story often has a beginning middle and an end, and to engage the audience tension and rising/falling action are key. Image courtesy of (Knaflic 2019).

(what they then called) *narrative visualizations*. Among some other things, they identified that most narrative visualizations utilize one (or a combination) of *seven genres* (see Figure 3.4); and any visualization can be mapped onto a *author- vs reader-driven* spectrum (see Figure 3.5). This means, as the name suggests, that either a story is more narrated by the author or more open to exploration by the reader.

Segel & Heer (2010) also talk about three different patterns of incorporating interaction in data stories: *Martini Glass Structure*, *Interactive Slideshow*, *Drill-Down Story*. Except for the martini glass structure, the names speak for themselves (see Section 3.1.4 regarding drill-down). In the Martini Glass Structure the user is presented with a broad introduction (the bottom of the glass), which then narrows down to a particular point and ends by opening up for user exploration and interaction.

### 3.2.3 Visual Narratives

Aesthetics, color, and iconography plays "an integral part of data communication" and can "powerfully shape audience perception" (Alamalhodaei et al. 2020). Furthermore, symbols and icons are often used in infographics and can function as a pedagogical help. They can have a way of inducing strong emotional responses in the observer. For example, think of a hand pointing towards a clock and how that image probably causes more feeling of urgency than the text "the time is running out". This could be emphasized further with the use of motion.

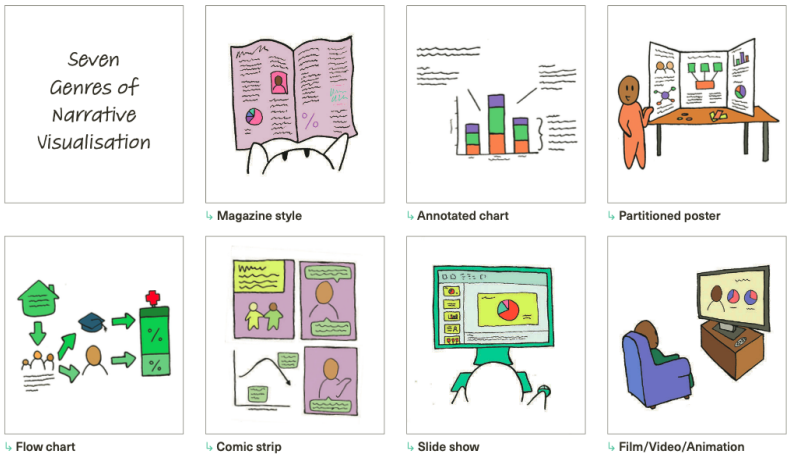


**Figure 3.4:** According to Segel & Heer (2010) there are seven different genres of narrative visualizations: magazine style, annotate chart, partitioned poster, flow chart, comic strip, slide show and film/video/animation. Image courtesy of Feigenbaum & Alamalhodaei (2020).

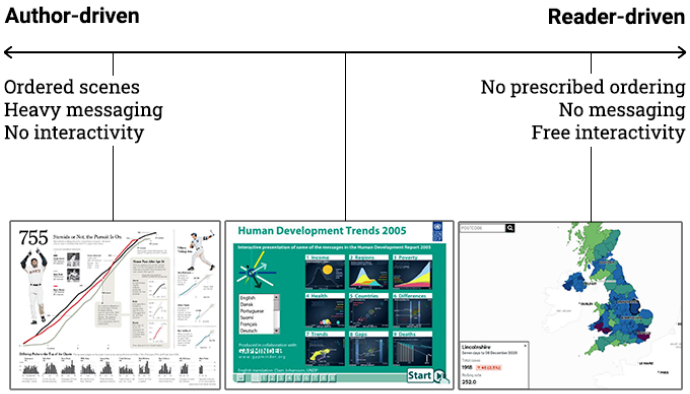


**Figure 3.5:** The spectrum of author- vs reader-driven approach. A visualization that utilize more narrative techniques reside further on the left while a visualization that allow for more interactivity reside on the right.

Feigenbaum & Alamalhodaei (2020) explains two key principles that should be considered when using symbols: they should be *resonant* and *relevant* (see Figure 3.6). A symbol is resonant if the audience instantly understand its meaning and it is relevant if it matches the expectations, or mental model, of the audience. Unicode[1] is an industry standard of how computers should handle text and today it provides emojis with respective representations on most devices.

Color is an useful in explaining the properties of objects powerful and they can be used as a means of guiding the users attention (Ware 2021). Colors also have emotional significance, humans relate different colors to different attributes such as cold, warmth, growth and health. Colors can thus be used both to emphasize important aspects of a visual, but also as a means of conveying and invoking emotion. We should always consider the different significance colors can have in different cultures, because the underlying meaning is often

[1] https://home.unicode.org/basic-info/overview/

**Figure 3.6:** The symbol on the right is probably more *resonant* to most, since it can quickly be interpreted, while the symbol on the left might be a bit unclear. Both of the symbols are not *relevant* if the observer is unfamiliar with wheelchairs and hiking. Image courtesy of Feigenbaum & Alamalhodaei (2020).

multifaceted. For example, red is often used in interfaces as way to indicate something gone wrong (like a red sign) and green as something done right. Green is however poisonous in China and represents death, and consider how red also represents love.

## 3.3 Web Interfaces

The web has become the main source of information for people and today there are alot of capabilities that we can utilize in order to create engaging interactive interfaces. Additionally, there are some important things we should consider, in order to both engage and retain visitors.

### 3.3.1 Mobile Interfaces

Most of the internet users today are mobile users.[2] As Tidwell (2020) puts it "designing for mobile is not just good design practice or a practical business concern, it's common sense". This is why concepts like *mobile-first* and *resposive-design* have become both important and popular. Desktop users and mobile users are not often not the same type of users, but it is important that we cater for both of them.

If we have grids or tables on our website, we should make sure that the are accessible to mobile too. This can be done using *media queries* in CSS (Cascading Style Sheets). For instance, we can make it so that a grid of cells on a computer transforms into a row of cells on mobile. Furthermore, because of the much smaller screen sizes it is often also recommended to hide some of the content for mobile, so that only the most essential stuff is displayed (Tidwell 2020, p.299).

### 3.3.2 Navigation and Wayfinding

A typical web application will have a multitude of pages. This is a helpful thing because it lets developers and designers provide a multitude of information on-demand. The challenge is making it easy for users to find the information they are seeking. *Primary navigation* is a way for users to explore the primary content of the website, and *top navigation* is often the superior approach (Cooper et al. 2014, p.572). If the potential users include mobile users, then it is important to carefully consider what to include in the primary navigation not to take up valuable space.

[2]https://gs.statcounter.com/platform-market-share/desktop-mobile-tablet

Breadcrumbs is another popular means of navigation that helps the user speed up their navigation and exploration. It facilitates users in reaching lateral pages and helps reveal the underlying hierarchies and relationships. Breadcrumbs should use ">" between levels and be at the top (Krug 2014, p.167).

### 3.3.3 Performance

Another important concern in regard to web interfaces, especially in considiration of mobile users, is to optimize performance. Performance is about retaining users, but it is also about the general consideration of people and their experiences.[3] Slow loading steals time, frustrates people, and will often make them choose another website.

Google have introduced what they call *Core Web Vitals*, which is a collection of three important metrics that relate to ultimately user experience: *loading*, *interactivity*, and *visual stability*. In fact, all of these relate to different aspects of speed and loading time. The first is concerned with how long it takes to load the interface, the next how long until users can interact, and the third regards how much the layout *jumps around* during loading.

Core Web Vitals are the subset of Web Vitals that apply to all web pages, should be measured by all site owners, and will be surfaced across all Google tools. Each of the Core Web Vitals represents a distinct facet of the user experience, is measurable in the field, and reflects the real-world experience of a critical user-centric outcome.
If visitors have to wait for too long for a page to load, they will simply go somewhere else.

### 3.3.4 Animation

Animation can be utilized to seamlessly transition a page from one state to another. It can also be used to indicate and give feedback to the user on input; effects that are popular and useful for mobile applications (Tidwell 2020, p.202). When done correctly, animations can improve upon the users awareness by boosting liveliness of the interface and the users sense of immersion. Animations should be immediate rather than delayed, not too long, and combinations of animations should be done in parallel rather than sequentially (Tidwell 2020, p.205).

Moving objects utilize another perceptive channel in the brain than static objects, a viewer can easily choose to focus on or ignore an animated layer (Ware 2021, p.204). However, we have to be careful not to overdo it, since overdoing animation can cause motion sickness and frustration. Animations and transitions should have a rhytmic quality that enhances the users sense of awareness by guiding their attention and helping them anticipate what is coming (Cooper et al. 2014, p.267-268).

### 3.3.5 Direct Manipulation

According to Shneiderman (1993), *direct manipulation* provide a satisfying experience to users by making the functionality of an interface more transparent and intuitive. As the name suggests, direct manipulation means that things on the screen can be directly manipulated. For example, whenever input fields are modified the interface immediately updates accordingly, rather than (for example) navigating the user to a new page. Real-time feedback on state changes facilitates situational awareness, mastery and enjoyment (among

[3] https://web.dev/why-speed-matters/

many other things) (Shneiderman 1997; Jones & Endsley 2000); but have also gained popularity in modern mobile interfaces as a means to utilize hand gestures and minimize complexity (Tidwell 2020, p.382). In order to better demonstrate the direct manipulations, animations and transitions can certainly be helpful. Transitions and animations allow us to demonstrate changes frame by frame, like a movie, rather than abruptly "jumping" from one state to another.

### 3.3.6 Dynamic Queries

Dynamic queries are often mentioned in both interface design and information visualization as a means of adding easy-to-use controls that encourages users to explore data sets on their own (Tidwell 2020, p.466; Ware 2021, p.387). A dynamic query is a type of method where users can filter out relevant data by changing settings through, for instance, sliders or checkboxes. Dynamic queries are intuitive, easy to learn, and they provide quick feedback which consequently makes the user exploration more seamless (Tidwell 2020, p.456). With dynamic queries, the number of pages can be minimized and thus the number of steps to identify any specific data point can be decreased. Rather than having separate views for different subsets of the data, the whole data set can be presented at once and subsets can conveniently be filtered out.

## 3.4 Nudging

Nudging is a way to support peoples decision making by, for example, facilitating reflection or through manipulation (Caraban et al. 2019). Though some types of nudging can be seen as directly unethical, nudging might also be "required on ethical grounds" when it comes to welfare (Sunstein 2015). Arguably, the most ethical nudges are those that are transparent and facilitates reflection rather than being manipulative. (Caraban et al. 2019) contribute a diagram that positions some nudges according to these parameters (see Figure 3.7).

Just because a nudging technique is transparent and reflective does not mean that it is ethical. For instance, we can *facilitate* user action by, *suggesting alternatives*, but we must carefully consider what those alternatives are. On the other hand, we might have to *hide* information not to overwhelm novice users, and we might be morally obliged to *remind the consequences*.

## 3.5 Web Technology

The debut of JavaScript in 1996 made the web go from static to dynamic, and visitors could start to *do things* as opposed to only *read things* (MDN Web Docs 2021). Today 95% of all websites use JavaScript, and major updates (most recently ES6) makes the language grow stronger. Together with HTML (HyperText Markup Language) and CSS, JavaScript makes up the *web standards model*. To make the development manageable, maintainable, and scalable it has become popular to use *frameworks*. One very helpful aspects about frameworks is that they make it easier for developers to manipulate the DOM (Document Object Model), and changes in code automatically updates/demonstrates the web page. React is currently the most popular framework, and it was released by Facebook.

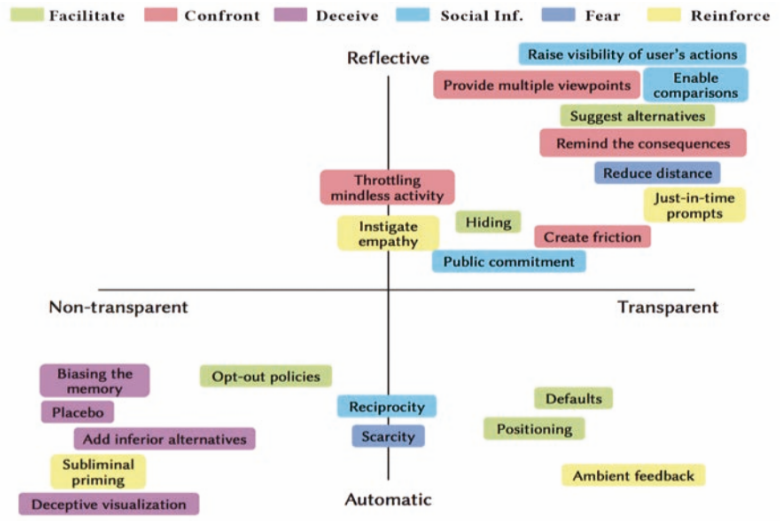


**Figure 3.7:** Nudging techniques presented on a x- and y-axis of reflective vs automatic, and non-transparent vs transparent. Image courtesy of Caraban et al. (2019)

### 3.5.1 Client- Versus Server-Side

Most often, CSR (Client-Side Rendering) is utilized in JavaScript applications, making the client responsible for compiling the code. This puts requirements on the users device, consequently affecting performance. It also makes it harder for search engines to do their job, something that (in addition to performance issues) will affect search engine ranking. In response, something called SSR (Server-Side Rendering) has become popular. SSR lets a server, not the client, build the pages as they are being requested by the user. SSG (Static Site Generation) works similarly, but takes the performance to an even higher level. With SSG all pages have been pre-rendered and prepared prior to any user request, as opposed to SSR which does the rendering *upon* request. SSG and SSR are also more secure, since there are almost no way of attacking pages that are not dependant on anything from the outside (users hold everything locally).

One disadvantage with SSG is that, since all pages have to be pre-rendered, no new pages can be made or requested by the user. For instance, if there are combinations of filters then all of those combinations have to be pre-rendered. This is simply too many pages. The alternative would be that the client handles the filtering functionality, but that means that the client maintains all items to be filtered. This is one example when SSR is more advantageous. Since pages are built upon request, the user can request whatever they like and the server adjusts, and serves the relevant result.

### 3.5.2 Visualization Libraries

D3 (Data-Driven Documents) is the most powerful visualization tool for the web. D3 is written in JavaScript but it can take some time to master but allows for full customizability and can therefore be seamlessly integrated into web interfaces. Chart.js is another example of a visualization library that requires less of a learning curve than D3. It comes with prebuilt visualizations and the developer simply have to choose the ones of their liking and inject the appropriate data. Though there are ways to customize the appearance in

Chart.js it is not as customizable as D3. It is simply less powerful and harder to integrate with other components in general.

# 4
# Methodology

There are many relevant to consider for this project, and in this chapter some of them are presented. Not all of them will be utilized in the actual process, and some of them might be combined in order to fit the context of this project.

## 4.1 Research Through Design

Through a careful and reflective practice, this thesis aims to contextualize current and relevant research in a novel and practical context. In doing so, it follows a *research through design* approach, with the end goal of contributing new knowledge and understanding through practice.

Throughout the 20th century debates were held regarding what it means to be a designer and how much the activity of designing should be done in a scientific manner (Cross 1982). Schön meant that many problems designers face are often not well defined and cannot be rationalized or made scientific. He instead proposed a reflective practice since designing often introduces new, interdisciplinary challenges. With new technologies and materials designers must find new ways of interacting. As designers, we should "reflect on the appropriate ways to pursue our research on its own terms", rather than focusing on seeming scientific (Gaver 2012). Furthermore, Gaver (2012) suggests that new artifacts and annotated portfolios can be valuable contributions to inspire further research.

## 4.2 Processes

### 4.2.1 The Double Diamond

*The Double Diamond* is a visual representation of the design process (Design Council 2015). It follows an iterative process of divergence and convergence, that is, an alternation between exploration and narrowing down. The process consists of four steps, but the framework also consists of some core principles and suggested methods (see Figure 4.1). Ultimately The Double Diamond is a high-level framework that can inspire, rather than impose, an innovative design process.

### 4.2.2 Goal-Directed Approach

The *Goal-Directed Approach* revolve around the goal and purpose of the final artifact, which should be based on the needs and goals of the user (Cooper et al. 2014, p.3). For visualizers, this can be a useful approach, not to get get lost in biases and assumptions. Furthermore, it can be useful in terms of evaluating feasibility and thus resulting in a more cost-beneficial process (see Figure 4.2).

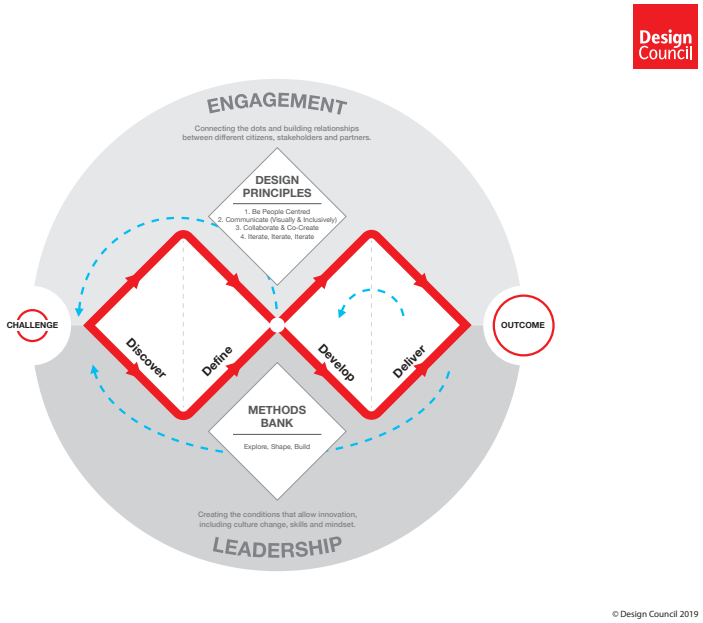


**Figure 4.1:** The Double Diamond follows an iterative process of divergence and convergence. Image courtesy of Design Council.

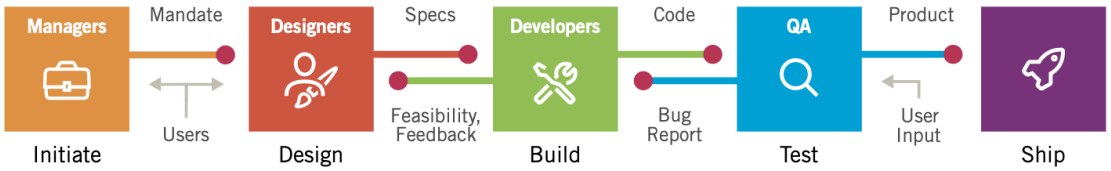


**Figure 4.2:** A figure of the Goal-Directed Approach. Stakeholders are invited early on, programmers and designers collaborate to meet the user needs and end-users are then re-invited to validate the product. Image courtesy of (Cooper et al. 2014)

### 4.2.3 Data Visualization Process

In the most recent version of "Information Visualization: Perception of Design" Ware (2021) explain the abstract process of *designing cognitively efficient visualizations*. The process involves seven basic steps:

1. A High-Level Cognitive Task Description
2. A Data Inventory
3. Cognitive Task Requirements Analysis
4. The Identification of Visualization Types
5. The Identification and Choice of Cognitively Efficient Interaction Methods
6. Prototyping and Application
7. Evaluation

The process starts out by exploring the problem and defining overarching goals, followed by collecting of data. With an understanding of the data, more specific, important questions start to shape and we can start to consider visual representations. We also consider what type of interactions that can be helpful and start the development. Lastly, the visualization

is evaluated and reiterations of steps necessary for improvement occur.

### 4.2.4 Data-Driven Storytelling Process

Like most processes, data-driven storytelling process is rarely linear, and can consist of many iterations. Generally, this process is composed of three steps: exploring data, making a story and telling a story (see Figure 4.3).

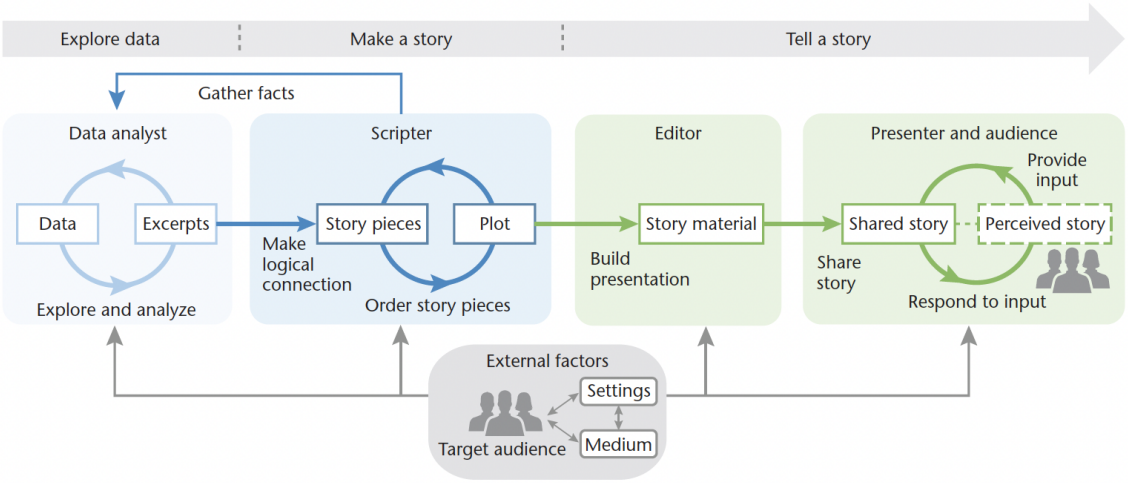


**Figure 4.3:** The high-level process of storytelling consists of three steps: exploring data, making a story and telling a story (Lee et al. 2015)

## 4.3 Methods

### 4.3.1 Questionnaires

Questionnaires are a way of collecting data about potential users, both in terms of their characteristics and their opinions (Rogers et al. 2019, p.278). A questionnaire that is clear to participants, while producing results that can be analyzed, requires skill and effort; but can allow new insights and a diversity of opinions to shine through. A combination of open-ended questions and subjective measurements can be useful to get both categorical as well as more opinionated answers. Furthermore, Likert and semantic differential scales can be useful for comparing different attitudes in regards to specific statements (Rogers et al. 2019, p.280).

### 4.3.2 Interviews & Observations

Another way to gain insight of our users is with interviews. A clear advantage is the direct contact (Rogers et al. 2019), which lets us better understand motivations of the users through a more personal connection. Early interviews tend to be broad and contain open-ended questions with less details on specficis, since they are often exploratory in nature (Cooper et al. 2014, p.50). Furthermore, unstructured interviews can generate rich ideas and invite thoughts that the designer has not previously thought of (Rogers et al. 2019, p.268-269).

According to (Cooper et al. 2014, p.44), the best gathering of qualitative data uses a combination of one-on-one interviews and observations. The act of observing a user trying

to use an interface that we have designed can dramatically change how we understand our users (Krug 2014). Furthermore, usability studies and observations can be kept simple and executed consistently, what matters is that they help us better understand our users as well points of improvements.

### 4.3.3 Affinity Diagram

To make sense of all the gathered data it is often helpful to categorize that information within an affinity diagram. Data and findings are written down or drawn onto post-its and grouped on a wall, helping designers to get perspective while also letting them move post-its around.

### 4.3.4 Focus Groups

Great ideas often come from collective efforts. As opposed to the standard interview, focus groups are done with multiple people allowing for discussion and perspectives of various opinions. The idea is to gather individuals that can represent the target population and discussion issues that are central to all (Rogers et al. 2019, p.271-272).

### 4.3.5 Co-Creation Workshop

Alternatively, we can invite people to a co-creation workshop. Here the participants become designers and the designer becomes the facilitator, democratizing the design process. This is a good way of letting users feel involved and getting new perspectives and fresh ideas. The Five Design-Sheet Method is a type of collaborative workshop where users are invited to sketch on a potential interface and visualizations (Roberts et al. 2015).

### 4.3.6 User Stories

User stories are a cost-beneficial way of considering generalizations of potential users. User stories are short, accessible and user-centred sentences explaining different users and their respective goals using the product. User stories are created after we have understood who the users might be and it is a way for designers to try and match their ideas with real user needs [1]. They can be framed as "As a X, I want Y so that I achieve Z".

### 4.3.7 Think, Feel, Do

Feigenbaum & Alamalhodaei (2020) suggests a method called *Think, Feel, Do* as a means to explore and better understand our potential audience. By combining this method with user research methods we can get a more accurate image. After we know what people currently think, feel, and do we are better equipped to close the gap to what we want them to think, feel, and do.

### 4.3.8 Sketching

Sketches are a great way of quickly externalizing ideas so that we can think more openly, reflect and discuss them with other people (Spence 2014, p.230). We externalize our thought on paper and then reflect on what we have drawn, open up for new ways of seeing things and reflecting. This type of low-fidelity prototyping is also a great way of getting other people feel less intimidated to participate and give feedback.

[1] https://www.interaction-design.org/literature/topics/user-stories

### 4.3.9 Web Analytics

As opposed to subjective user experience evaluations, web analytics can give a broader view of the general visitor Rogers et al. (2019). Metrics include seeing how many people that visits the website, how long they stay, but also how they interact with the content and what paths they take.

### 4.3.10 Heuristic Evaluation

Evaluation must not only involve potential end-users of a system, but can be done by any individual, and is therefore often a cost-benefical approach to identify general issues. Heuristic evaluation is a set of principles that can help determine if an interface meets quality expectations (Rogers et al. 2019, p.550).

# 5
# Planning

The planned process was very much inspired by the Double Diamond and would consist of four phases: explore, define, develop, and deliver. However, various aspects of the different processes mentioned in Section 4.2 would be utilized in some regard. For example, the user research would be very goal-oriented, and the data visualization process would naturally fit with this project as well.

## 5.1 Explore

The plan of the first phase was to establish the purpose of the project by studying relevant literature, conducting user research and gathering data relating to dietary habits. Technical tools would also be considered and evaluated because it was important to consider possibilities and limitations.

In regards to the user research, various methods was considered. Since it was planned to develop something new, as opposed to revise something existing, a qualitative approach was fitting. Qualitative data gathering advantageously includes one-on-one interviews combined with observations (Cooper et al. 2014, p.44). However, because of the ongoing pandemic, it was plausible that gathering enough people for interviews could prove to be challenging. It was therefore decided to also utilize questionnaires as a means of collecting user data. The questionnaire had the possibility of reaching more people, and it could also give more insight regarding a broader audience.

Data gathering was planned to be conducted in parallel to the literature study and user research. The reason was simply that all of these factors had to be considered in parallel to adjust the focus of the development in valuable and feasible directions.

## 5.2 Define

With the data gathered from the previous phase, some analysis would be useful. In the second phase, important findings would be extracted and decisions on what to include or exclude in the artifact would be made. Questions like "what are some common patterns of the audience and what type of data can accommodate for their needs?" would be asked. It was planned to use an affinity diagram to externalize and categorize some of the findings from both user research and data gathering. Furthermore, user stories and a "Think, Feel, Do" could help in terms of consideration of potential users and their experiences.

## 5.3 Develop

The third phase was planned to consist of ideation and development. First of all, some sketches would be made both to explore some various types of charts and interface structures, but also as a means to communicate the idea of the artifact to participants of an upcoming co-creation workshop. The co-creation workshop was to focus on exploring different ways of storytelling with visualization. It would consist of both sketching and discussion.

After initial ideation through sketching and workshop, the development would start. This was where most of the time would be spent. The reason was simply because the goal was to create a functional website, and spending any more time on other aspects would make this hard to achieve. Furthermore, working closely with technology would be necessary to identify both limitations and possibilities in the software. There was not much specifically planned for this phase, but there was a general sense of what to focus on. For instance, libraries like D3 and Chart.js would be compared and data would be transformed into information presented in the interface.

## 5.4 Deliver

The web interface would have to be validated and evaluated. Some of these usability studies would have to be conducted early enough to have time for refinement. The user feedback was planned in the form of interviews and usability tests at the middle stage of the design process. Evaluation would occur for when the final product was published, at the end of the project. The reason for planning the user feedback earlier was because it was assumed that those would be more formative in nature.

Heuristic evaluation was planned, because its a cost-beneficial and efficient way to quality measure an artifact (see Section 4.3.10). Furthermore, it can be done whenever there is time. Since the availability of participants was unclear, given the ongoing epidemic, heuristic evaluation was deemed a good choice. It would be conducted by the author.

A final evaluation was planned at the end of the project, with the purpose of evaluating the efficiency and effectiveness of the final product. The plan was to evaluate the website in a controlled setting through a combination of observation, likert scale evaluation and general feedback.

## 5.5 Time Plan

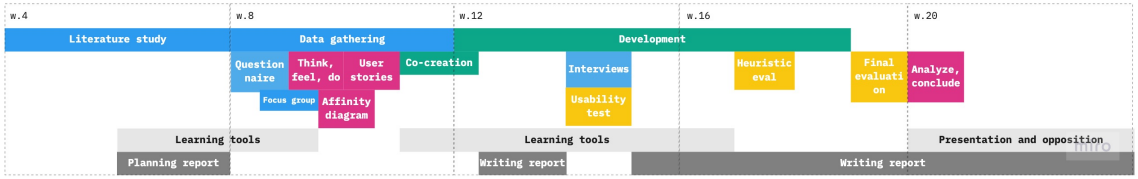


**Figure 5.1:** Time plan. Explore in blue, define in pink, develop in green and deliver in yellow.

# 6
# Ethical Considirations

This chapter focuses on *ethical considerations* taken *prior* to executing the project. In Section 9.3 *ethical concerns* will be discussed regarding the outcome of the project.

Creating visualizations always comes with responsibility, but the ethical considerations are even more important when the solution revolves around health decisions. First of all, information should be based on scientifically established evidence. Secondly, visualizations must be clear not to risk misinterpretation. Data is based on numbers, and numbers are often taken as facts; but the truth is that statistics are imperfect estimations, consciously stripped of context. If statistics, rather than raw data was utilized, there could be a value in being transparent to the observer regarding these matters. Furthermore, the act of transforming raw data into meaningful information always requires some filtering, but there is no harm in being transparent about how a visualization came to be. Lastly, our society could benefit from more important information being accessed by more people, as opposed to misinformation. Hence, the goal should be to strive for as much inclusiveness and accessibility as possible.

## 6.1 Misinformation in Visualizations

The main purpose of data visualization is to make information more available through visual representations, as Tufte (1983) puts it: ”above all else show the data”. This might be obvious, but it is important to put emphasis on integrity and the intended message, rather than focusing solely on aesthetics. In fact, misinformation in visualization is often caused by visualizers spending more focus on appeal rather than clarifying the intended message (Cairo 2014). The data gathering must therefore be methodical and rigorous, and it is important to get calculations and transformations right. More specifically, when working with diets and nutritional information, there is already an extensive amount of information available (see Section 2); and rather than adding more information, there might be value in gathering and combining what already exists. One tactic to ensure quality of content is to verify any information in the interface with at least two authoritative sources.

Other common pitfalls of misinformation include poor designed, displaying questionable or insufficient data, concealing or confusing information, and misleading patterns (Cairo 2019). Usability studies will be conducted to verify whether people interpret information correctly. It would be even better if information also could be verified by a health expert. In any case, transparency of both calculation and sources will be required, so that any faulty information can be pointed out and addressed. However, for the scope of this project, it might not be possible to incorporate features where users can flag or report faulty information. This is concerning since misinformation is bad. Instead, more focus will have to be put on ensuring validity of the main narratives displayed.

## 6.2 Inclusiveness and Autonomy

Emphasizing certain narratives and calling upon the user to take action or change their behaviour is a type of nudging. Nudges can be used for good and bad, to help people to understand and engage with important concerns can be seen as well-intended nudging. It can be argued that when we talk about things that can cause harmful outcomes, we have a moral obligation to point out that it is bad. Bad dietary habits is one such case, and designers (and society as a whole) therefore have a moral obligation to continuously revise what, why, and how information is communicated. What nudges the web interface utilize will be evaluated, and focus will be on nudges that are transparent and reflective, rather than nontransparent and automatic (see section 3.4). Furthermore, it is important to carefully consider the different default modes and how things are screened.

This project focus on a broader audience, meaning that the information will be general. This will make the process more manageable, because considering all different people and their preferences and allergies is simply not feasible. For instance, there is not enough time to fully understand and accommodate for pregnant women, people with gluten intolerance, or people with IBS. Doing so would require more expertise and more careful consideration. Furthermore, the author have less access to these types of people. Clearly, the generalized approach is flawed because it excludes certain groups of people, but again all people can not feasibly be accommodated for. Prioritizing the majority arguably means greater chance to impact more people. By providing explorative features the hope is that minorities can find a purpose with the final product too. Accommodating a larger diversity of different people is considered in the future work (see Section 9.4).

Accessibility is a main concern when providing information to the general public. Some people do not have less developed literacy. Arguably, the effort to make information more enjoyable alone is a means of improving data literacy. Additionally, there are some specific groups of people worth considering. Colorblind people might not be able to see the different various and categorizations provided through inc. A way to tackle this is to use multiple ways of encoding, such as text and shape. People with impaired vision might not be able to see smaller text, and the smallest font size for readable text is therefore often suggested to be 16 pixels.[1]

In this project, web analytics will be utilized to test the website. Web analytics is of ethical concern because it can be used to store personally identifiable information. In this project, every precaution will be taken to not track such information. Instead, only anonymized and consequently less accurate data will be stored. Furthermore, if implemented, any user input or settings will be stored locally on the user device to ensure that no IP-adresses, device IDs, and such is in anyone elses hands than the user.

[1] https://health.gov/healthliteracyonline/display/section-3-3/

# 7
# Process

## 7.1 Research

Research consisted of a literature study, data gathering, user research and exploration of technical tools. These stages were interdependent, overlapped, and often done in parallel or reiterated. For instance, after user research new considerations had to be made about the data, and exploration of tools lead to a better understand of what theory to utilize. Hence, one of the main challenges involved balancing consideration of the audience with technological limitations and characteristics of the data.

### 7.1.1 Literature study

The initial literature study focused on exploring the balancing act of exploration and explanation in data-driven storytelling. Around 20-30 papers and four books were identified using Google Scholar and IEEE Xplore. Keywords (mainly) included: "narrative visualization", "data-driven storytelling", and "visualization storytelling". Papers were filtered down into a handful given consideration of recurring authors, number of citations, and using the "Popular"-filter on IEEE Xplore. The study resulted in the identification of commonly used techniques, both exploratory and explanatory in nature. Some of these findings are presented in Section 3.2.

Furthermore, the literature was broadened to include books on the topics of information visualization, misinformation in visualizations, and interface design. All of these topics would be relevant in the process of creating an interactive web interface with visualizations that engage a broader audience with important data. The authors of the books are all renowned contributors in their respective fields and included (among others): Colin Ware, Andy Kirk, Edward Tufte, and Alberto Cairo. Lastly, a paper from the course "Designing User Experiences" on nudging was included to the literature list.

### 7.1.2 Researching Technology

What type of research that is appropriate should always be reflected upon in consideration of the circumstances (Gaver 2012). In this project, the focus was on exploring how theory could be applied given modern technology, something that could give meaningful insight. Some disadvantages with a more technical approach was that it would take more time to design and implement each alternative, and some approaches would have to be dismissed because of technical difficulties and time constraints. Furthermore, continuous cost-beneficial reflections had to be made to focus attention on things that were both valuable and feasible. On the other hand, with a fully functional interface, real interactions could better be understood and evaluated.

In addition to using HTML, CSS, and JavaScript, various frameworks were compared in respect to community support, performance, and access to third-party libraries. Because of React's community support and availability of third-party animation libraries, it was superior over Vue in this project (see Figure 7.1). Generally speaking, React is more powerful than Vue but Vue is more easy to learn. Since the author had experience using both frameworks, the learning curve was not an issues. However, the accessability to third-party animation libraries such as *Motion Framer* and *React-Spring* made React a clear winner.

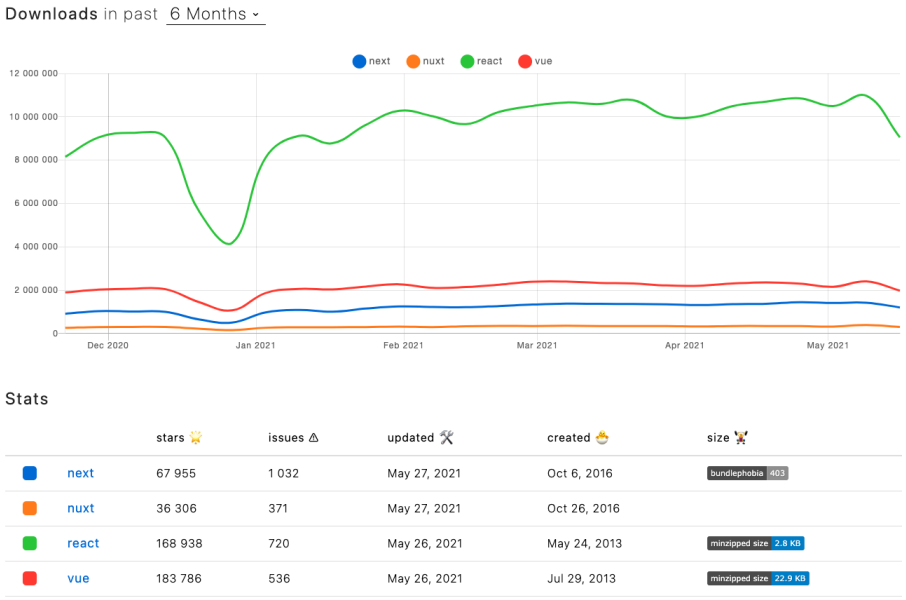


**Figure 7.1:** Comparison of package downloads between the frameworks React and Vue, as well as their minimalistic counterparts Next and Nuxt. Retrieved 27/5-2021, courtesy of npmtrends.com

In recent times, it has become popular to use SSR and SSG for improved performance (see Section 3.5). Since Next.js is a framework built on top of React that utilize both SSR and SSG it would be a good fit for this project. However, it was unclear whether SSR or SSG would be best for this project. Later on it was decided that the most optimal approach would be to use a combination of the two (see Section 7.5). Relevant documentation was acquired from either *Next.js Offical Docs*, *MDN Web Docs*, *Google Web Updates*, or from the respective library documentations.

Time was spent on exploring the JavaScript library D3. D3 is the most powerful visualization tool for the web, but it can take some time to master. The advantage was that, compared with other tools, it allowed for full customizability and could therefore more seamlessly be integrated into the web interface. Chart.js and React-wordcloud are two other visualization libraries that were also explored. To better understand the possibilities and limitations of these different libraries they had to be tested out, something that was done later on (see Section 7.3.2).

### 7.1.3 Data gathering

To make the data gathering manageable some delimitations was made. Eating habits and nutritional recommendations vary between different countries, and because most users involved in the process would be Swedish, the nutritional recommendations was delimited to

Sweden. Furthermore, because the intent was to make information accessible to a broader audience, the target audience was people with basic or little knowledge (as opposed to health experts or nutritionists).

Several Swedish public authority websites were explored. They included (but were not limited to): Statistiska centralbyrån, FHM, Jordbruksverket and LIVS. Four prevalent sources of information were identified in the process. The first one was the Nordic Nutritional Recommendations NNR (2014), which provide a 629 page long report about nutritional recommendations for Nordic citizens based on the latest scientific research. The second one was Riksmaten, a 180 page long report presenting the results of a survey on swedes food habits conducted in 2010-2011.[1] Third, GBD (Global Burden of Disease) provide statistics on how much death and disease correlate with risk factors (such as diet), both globally and in Sweden. Lastly, The World Cancer Research Fund provides insights into how strong the evidence is in regards to what foods can cause or prevent cancer.

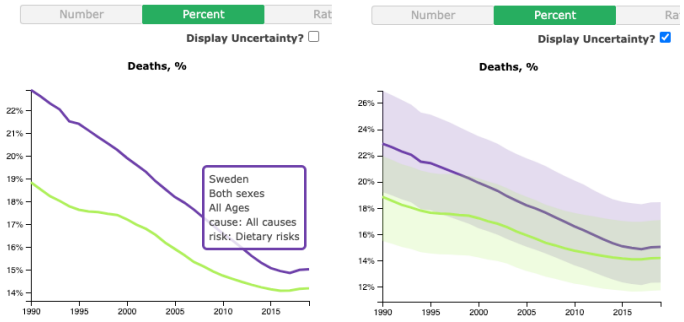


**Figure 7.2:** Percentage of deaths related to dietary risk factors in Sweden (purple) and USA (green). Left shows without considering uncertainty and right with consideration of uncertainty. Image courtesy of Global Health Data Exchange.

GBD provided an interactive tool where their data set could be explored. Various filters and sorting revealed surprising results, and it became clear that their data (based on accumulated data and mathematical formulas with uncertainties) had to be taken with a grain of salt. As an example, the uncertainty interval for death related to diet was more than 10%, something that had to be toggled to be revealed. If this uncertainty was not considered, visualizations suggested that more people in Sweden die from diet related deaths than in the USA (see Figure 7.2). This statement might be true, but it is not very probable.

The gathered data gave insight into eating habits, outcome of those habits, as well as recommended habits; information that might be interesting (and important) for people to better understand and explore. To contextualize this information, nutritional food databases were considered. For instance, if we know that salt is unhealthy and wholegrain is healthy, then it might be helpful for people to connect (and contextualize) this data with food from their everyday life.

Two food databases exist that contain nutritional data relevant to Swedes consumption: LIVS-DB (Livsmedelsdatabasen) and the Finnish equivalent Fineli. Their different structures would affect the possibilities and limitations of the web interface, and therefore a comparison was made. LIVS-DB provides 2245 food items, all in one CSV-file and they

[1] https://www.livsmedelsverket.se/globalassets/publikationsdatabas/rapporter/2011/riksmaten_2010

provide nutritional data regarding wholegrain. Fineli does not provide data regarding wholegrain, but their database contain 4156 items, includes portion sizes, and provides data in multiple CSV-files.

The Fineli database was superior in many ways. First of all, more items would increase the likelihood that users could find the food they were looking for. For example, vegan oat alternatives to dairy are not included in LIVS-DB. Secondly, Fineli had a relational structure meaning that foods from specific categories could be fetched in isolation, rather than having to filter them out manually. This would result in better performance for the user when searching, filtering etc. Furthermore, Fineli have portion sizes for many of their items, something that would be very helpful for the user, rather than having to guess how many grams a banan weighs, for example. Given all of these considerations, Fineli was soon replaced with LIVS-DB in this project. Too much salt and too little wholegrain was emphasized by so many authoritative sources that the positive aspects of Fineli could not compete. It was too important to let the user explore examples of foods that related to what was presented as key factors of a healthy diet.

**Takeways**

- *A purpose, or high-level cognitive task, is necessary in order to conduct a meaningful data gathering.*
- *Take a step back and consider plausibility before drawing drastic conclusions, especially when attempt to confront.*
- *Identify characteristics and consider if different data can be combined.*
- *Transform what the users need to hear and consider into something they want to hear.*

### 7.1.4 User Research

To better understand what a meaningful product could look like, early user research was conducted. The research followed a goal-directed approach, as suggested by (Cooper et al. 2014, p.3-40), and focused on exploring user needs and behaviors rather than specific tasks and implementations. One questionnaire and two interviews on the topic of food and health was conducted.

#### 7.1.4.1 Questionnaire

The questionnaire was conducted online using the tool Typeform. Typeform can provide more playful and possibly enjoyable experiences than, for instance, Google Forms. Access to one-year trial of the professional plan for free (via GitHub Student Developer Pack) made Typeform a good choice.[2] For the structure of the questionnaire, emphasis was on making it clear, concise, and playful to increase the likelihood of participation and retention. It was composed of a mixture of subjective differential scales and open-ended questions (see Appendix A). Extreme scenarios, such as "What would you choose to eat if you had infinite access to food?", were meant to spark the imagination of respondents and reveal underlying motivations. A pilot study with three people prompted changes improving upon clarity of questions and the likelihood for elaborate answers. For instance, "Would you" was replaced with "What would you", and "is there" was replaced with "what is".

[2]https://education.github.com/pack

The questionnaire was published over two days on Facebook and in a Slack group for master students in Interaction Design. 60 people responded to the survey. 32 of them were *between 18 and 30*, 26 *between 31 and 63*, and 2 were *above 64*. Answers to subjective differential scales were automatically calculated, while open-ended questions were categorized into an affinity diagram.

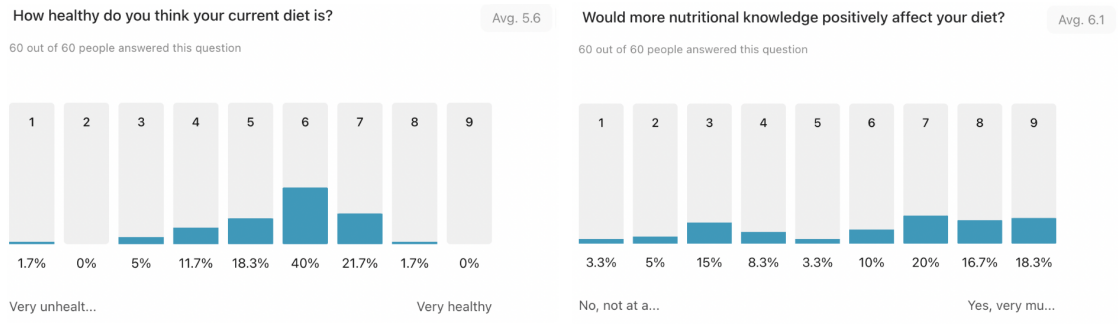


**Figure 7.3:** The average person scored their diet on the healthier end (left). Generally, people thought that more nutritional knowledge would be helpful, but the variance was quite high (right).

Generally, people ranked their diet on the healthier end, and they thought that more nutritional knowledge would be helpful (see Figure 7.3). On the question of what in their diet that could be improved, only 4 people said "Nothing" or "Don't know". Other respondents were mainly concerned with eating more vegetables and less meat, junk-food or sugar. None of the 60 participants mentioned cutting down on salt or increasing consumption of whole grain. This was interesting since these were two big risk factors of an unhealthy diet identified in the data gathering.

Apart from health aspects, the most common factors that affected what participants eat:

- Time: 22 mentioned
- Price: 17 mentioned
- Taste: 17 mentioned
- Ethical concerns: 12 mentioned
- Availability: 8 mentioned

Two questions related to what would be some helpful and unhelpful characteristics of a website about food and health. An affinity diagram was used to categorize similar answers and identify patterns. Some of the most helpful characteristics included:

- Only show interesting information
- Comparisons and suggestions
- Easy to use and guiding
- Uses pictures and visuals
- Personalized content

Some of the most unhelpful characteristics that were mentioned:

- Too much information
- Boring tables and numbers

- Bias and misinformation

#### 7.1.4.2 Interviews

The plan to conduct a focus group was replaced with interviews, because it was hard to find and gather people that could participate at the same time. Instead, two male students from the Computer Science master at Gothenburg University were invited for two one-to-one interviews via Zoom. These were two individuals not particularly interested in eating healthy. The goal was to get further insight into how a website about food and health could facilitate for their needs. Interviews contained open-ended questions from the questionnaire, now allowing for follow-up questions. The research was still goal-directed, meaning that dialogue was steered away from talking about implementation and instead focused on general attitudes.

For both interviewees, *time*, *convenience*, and *taste* were of bigger concern than *health* when it came to what they ate. One interviewee said that the consequences of unhealthy eating is not immediate enough for him to be concerned, compared to, for example, the effects of too little sleep where he would directly experience physical discomfort. Conscience and common sense were mentioned as factors for not only eating unhealthy food. It was attempted to explore the meaning of "conscience", but it led to quite unfruitful philosophical dialogues. The interviewees were also asked to consider how a website about health and food could be helpful for them. One person said that authoritativeness is important, and if it was a third-party website, it would have to be transparent about sources. If he could trust the website and it presented interesting information that "pointed out what is bad and why", then he would be interested.

At the end of the interview, participants were asked to browse a to Matkalkyl (see Chapter 2) and give their impression along with some suggested improvements. The bad characteristics of the website matched quite well with the unhelpful characteristics mentioned in the questionnaire (see section 7.1.4.1). Answers are paraphrased and translated from Swedish:

- "I become immediately tired of looking at it"
- "A lot of numbers that doesn't tell me anything"
- "Not for casual people"
- "Here they present everything!"
- "Wikipedia for foods, rather than a general image, making it very hard to draw a conclusion"

Some suggested improvements:

- "Show more context"
- "Tell me what to look at"
- "Give information about what is good and bad"
- "Hide the advanced stuff"

**Takeaways**

- *People wanted to be served with the interesting and important information*
- *People were frustrated with too much (and irrelevant) information*
- *People wanted guidance, suggestions, and pointing out the bad stuff*

- *People wanted personalized content and ability to compare on their own*

## 7.2 Ideation

From the research, it was clear that people found too much data, boring tables, and misinformation frustrating. Interestingly, none of the answers had suggested a concern with some of the most urgent factors identified in the data gathering. Sketches were made to explore how the interface could make nutritional information more fun. This was also a way to communicate the idea of the interface to participants of the upcoming co-creation workshop. The workshop was aimed to explore how storytelling could be utilized with help from fellow designers. In terms of nudging, the sketches would explore how to *facilitate* the user to explore, while the co-creation workshop would explore how to *confront* them on important issues.

### 7.2.1 Sketching

Users wanted an interface that showed them the interesting stuff, guided them, and allowed them to compare. Two pages were sketched: one page for displaying nutritional information regarding a specific food, and one where users could combine foods and display aggregate data (see Figure 7.4). Focus was on creating a more visually driven layout, where only the data that mattered to most people would be shown.

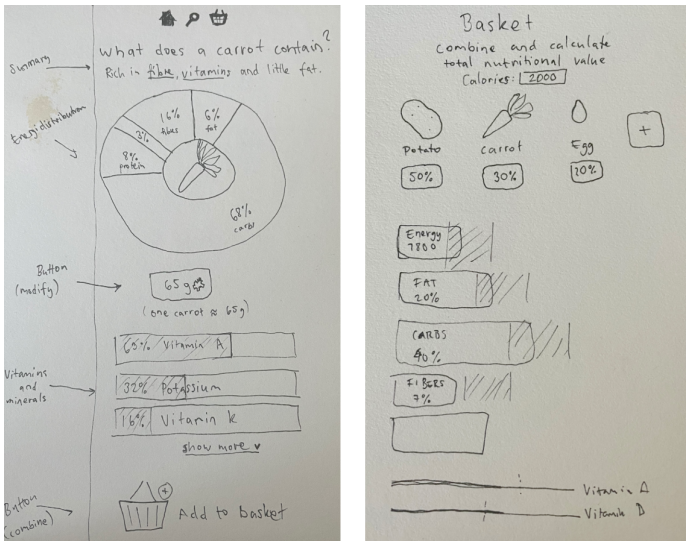


**Figure 7.4:** Two sketches of the web interfaces. One page (left) displays information regarding a specific foods, the other allows the user to combine foods.

The first page shows nutritional information for a specific food. It uses a pie chart because of the part-to-whole relationship of energy-distribution, and because it probably fits with most peoples mental model. Furthermore, progress bars were used for vitamins and minerals, visualizing progress towards the daily recommended intake.

The "basket"-page was meant to allow people to combine foods according to interest. Here, the energy is not displayed within a pie chart but instead utilizes horizontal bar charts.

NNR (2014) contribute with suggested intervals that each macronutritient should stay within, and this seemed like a good way to visualize that.

### 7.2.2 Co-Creation Workshop

Though data-driven storytelling had been researched extensively, it was unclear how it could be incorporated into the website. The co-creation workshop was meant to help with this exploration by getting help from fellow interaction designers. Furthermore, the participants were all enrolled in the course "Information Visualization" at Chalmers. Participants consisted of three males and one female in their twenties. The workshop was held remotely via Zoom and took around 70 minutes.

On a digital whiteboard, sketches was presented along with findings from research that had been summarized to give participants a sense of the purpose of the website. Furthermore, some techniques and tools found in the data-driven storytelling research were presented (see Section 3.2). All of the materials were meant to help facilitate the participants ideation. However, it was hard to know how much material the participants would want thrown at them. Worst case it could hinder their creative outlet.

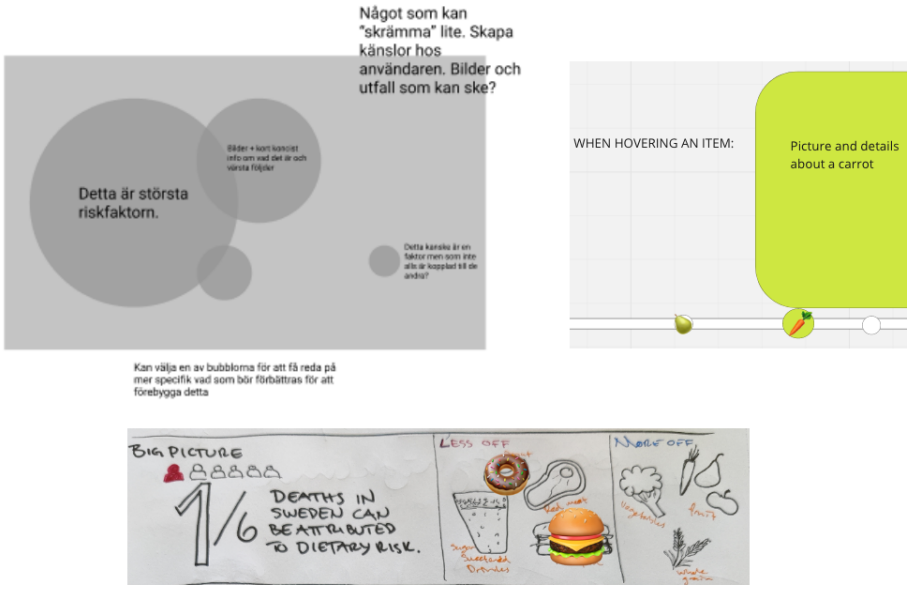


**Figure 7.5:** Some of the sketches from the co-creation workshop. One person suggested a bubble chart, another a pictorial, and a third a horizontal bar chart.

After the introductory presentation, each of the participants were instructed to sketch for 30 minutes on their own. Afterwards, the sketches were presented on the digital whiteboard and participants were asked to pick some features from each other's design that they liked the most. All designs included the aspect of being able to choose sex and age, in order to get personalized recommendations. One of the suggested solutions utilized a bubble chart were the different risk factors was represented with diameter size, and the visitor could click on the bubble that interested them to get more information (see Figure 7.5).

## 7.3 Development: First Iteration

The development process involved not only creating a website; but also learning different visualization techniques, as well as determining feasibility of different approaches. In dialogue with tools and data, and informal feedback, new ideas evolved and emerged throughout development.

### 7.3.1 The Basic Setup


**Figure 7.6:** View 1 shows the home page, containing a sub selection of foods to explore. When clicking any of the foods the user is navigated to View 2, with more detailed information. View 3 is accessed from the food cart in the top header, and can be used to combine foods.

Initial development focused on incorporating relevant data into the web interface and exploring ways of presenting that information in an interesting and playful way. Data from NNR (2014) was combined with data from LIVS-DB, and various visualizations were explored. Many of the suggested features, such as comparisons and suggestions or personalized recommendations was put on hold for later stages. The result was a functioning web interface based on what had been ideated during the sketching phase. At this stage, only a subset of foods in the database could be selected and explored by visitors (see Figure 7.6), focus was first and foremost on making the different data sets work together.

Unicode emojis were utilized to give the user visual representations, both in accordance with their needs (see Section 7.1.4.1) and in terms of making the interface more playful, engaging and accessible. Color encodings were used to display the different categories and they were consistent between the different views. Any part of the visualization contains both a visual and a numerical value (and or text). This type of double-coding increase the chance of accessibility and decrease the chance of misinterpretation.

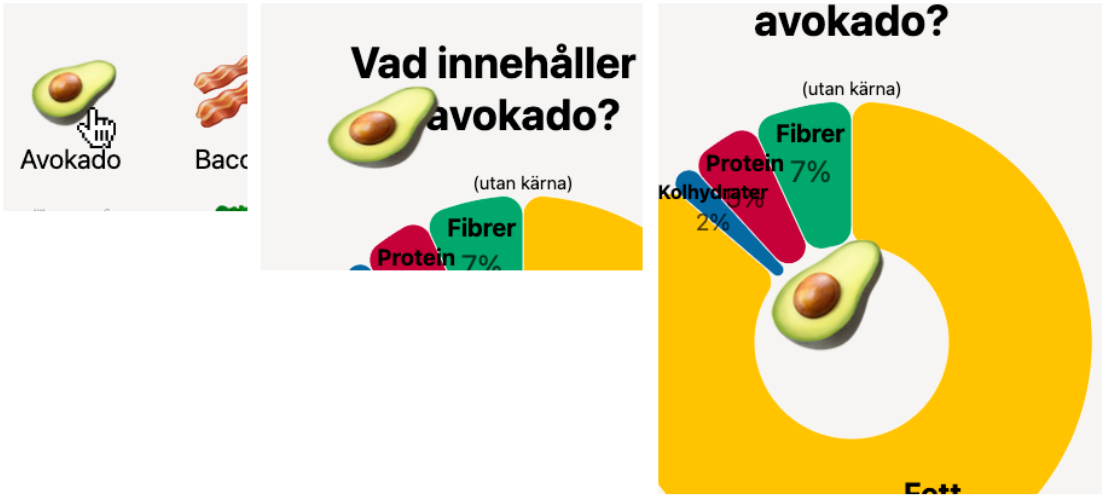


**Figure 7.7:** When a user clicks a food item on the home page, the food emoji is transitioned to its new position on the next page.

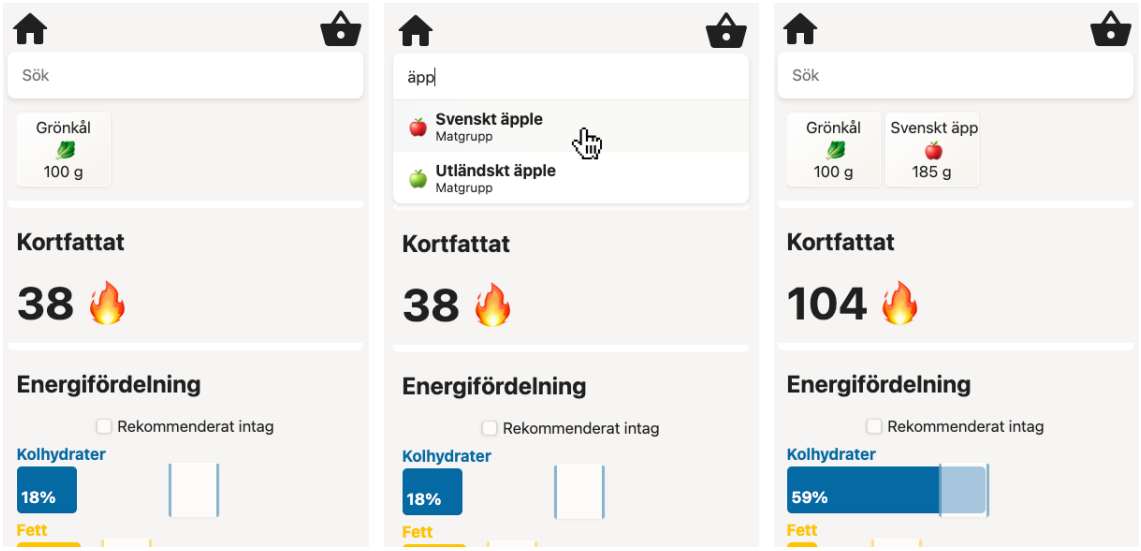


**Figure 7.8:** On the combine page users could search and combine different foods. Whenever a food item was added the values and visualizations would transition to their new values.

For consistency, and considering that the audience read from left to right, the donut chart started at 0 degrees. In later iterations they would also be sorted so that the larger values were displayed first in the "clockwise" order (see 8.10). Margins and border radius were utilized for the different slices and components in order to distinguish groupings. Values in the donut chart had to be carefully considered. One gram of fat, for example, equals 9 calories while one gram of carbohydrates equals 9 calories, and these calculations had to be made in order to display the correct relationships.

Animated transitions were implemented utilizing Framer Motion. For example, when clicking a food emoji in View 1, it would be translated towards its new position in the centre of the donut in View 2 (see Figure 7.7). Additionally, both the numbers and widths of the bars are transitioned to their new values in View 3, whenever the user changes

weight or food items. These animations were implemented using CSS and React-Spring. In View 3, a search bar was added, which allowed the user to access all foods in the nutritional database. On user input, suggested foods are displayed in a *drop-down chooser* (see Figure 7.8) allowing visitors to directly see suggested results (Tidwell 2020, p.510). To allow users to change the weight of foods, user inputs were also added. The inputs were shown when the user clicked an item and when modified, the page would update directly, indicating in real-time how changes affect the content.

### 7.3.2 Presenting a Story

Up until this point, the web interface was mostly focused on explorative, or *reader-driven* aspects (see Section 3.2). More author-driven would mean more focus on presentation and facilitating visitors attention. Different ways if doing this had been explored in the co-creation workshop (see Section 7.2.2). Both Chart.js, D3 and React-wordcloud were tested out during this process. Most of these libraries could be customized enough to result in a similar style. With Chart.js, a bar chart was made, emphasizing how much more deaths are correlated with bad diets as opposed to, for instance, physical activity (see Figure 7.9). Chart.js was easy to use and tooltips could be added seamlessly. The biggest downside was that it would be hard to match the style of tooltips and labels for other visualizations on the website that were not using Chart.js, which was important in terms of consistency.

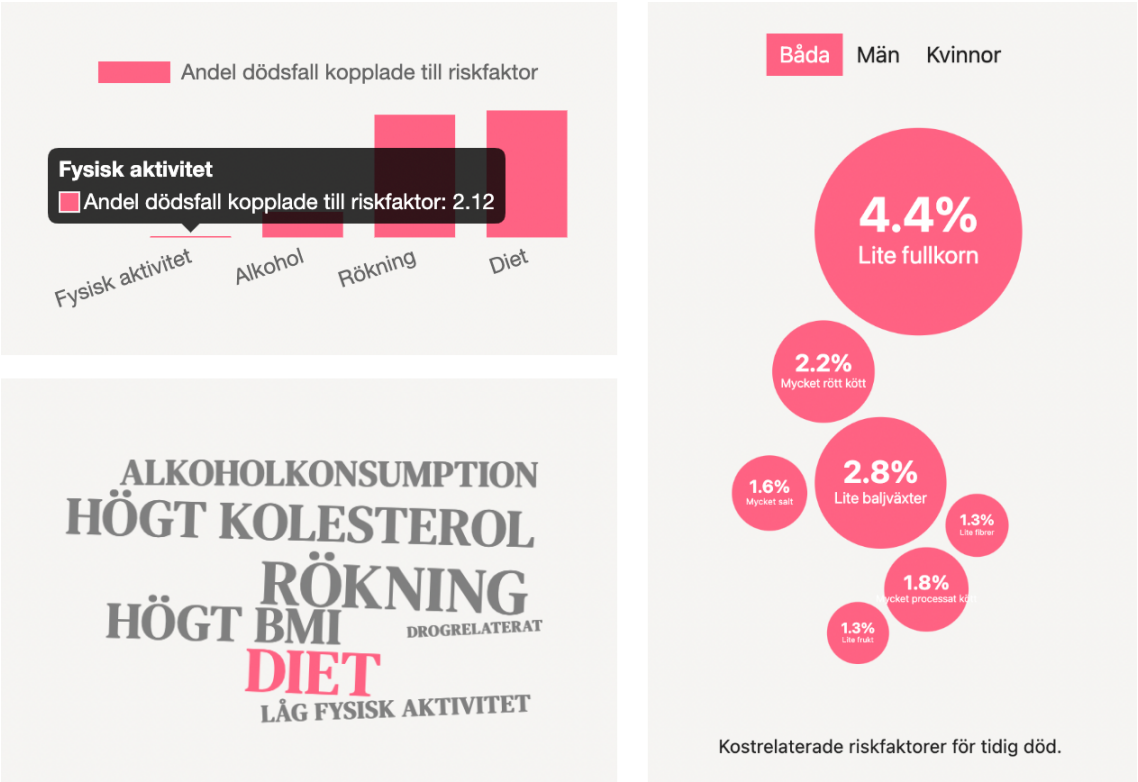


**Figure 7.9:** Different charts were tested out with data on risk factors for death. For instance, a bar chart using Chart.js were tested out, a third-party library for generating a word-cloud, and D3 for testing out a bubble chart.

The wordcloud was an alternative way of displaying deaths related to risk factors. A

problem with this approach was that it did not reveal the underlying numerical values as well. Furthermore, the words were generated upon client request and would often fail on smaller devices where it was harder to calculate how to position the different words. Lastly, a bubble chart was made using D3. The bubble chart was suggested during the co-creation workshop (see Section 7.2.2). One idea could be to first present the viewer with a "zoomed-out" image of death-related risk factors in general (bar chart), and then show this view with a more "zoomed-in" perspective (bubble chart). With the bubble chart, the user could also toggle between the different sexes and explore differences between the two.

The general idea was that the web interface would first introduce the story and then open up exploration for the other part of the interface. One challenge was to keep the story short enough for users not to drop out and miss the explorative parts of the website. Another challenge revolved around the length of words and sentences, specifically for smaller devices.

This phase was necessary in order to explore different ways of presenting a story to the viewer regarding technical limitations and in consideration of the underlying data. However, though many different visualizations showed potentials, it was harder to determine the best way to present an overarching story. It was time to take a step back and think of the bigger perspective.

### 7.3.3 Heuristic Evaluation

A heuristic evaluation was conducted to step back and reflect on the general structure of the web interface. This was a cost-beneficial way to get some quick insight into some points of improvement. Questions were examples of what visitors might ask themselves when visiting the website, and mainly inspired by the questions suggested by Krug (2014). For each different page, the following questions were considered:

1. What is this website about?
2. Where am I?
3. What can I do on this website?
4. What can I do on this page?

First of all, when asking these questions it became clear that more focus was needed on the overall hierarchy and structure. For instance, when browsing a food page, it was not clear how it related to the rest of the website. Secondly, Krug (2014) talks about "the importance of getting people off on the right foot", that is, the importance of a clear home page. Maybe the idea of having a story presented to the viewers before they could access the other content was not so good. Maybe it would be wiser to try to incorporate the story into the home page.

**Takeways**

- *Home pages are an important tool of communicating purpose of a website* (Krug 2014, p.171-196)
- *Reveal the hierarchy of a website on every individual page, allow for global search* (Krug 2014, p.125-169)

### 7.3.4 Informal feedback

Some informal tests were conducted with family and friends to identify some more general points of improvement based on actual usage. Similar to the heuristic evaluation, this was a way to clear out some of the biggest issues prior to any formal evaluation. Some structural issues were identified as well and different ways of how to phrase things were discussed.

One thing that was revealed was that it was not clear how to interpret the horizontal bar charts (on the page where foods could be combined). For instance, one person did not recognize the suggested intervals and thought that the bars were progress bars similar to those for the vitamins and minerals. Furthermore, when searching, some people were not used to only having to click the results in a drop-down chooser, and when they pressed "enter" they expected to navigate to a page with a list of results.

**Takeways**:

- People expect the searches to work in different ways
- Bar charts might not be effective in displaying part-to-whole relationships (see Figure 3.2)

### 7.3.5 Continued Development

Based on insight from heuristic evaluation and informal feedback, some major changes were made. The development had started out with a focus on explorative features of the web interface. After this phase, the focus was to present a story on the home page. The idea was to utilize the *Martini Glass Structure* (see Section 3.2.2), where the user is introduced to the topic and then are free to explore on their own. However, it was unclear how to present the story in a directed way that would be meaningful to most visitors. In the co-creation workshop, most participants had instead suggested interaction throughout the experience (see Figure 7.5).

Instead of having only the narrative presented first, and then opening up for exploration, it was decided to incorporate the story as an integrated part of the home page using a slideshow (see Figure 7.10). A slideshow meant that users could engage with the information (or narrative) if they wanted. On the other hand, if they wanted to explore the content, and nutritional value of specific foods, they could do that instead. Hence, the focus became less so about directing the users experience and more so about providing a presentation in complement to the exploration. This was also an attempt at making the home page clear while revealing what it could be used for.

Charts explored in the previous development of the story (see Section 7.3.2) was replaced with a pictorial chart that had been suggested in the co-creation workshop (see Section 7.2.2). The pictorial chart was shown as the first slide, while the rest of the slides corresponded to specific types of foods that were important aspects of a unhealthy versus healthy died (see Figure 7.11). What these aspects were depended on what had been found in the data gathering: reducing salt and red/processed meat and increasing fibre and wholegrain.

A more structured hierarchy was also incorporated (see Figure 7.12). On the home page, below the slideshow cards where added for different groups of foods. In addition to the

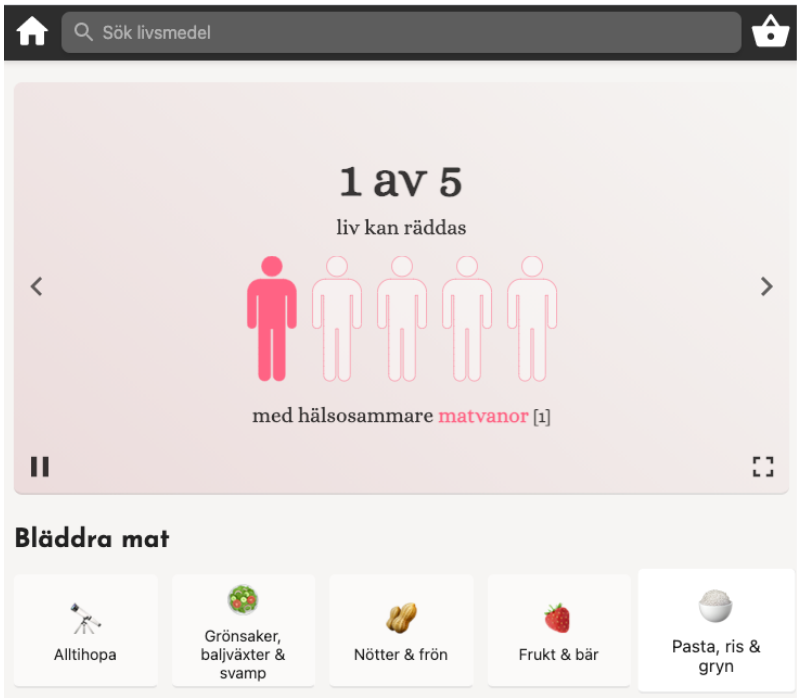


**Figure 7.10:** A slideshow was implemented on the home page. Here the first and second slides out of five are displayed.

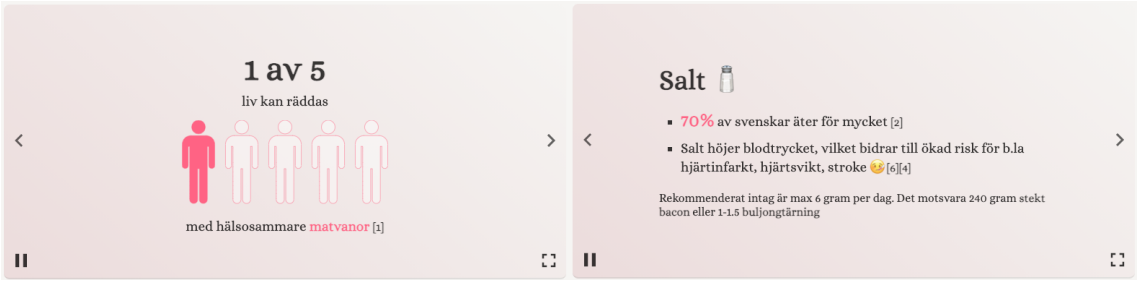


**Figure 7.11:** The first slide in the slideshow attempted to underline the importance of eating healthy, while the other gave more specific information on what could be important things to consider.

card styling, affordances were implemented in the form of hovering animations. Clicking on any of these cards leads the visitor to a list of foods for a certain food category. Here, they could also sort the list according to some criteria, such as energy content or whole-grain content. Each food page now also had a breadcrumb on top and under the header the food group was displayed. Lastly, the search bar was added to the global navigation bar, meaning that all foods could now be directly accessed from any page.

The only change made to combine page was to replace the horizontal bar charts with

## 7.4 Testing

GitHub had been used as a host for the software development. Next.js is provided by Vercel, and Vercel makes it easy to connect and deploy a Next.js GitHub repository with their services. The website was published at www.näring.nu and could now be tested.

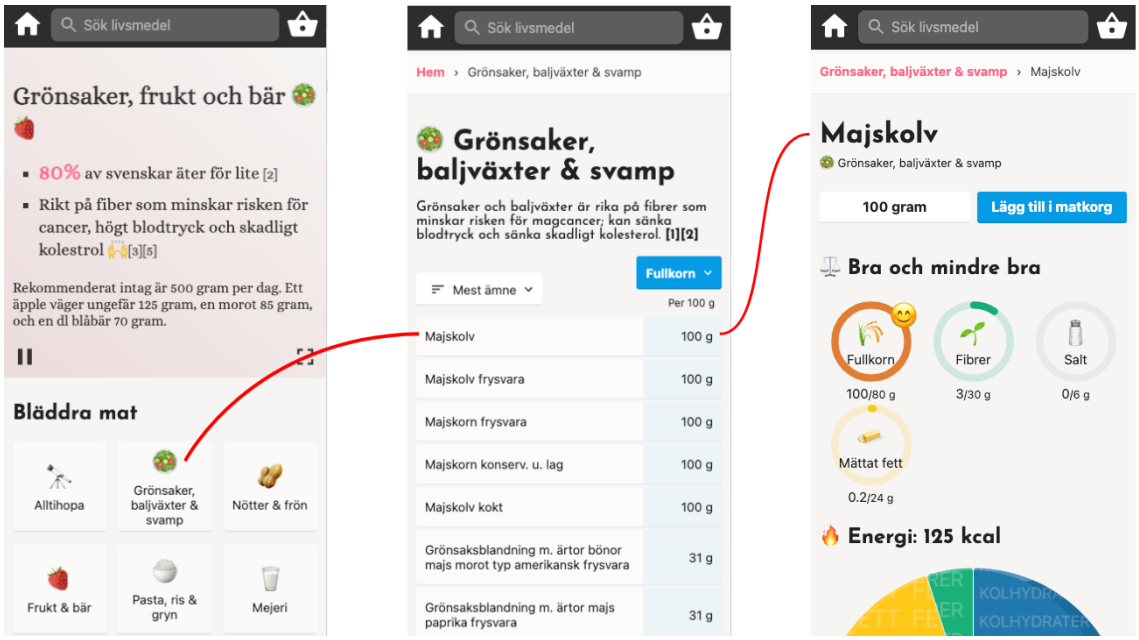


**Figure 7.12:** A more structured look. Here the path to a corn cob from the home page i displayed.

It was shared on Reddit, specifically in a forum called "Sweden", and it was also shared on the authors Facebook feed. After two minutes of visiting the website, visitors would be prompted to give feedback through a questionnaire (a button with a waving hand appeared). Web analytics were used to gather additional insight.

### 7.4.1 Questionnaire

The questionnaire was (the same as previously) created with Typeform. It consisted of seven questions asking people for their general impression, trustability, and if they had suggestions of improvement (see Appendix B). 25 people responded this time, 17 between the ages of 18 and 30, 6 between 31 and 63, and two above 64.

One question related to if there was something they liked about the website. 13 people answered this question and most common people noted that they liked the clarity, design, and transparency of sources. Many people also expressed a liking towards the use of colors and emojis. In regard to points of improvement, some people suggested that it was hard to find foods in search results and suggested adding an alphabetical sort. Furthermore, one person suggested it was hard to know what to do with the information in the slideshow and suggested adding "most-of" lists to the home page. Lastly, many people suggested that the search functionality did not work optimally. Indeed, the search functionality was one of those things that there had been little time to spend effort on.

**Takeaways**

- *People generally trusted the website*
- *People specifically liked the clarity, design, and transparency of sources*
- *Search and sort does not work optimally*
- *It is not always clear what to do with the information in the slideshow*

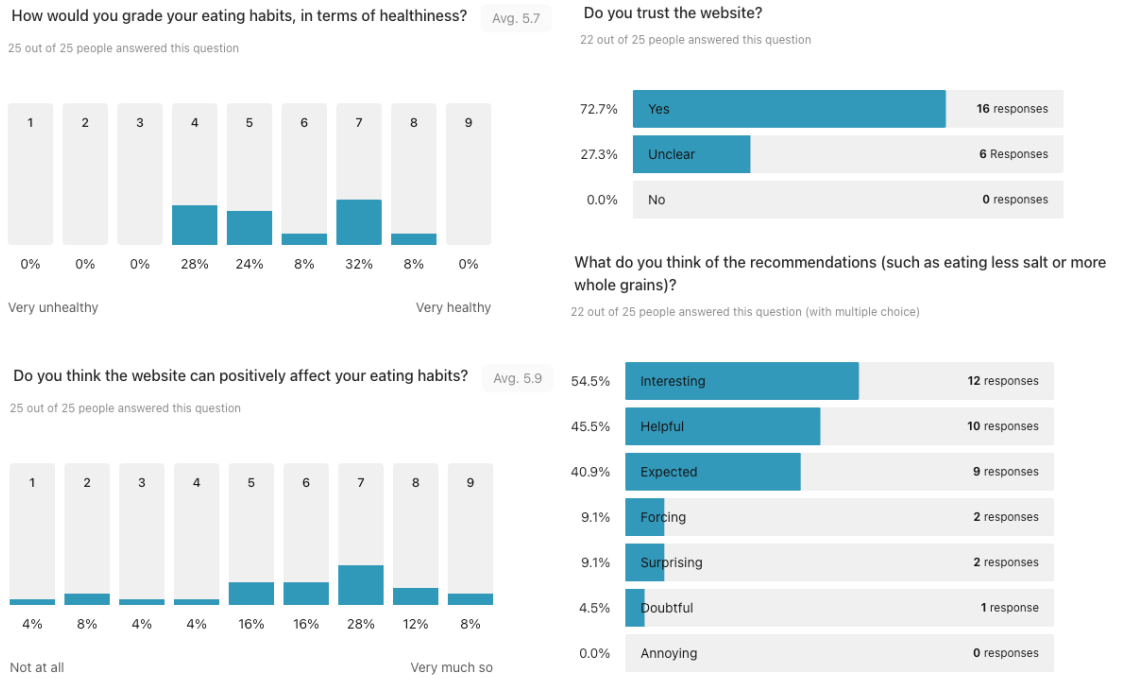


**Figure 7.13:** Result from second survey. Similar grading for healthiness of habits as first questionnaire (top-left). 27% of people was not sure if they trusted the website, 3 people did not answer (top-right). The average visitor thought that the website could be helpful (bottom-left). Most people had positive feelings about the recommendations (bottom-right).

### 7.4.2 Web Analytics

Web analytics was a way to gather data about user activity unobtrusively, given that ethical considerations have be taken and performance is not affected (Rogers et al. 2019, p.567). Indeed, every action was taken to respect user privacy, so analytics was less accurate in terms of, for example, identifying reoccurring users and geographical locations. However, enough insights could be made regarding what users interacted with, and which pages they visited.

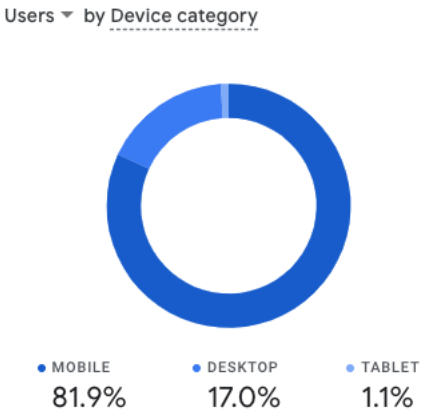


**Figure 7.14:** 81.9% of visitors were mobile users.

| | Page title and screen class | Views | Users |
|---|---|---|---|
| | Totals | 1,375<br>100% of total | 91<br>100% of total |
| 1 | Mat & näring | 516 | 90 |
| 2 | Matkorg | 152 | 9 |
| 3 | Grönsaker, baljväxter & svamp - Jämför näringsinnehåll | 71 | 16 |

| | Page title and screen class | Views | Users |
|---|---|---|---|
| | Totals | 223<br>16.22% of total | 21<br>23.08% of total |
| 1 | Banan - Näringsvärden | 21 | 1 |
| 2 | Majskolv - Näringsvärden | 17 | 4 |
| 3 | Granatäpple - Näringsvärden | 11 | 1 |

**Figure 7.15:** Views and users for different pages. Left table shows all views, right has filtered out food pages. Only 23% of users visited these pages.

The analytics revealed that only 23% of visitors had reached the individual food pages. This was bad because those pages were arguable the pages that contained most of the interesting visualizations. The issue was confirmed by reaching out to people that had visited the website, some of them was indeed not aware of the food pages. One big issue with the design was that the affordances and visual cues was only for desktop, and most visitors had been mobile users (see Figure 7.14, 7.15).

Additionally, the second most visited page was the "Food basket"-page where foods could be combined. The problem with this was that foods had to be added to the basket from the food pages before there was anything useful to display on this page, otherwise a placeholder image would be shown. All in all, the interface was not helpful enough to facilitate and guide the user through the relevant aspects of the content.

**Takeaways**:

1. *Complementing surveys with analytics can reveal more insights*
2. *People did not reach food pages, maybe they did not know they existed*
3. *Realization: Most visitors were mobile users, and affordances was mostly focused on desktop (see Figure 7.12)*

**Quick fixes**:
When these issues had been identified, changes were made instantly. Suggestions were added to the home page and affordances for list items were improved (see Figure 7.16). These adjust were made prior the upcoming usability study.

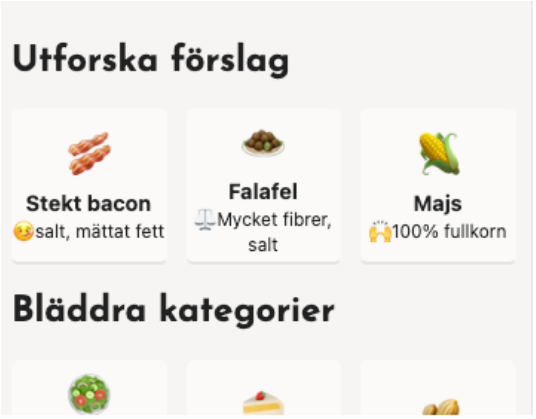



**Figure 7.16:** Suggestions were added to the home page, with some example foods exemplifying some data. Affordances for list items were improved on mobile.

### 7.4.3 Usability Study

The feedback from analytics and questionnaire was helpful but only gave a simplified and general impression. In order to further the understanding of visitor impression, some in-person usability studies were conducted. Three male students in their mid-to-late twenties participated on campus, two from the Interaction Design Master at Chalmers and one from the Computer Science program at Gothenburg University. The participants had no special relationship with the author, because that could have had affect on the feedback. Each session took around 40 minutes and consisted of warmup questions, an observation and a discussion at the end (see Appendix C).

During the observation, the participants were asked what they thought the website was about and what thought they could do on it. The participants were then asked to use the website to combine what they ate for breakfast and determine how healthy their breakfast was. After having used the website for about 10-15 minutes, the participants were asked some follow up questions relating to the use of the website.

Two of the interviewees really liked the aesthetics, colors, and animations on the website. One person was positively surprised with every new feature he identified. For instance, when he opened the input modal and changed weight for a specific food (presented in Section 8.1.5) he was amazed over how the visualization instantly transitioned to their new positions. In fact, all of the interviewees were positively surprised by this feature, even though some of them would have liked the option to choose preselected sizes.

One person was a non-Swedish person and meant that he could understand the content enough with his limited knowledge of Swedish just because of the imagery and visuals utilized. In fact, he said he could see himself use the website in the future. Another person did not see himself use the website, he thought that it had to do with shopping and the amount of colors and emojis was a bit too much for him. The most important identified issues and points of improvements are presented below.

Suggested improvements included:

- Save/share button on the combine page
- Add alphabetical sort to search results (same as suggested in Section 7.4.1)
- Recommend complements when DRI is not reached
- Be able to see e.g. how much B12 comes from each food when combining

Most important issues:

- Clarify the purpose of the website on the home page
- People are confused by the shopping cart icon
- Food category pages might not be helpful
- "Progress" of unhealthy foods (such as salt) should not be indicated with green colors
- Too much colors and emojis might be overwhelming and negatively affect visual cues
- Too much information in the slideshow can be overwhelming
- Too small emojis can be misinterpreted

## 7.5 Development: Second Iteration

It was clear that there were some issues with how the website was structured and presented. From the analytics, it had been found that many people did not reach individual food pages (see Section 7.4.2). The problem was that users had to go through categories to reach those pages. Furthermore, people could not not always find what they were looking for using the search and sort functionality. A big part of the website revolved around helping people find the specific food they were interested in, and it was therefore important to improve both search and filtering functionality.

This was the last development phase and lead to the final design. The resulting design will be presented in Chapter 8.

### 7.5.1 Revise Structure, Improve Performance

One reason why people did not reach the food pages was because the affordances were not clear enough. On category pages, visitors were presented with lists of foods, but it was not communicated that these were clickable. It had been avoided to use the conventional blue color for links. However, this was the case when focusing too much on aesthetics clearly affected the facilitation for exploration. Adjustments were made, and all links were made blue so that users clearly knew what elements were points of navigation.

The food category pages imposed a structure on the visitors that was found to be unhelpful. For instance, if the user navigated to the vegetable food group, they could only access foods from that category. They had to go back to the home page, and then go to another food group to look for different foods. To fix this, all categories were merged and *tags* were added allowing groups to be filtered using dynamic queries. This meant that all foods were now collected in one place and it would be easier for users to seamlessly find what they were looking for. However, this also introduced new challenges. Previously, SSG had been used because category pages could simply be pre-rendered by the server. Now, the user could apply thousands of different combinations of filters and it was impossible to pre-render all of those combinations.

The browse page had to be updated to use SSR instead. This way a new request was made to the server every time the user made changes to the search/sort/filter, and they would be served with only the top 20 results. All code that had previously been executed on the client-side was moved to the server-side. Consequently, the performance increased substantially (see Figure 7.17). The user did no longer have to do the hard work, but they also did not have to maintain a copy of the two thousand items in the food database. However, it was still more efficient to use SSG for all other pages. But because all other pages had access to the global drop-down search, they *did* have to maintain a copy of the whole database *anyway*. Having the server handle requests for each visitors whenever they changed one character in the search input would simply be too costly. A work around was implemented. The user *would* hold a copy of the database, *but* a minified version would be used, only containing what was necessary for the global search (food names and food category).

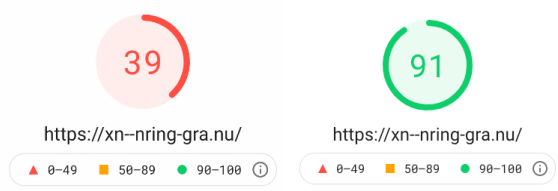


**Figure 7.17:** Performance was substantially increased by letting the server handle the filtering, sorting, and searching functionality. Courtesy of Google PageSpeed.

### 7.5.2 Search and Sort

In addition to making it easier to filter out foods, efforts were spent on improving both search and sort. People had complained, both in the questionnaire and in the usability study, that the search was not working as they thought and that it was hard to navigate the results. The search was indeed very basic, it identified food names that contained the exact search term meaning that searches like "cooked egg" would not match with the food name "egg cooked". The search functionality was improved by splitting up the words of the search term and looking for matches of words instead of the whole string.

Another challenge with the search was that it also had to manage to sort to give relevant results. For instance, if the search was "egg", it was likely that the user searched for cooked or boiled egg, but the first result might be a dish that contained an egg. Therefore, it was important to sort in accordance with exact matches. Furthermore, a search term should also affect how the result list was sorted. If a food name had two words that matched the words in the search term, it should be displayed above a food name that only matched with one word.

In addition to modifying the search, alphabetical sort was implemented as suggested by user feedback (see Section 7.4.1 and 7.4.3).

### 7.5.3 Better Integrate Narrative

User feedback had suggested that it was not clear to some people what to do with the provided information in the slideshow (see Section 7.4.1). Additionally, usability studies had suggested that the interface did not always clearly explain what was the good and the bad aspects of different foods (see Section 7.4.3). In addition to the slideshow, more emphasis was therefore put on visual narratives and guiding the user. Emojis and colors had been used as a way to double-code the different elements of the website, now they were also utilized as a means of clarifying what the good and the bad aspects were. For instance, salt and saturated fat were indicated by thumbs down emojis and red colors, while wholegrain and fibres where indicated with thumbs up emojis and green colors.

These aspects were reinforced on all pages of the web interface so that the red thread would be clear, and the overarching narrative would be more integrated with the interface as a whole. On the food page, important aspects to consider when deciding what foods to eat were also clearly indicated with vertical bar charts. For instance, if a food, or combinations of foods, contains more than the suggested intake of salt, then this is indicated by a red and glowing color around the bar chart for salt.

### 7.5.4 Implement Settings

From the user research, people had suggested interest in getting more personalized content and information that were relevant to them. Because of time limits not much time had been spent on implementing such features. It would simply take too much time to consider all different variations of content to display. However, daily recommended intake is very dependant on age and sex, and this was an important aspect worth spending some time on. The data related to intake was therefore complemented with specific dietary intake suggestions for the different groups.

The global navigation was complemented with a user icon, leading to a modal where users could update their settings. Upon changing these parameters, the recommended intake of micronutritions would be adjusted accordingly.

### 7.5.5 General styling

Some general styling were made to clarify the overall interface. For instance, some people from the user feedback showed some confusion in regards to the "food basket"-icon. This icon made it seem like the website had something to do with consumption. The icon was therefore replaced with a "cutlery"-icon, which would instead indicate having to do with consuming food. Furthermore, some color adjustments where made. Some were toned down a notch, not to be distracting or frustrating, and others were replaced. Every link was also made blue so that it was very clear what could be navigated.

# 8
# Results

The results consists of an functioning web interface along with techniques and considerations responding to the following research question:

*What are some useful techniques and important considerations when balancing the act of presentation and interaction, to facilitate engagement, in data-driven web interfaces?*

## 8.1 The Web Interface

The web interface is the final artifact. It contains, and thus contextualizes, some techniques utilized (see Section 8.2) and can help give context to the considerations (see Section 8.3). The full website is published and can be accessed, at: www.näring.nu.

### 8.1.1 Technical Specification

The web interface was developed with Next.js, JavaScript, CSS and HTML (see Section 7.1.2). Visualizations were done with pure CSS/HTML or D3; animations with third-party libraries Framer Motion, React-Spring or D3; and tooltips with third-party library Tippy.js. Unicode emojis, Google icons/fonts, and clipart from www.openclipart.org was also used. States (such as age/sex) are stored in localStorage, on client-side, using the state management library Zustand. Food data comes from Livsmedelsdatabasen (2021) and dietary suggestions from NNR (2014).

### 8.1.2 Global Navigation

At the top of the web interface is a global navigation (see Figure 8.1). Here visitors can navigate to the home page, modify settings, search for foods, or access the page where foods can be combined (see Section 8.1.6). Icons are used to visually communicate functionality, allowing for quick interpretation and saving up screen space on mobile devices. Whenever states or settings are modified, the global navigation is updated and changes are indicated accordingly (see Figure 8.2).


**Figure 8.1:** A global navigation provides quick access to some important pages and functionalities.

The search bar show drop-down suggestions according to user input and thus gives direct feedback (see Figure 8.3). In the drop-down list any food item is presented with its corresponding food group, so that users can better determine if the result is what they were


**Figure 8.2:** State changes appear directly in the navigation. Here the user have changed the sex to female, age to 28, and added four foods to combine.

looking for. On smaller devices, the search will take up the whole width of the navigation (on input), hiding all other icons the navigation so that the whole screen-width is utilized.

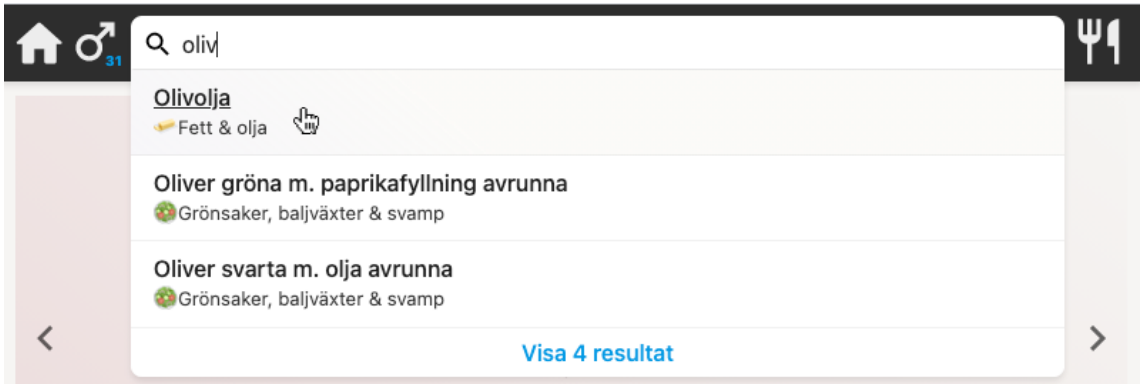


**Figure 8.3:** A global search uses a drop-down list to provide suggestions and quick access to all of the foods in the database.

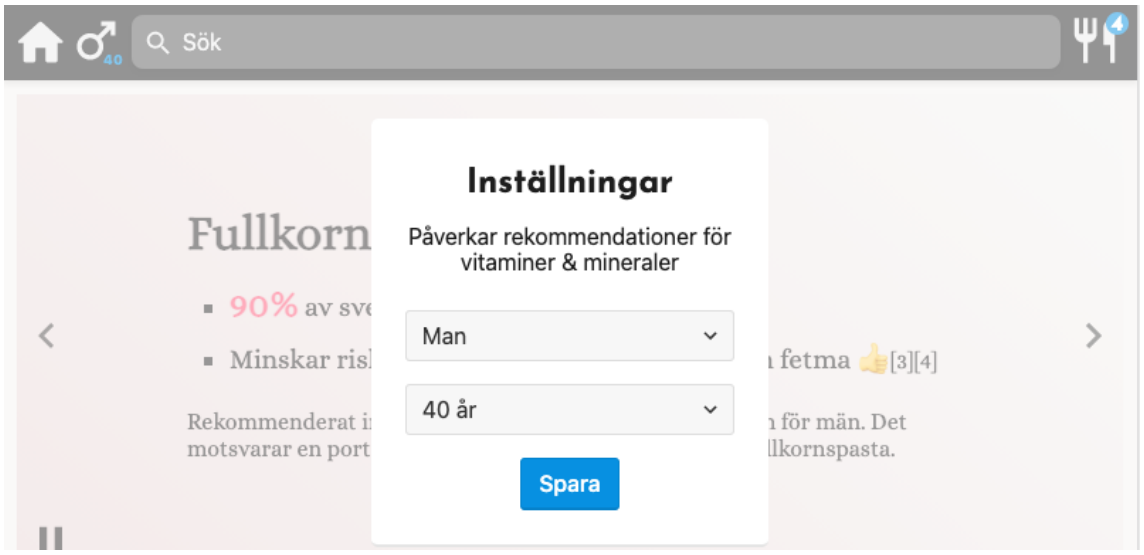


**Figure 8.4:** The settings modal can be accessed from the global header. It is used to modify the recommendations that appear on the website.

Between the home icon and search-input is an icon representing the user setting. When clicking this icon, a modal appears on top of the web interface (see Figure 8.4). Changes to these settings will directly affect the micronutritional recommendations on the food page (see Section 8.1.5). Hence, any changes directly impact what is being presented. Inputs are made with classic HTML select/option, and any browser will therefore utilized its built in functionality (improving on accessibility regardless of device). Whenever values

are changed in this modal, the icon and number in the header is updated accordingly (see Figure 8.2).

### 8.1.3 Home page

The home page is the first page that most new visitors will be presented with. It contains a slideshow on top, presenting the impact of healthy and unhealthy habits; and provides some points of interest below the slideshow, where the user can start their journey of exploration (see Figure 8.5).

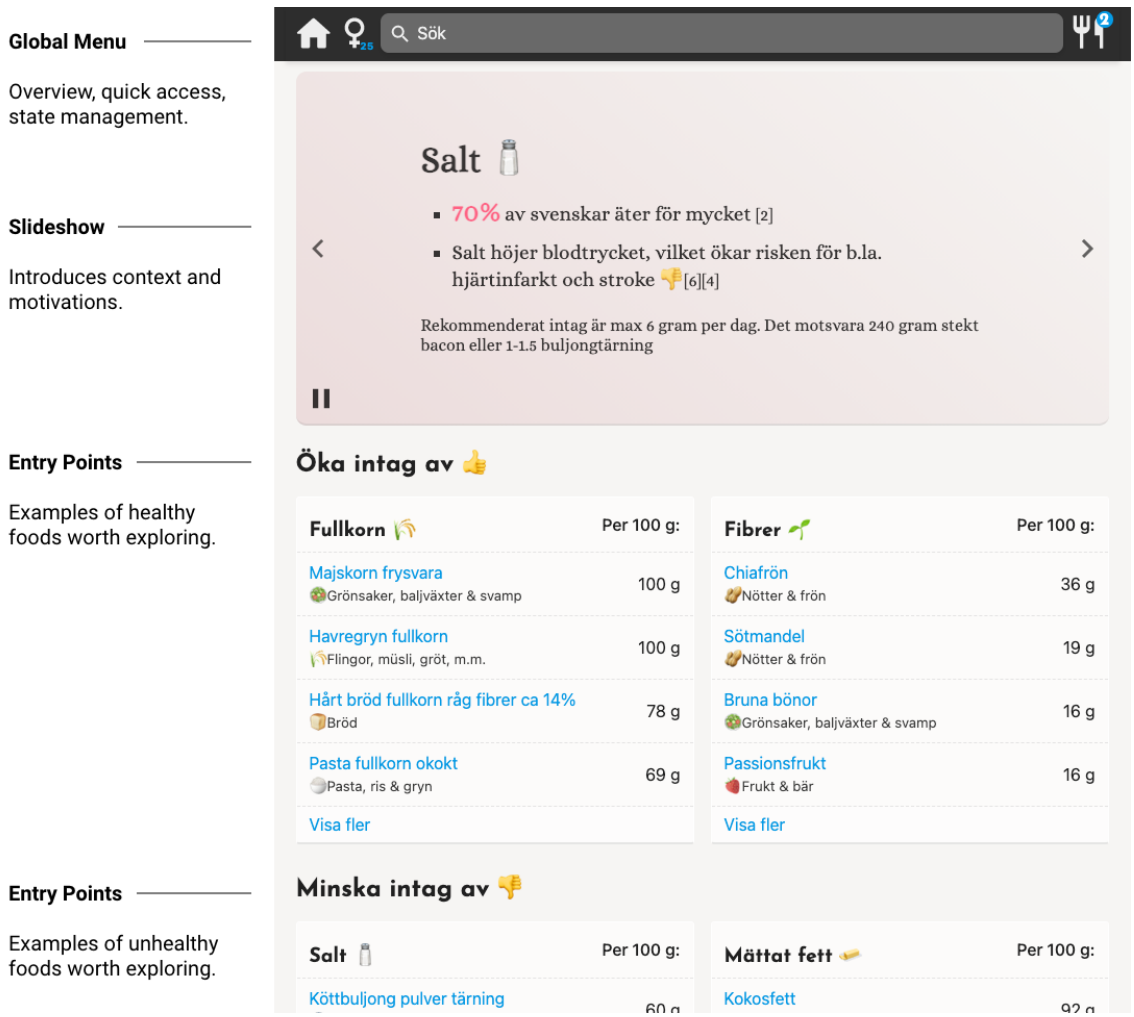


**Figure 8.5:** The home page provides an overview of the functionality and a type of summary of information available on the website.

The animated slideshow present some of the most important information found in the data gathering. It relates specifically to the outcome of good and bad dietary habits, as well as relaying information about Swedes current habits. Scaled up numbers are used to reveal some problems, for instance that 70% of people eat too much salt, and emojis (such as a thumb-down emoji) emphasize what is good or bad. The slideshow automatically transitions between slides, saving up screen space and introduces depth in the form of motion and temporality. Controllers are available to give the visitor a sense of control over what is being displayed. The slideshow can be paused and slides can be toggled laterally.

Cards with links below the slideshow provide *entry points* (see Section 8.2.2) and suggestions worth exploring. These suggestions directly relate to what is presented in the slideshow, and thus help users contextualize information and explore content relating to it. For each card, a "show more" button appears at the bottom, which navigates the user to the browse page (see Figure 8.6) where they find more items from the respective categories. This will allow people to further explore specific aspects of interest to them.

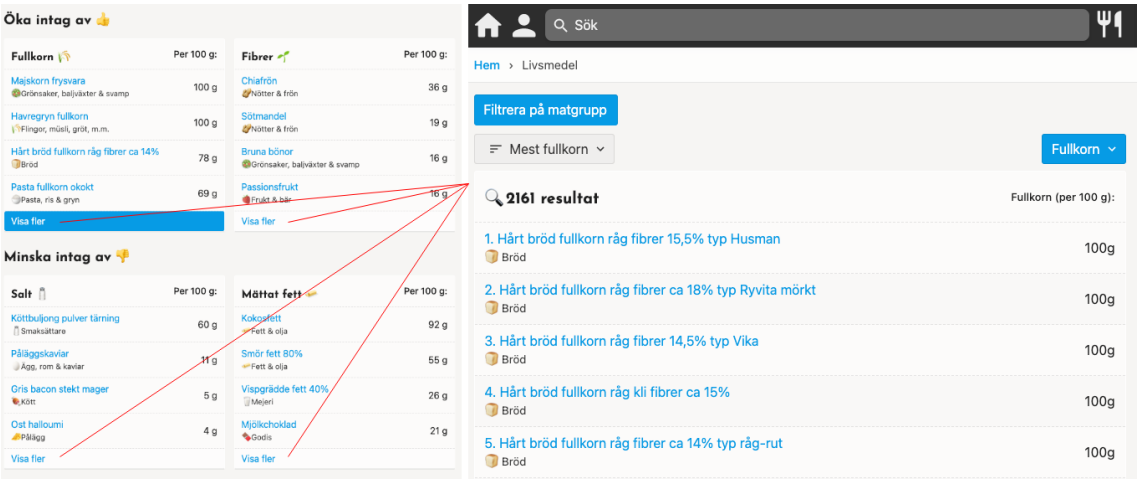


**Figure 8.6:** Clicking any of the "visa fler" ("show more") buttons navigates the user to the browse page. In this example the visitor pressed the button under wholegrain.

### 8.1.4 Browse Page

On the browsing page, visitors have access to all food items and can filter or sort the results according to food group, search, or nutritional content (see Figure 8.7). This page is accessed by pressing the "show more" buttons on the home page, through a search, or by interacting with the breadcrumbs on the food page (see Section 8.1.5).

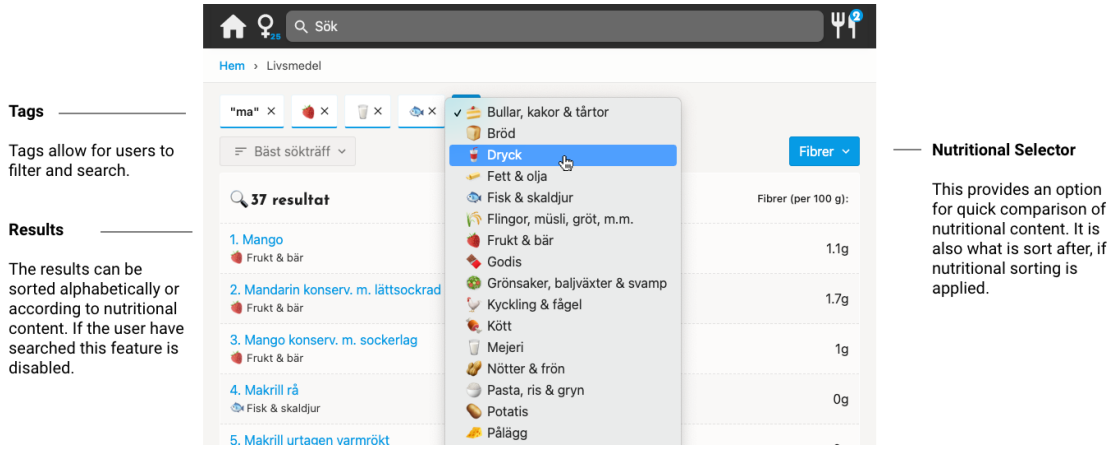


**Figure 8.7:** The browse page allows the user to explore the complete data set. In this example the user have searched for the term "ma"; filtered on fruits & berries, dairy, and fish; and chosen to see fibre content.

Filter-, sort-, and search- functionality provide *dynamic queries* (see Section 8.2.3) and facilitate for exploration according to need or interest. The user can provide a search

term, filter on food categories, or sort on different components. If the user arrives at the page from searching, the result will be sorted by "relevance", and the sorting can only be changed if the search term is first removed (see Figure 8.7). To give relevant search results the items had to be sorted, and letting the user change the sort after the search would remove that effect. If the user has not searched for anything, the list will be sorted by "most nutritional value" according to what nutritional component have been selected but they can also sort for "least nutritional value" or "alphabetically".

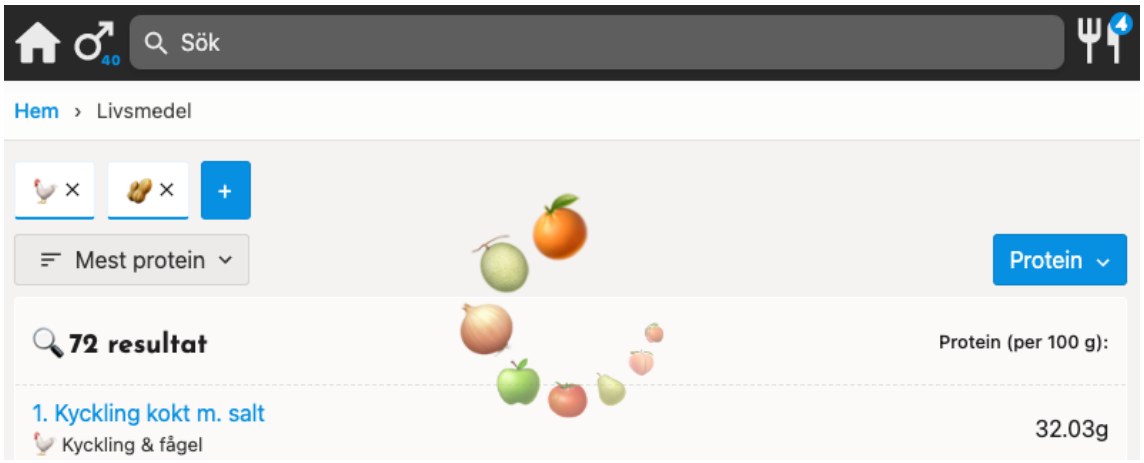


**Figure 8.8:** Whenever the query changes, a request is made to the server and a loading spinner is shown to indicate that new data is loading.

Whenever filter-, sort-, or search-functionality is changed a new request is sent to the server (see Figure 8.8). This way, the user only has to hold a copy of the 15 most relevant results of the query and the the server is responsible for doing the hard work, resulting in less data used and improved performance. Since the server does the work, there might be a bit of delay before the user retrieves the result, and a loading spinner is used to indicate this (see Figure 8.8).

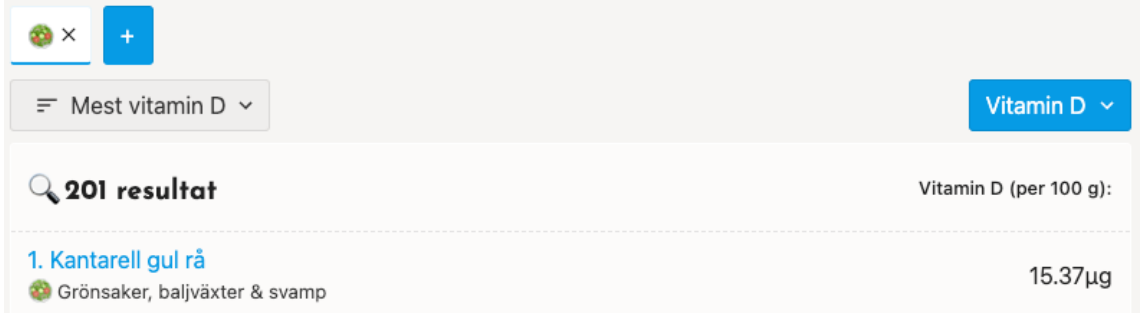


**Figure 8.9:** Example usage of a visitor looking for vegetarian food containing vitamin D.

The idea behind the browse page is to facilitate for various different needs by letting the user decide what to query for. In Figure 8.9 one example usage is presented, where the user is looking for vegetarian food containing vitamin D.

### 8.1.5 Food Page

The food page provide more details regarding nutritional values for specific foods. On top is a a breadcrumb allowing for lateral navigation while also revealing relationships of the data. Under the breadcrumb a header with the food name and food category is also presented. Below the header are some of the most important recommendations first presented in the slideshow on the home page (see Section 8.1.3). Hence, these recommendations are reinforced and emphasized, specifically through usage of visual narratives (see Section 8.2.1). For instance, chia seeds contain a lot of fibres which is good for health and thus indicated with a green bar chart and an accompanying emoji (see Figure 8.10).

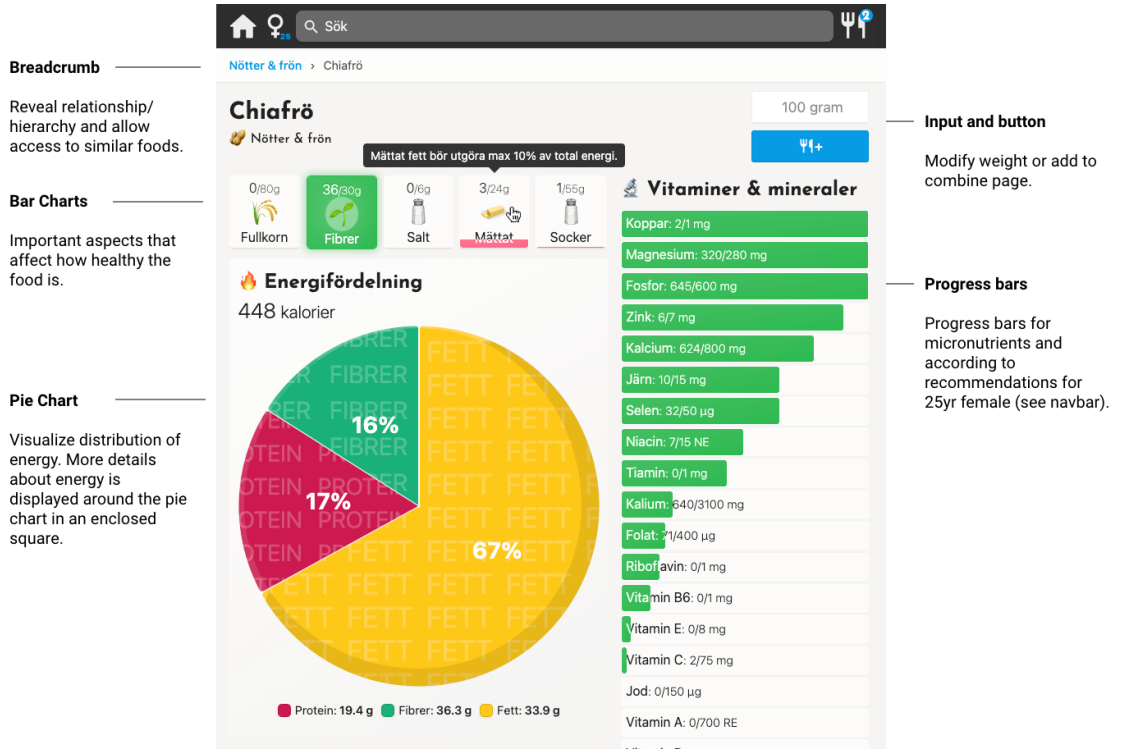


**Figure 8.10:** The food page provides a more detailed visualization interface with some of the most important information.

Progress bars are used to indicate progression towards daily recommended intake. Additionally, a conventional pie chart is used to display distribution of energy. Color-codings are used not only to emphasize good and bad, but to categorize the different parameters, such as fat, protein, and fibre. Furthermore, textures in the different slices of the pie chart additional coding. Hence, none of the text, percentages and emojis take up any extra space, since they are presented on top of the charts, but they provide further details and clarification. These are helpful not only for users to quickly verify the different categories but also in terms of accessibility (such as colorblind people).

The food pages also provide tooltips (see Figure 8.10). Tooltips appear when hovering on desktop or touch on mobile and provide additional information and "the physical proximity advantages of labels without the clutter" (Tidwell 2020, p.446).

Visitors can modify the weights of foods with the provided input modals. When clicking

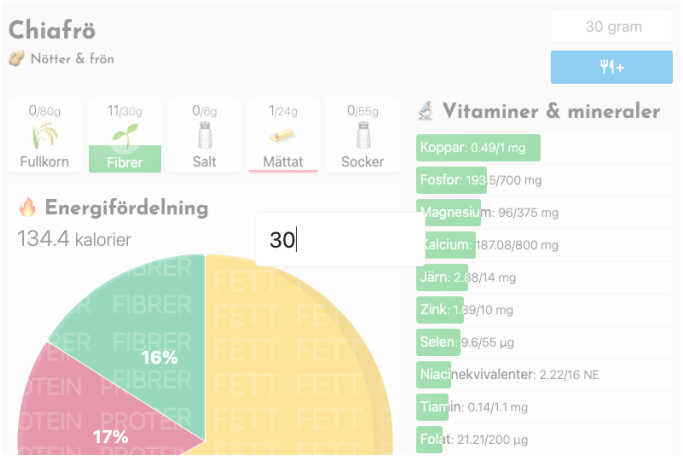


**Figure 8.11:** When pressing the box in the top right corner a modal appears on top of the web interface. On input change the visualizations and numbers in the background update directly.

the "100 gram"-box in the top right corner (see Figure 8.10), an input modal appears on top of the page and a transparent background is added. By changing the number in this input, users can directly manipulate (see Section 8.2.4) the visualizations and information provided in the background (see Figure 8.11). It is hard to convey this with images in a report like this, but just imagine how the progress bars animates and transitions according to the user changes. This provides a playful experience, lets the user understand the underlying functionality, while not requiring them to move between different pages or wait for new content to load.

Below the button which opens the input modal there is a cutlery icon, pressing this icon will add the respective food to the combine page. By then pressing the top right cutlery icon (in the global navigation), the user can navigate to the page where foods are combined.

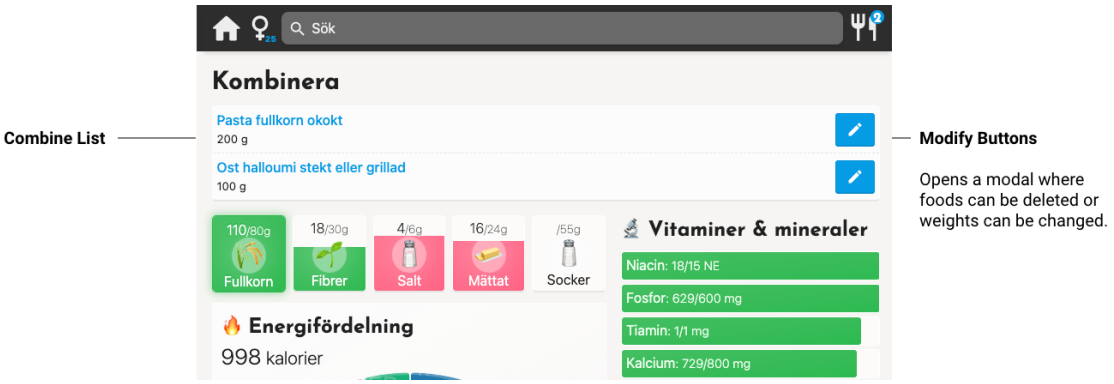


**Figure 8.12:** On the combine page users can create meals and see a summed values and visualization representing aggregate information.

### 8.1.6 Combine Page

The combine page (see Figure 8.12) provide an additional tool for people to explore and combine foods according to their interest. For instance, they can combine and calculate the foods they had for breakfast. The page looks exactly like the food page, maintaining

a consistent structure, but also provides a list where the user can see, and modify, what items are currently combined.

## 8.2 Techniques

In this section, some helpful techniques that were identified during this project are presented, namely: *visual narratives*, *entry points*, *dynamic queries*, and *direct manipulation*.

### 8.2.1 Visual Narratives

Early on, data-driven storytelling had been explored as a means of making data more engaging and relatable (see Section 3.2). However, it was not clear how to compose a relevant and engaging story that was also ethical. Creating such a story often requires the collaboration of interdisciplinary teams (see Section 3.2). A co-creation workshop and initial development revealed many possibilities of what a story could look like, but did not make it easier to decide on the right approach (see Section 7.2.2, 7.3.2). Heuristic evaluation (see Section 4.3.10), and revision of the literature relating to web interfaces, made it clear that adhering to any conventional storytelling framework was not as important as having a clear and meaningful structure of the web interface. It was determined that incorporating a story might best, and most conveniently, be done through the utilization of *visual narratives* such as icons, emojis, and colors.

Visuals and images was something that had been asked for in early user research (see Section 7.1.4.1). Visual narratives thus had the potential to meet the needs of potential users, but since they provided additional encoding they could also improve on both comprehension and engagement. The availability of emojis through the utilization of Unicode made it possible to create a visual vocabulary that could connect text with real world symbols (see Figure 8.5). For instance, a *sheaf of rice* emoji and a *plate of butter* emoji connects words with imagery and contextualizes the words wholegrain and saturated fat; consequently, improving data literacy. Furthermore, colors, different fonts, and font sizes helped emphasize what aspects of the information that deserved extra attention (see Section 7.3.5).

An emoji of salt in combination with "70%" in red, in combination with and a thumbs-down emoji could more efficiently communicate the important narrative than text alone. Indeed, user feedback suggested that this way of presenting information was appreciated and people generally liked the aesthetics, emojis, and design (see Section 7.4.1, 7.4.3). Furthermore, while the more playful design had the potential to improve on clarity (user feedback suggested) it did not come at the cost of trustability.

User testing suggested that visitors found the information presented on the home page useful but was not always sure what to make of it (see Section 7.4.1). Visual narratives were helpful in this regard, as they were easy to reuse and information could be emphasized on multiple occasions. For instance, the health benefits of fibres could be presented with accompanying emojis and heart symbols in the slideshow, and similar visual narratives could then be emphasized below the slideshow on the home page and at the top of the food pages (see Figure 8.13).

In summary, trying to adhere to a storytelling framework might require expertise and


**Figure 8.13:** Visual narratives are used to emphasize the good or bad, and to introduce a visual vocabulary. Here is an example of how a colors and various emojis were utilized on multiple places to present information relating to fibres.

introduces interdisciplinary challenges. Visual narratives, on the other hand, are more easy to implement but can still complement and enrich presentations without imposing any strict flow of interaction on the user. In interactive interfaces, presenting rich and vivid information like this has been "significantly correlated with user enjoyment, positive attitudes, and desirable behavioral intentions" (Yang & Shen 2018). All in all, visual narratives can help connect with the human experience and consequently make presentations more efficient and effective both in terms of comprehension and engagement (see Section 3.1.1, 3.2.3).

### 8.2.2 Entry points

First-time visitors need to be guided in what they can do, and are best served by reading "introductory text" or "doing an initial task" (Tidwell 2020, p.143). *Entry points* can be seen as on type of initial task, providing "doors" of exploration into the main system. Indeed, solely providing introductory text in the slideshow was not enough in this project, since many people did not know how to apply that information (see Section 7.4.1). The issue of not providing enough examples was further underlined when web analytics revealed that most people did not reach the pages where information was contextualized (see Section 7.4.2).

Providing a hierarchical structure with links to category pages from the home page was a decision made in response to the issue that the hierarchy of the web interface was not clear enough (see Section 4.3.10). It was assumed that copying the structure of the underlying nutritional database, and providing categories such as vegetables and meat, could help clarify what could be explored on the website. The problem with this approach was that accessing specific food pages was now one step further away, users had to first go through the category pages. Furthermore, users desire to be presented with suggestions and comparisons (see Section 7.1.4.1) was not being accommodated for.

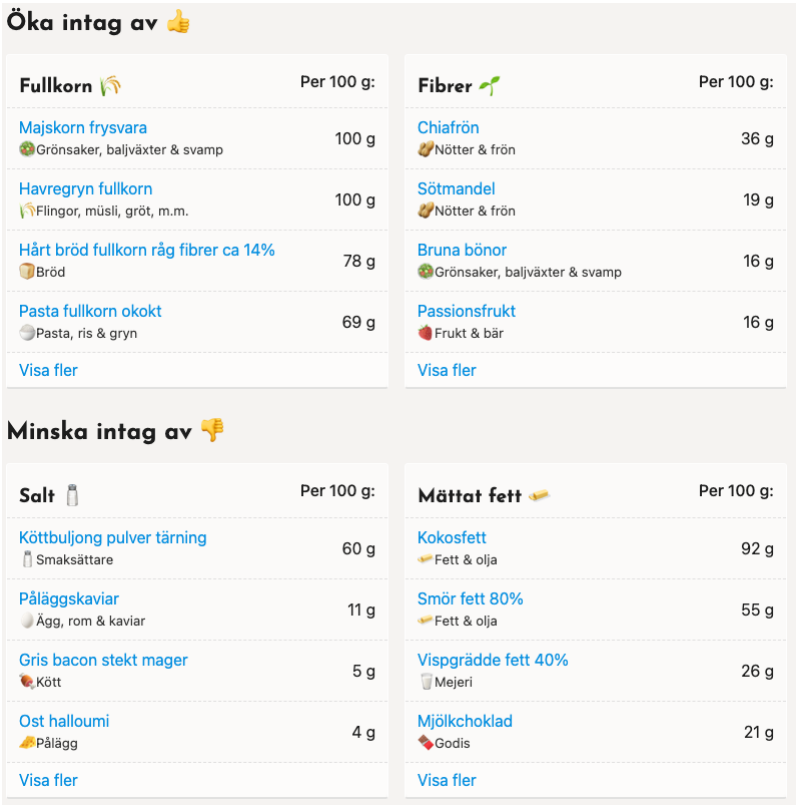


**Figure 8.14:** Entry points provide points of interest on the home page. They provide suggestions relating to information in the slideshow and helps quick start the users explorative journey.

Responding to the structural issues (identified in the later user testing, see Section 7.4), entry points were added to the home page. Entry points meant that the information presented in the slideshow would be contextualized and direct links to the suggested points of interest were now available (see Figure 8.14). Entry points thus better accommodated the users needs (see Section 7.1.4.1), and contributed with "initial tasks" by providing suggestions worth *drilling down* into (Tidwell 2020, p.143-147). Furthermore, providing direct access to specific "end nodes" of the system, rather than category pages, would arguably increase the chance of users identifying the pages where information was contextualized.

In summary, people want to be served with important information and suggestions and entry points can be helpful in this regard. Entry points provide a presentation of relevant content but also facilitate users in their exploration and engagement with the content of the website. Furthermore, according to Kirk (2016) we should try to minimize the number of steps users have to take in their quest of achieving understanding, and entry points help cut out any intermediate steps.

### 8.2.3 Dynamic Queries

In this project a database was utilized containing 2245 food items (see Section 7.1.3). It was clear that in order to provide helpful explorative features, a search functionality would be necessary (see Section 7.2.1, 7.3.1). However, according to Nielsen (2000) there are "link-dominant" people in addition to "search-dominant" people, and these groups are approximately equally distributed. Hence, search might not always be the preferred way of exploring information, but providing 2245 different links did not seem to be a useful

alternative either. This is an example where *dynamic queries* came in handy.

Dynamic queries provide functionalities that encourage exploration of a data set (see Section 3.3.6). In the first half of the development dynamic queries where only utilized half-heartedly. Food lists could be sorted but there was no way for users to filter out foods according to their needs and wants (see Section 7.3.5). For instance, rather than allowing users to dynamically filter out lists according to the different food groups, they had to navigate to the different food pages manually. This required more work from users because they had to navigate between pages, and it probably contributed to the fact that users where less prone to identify the different individual food pages (see Section 7.4.2).

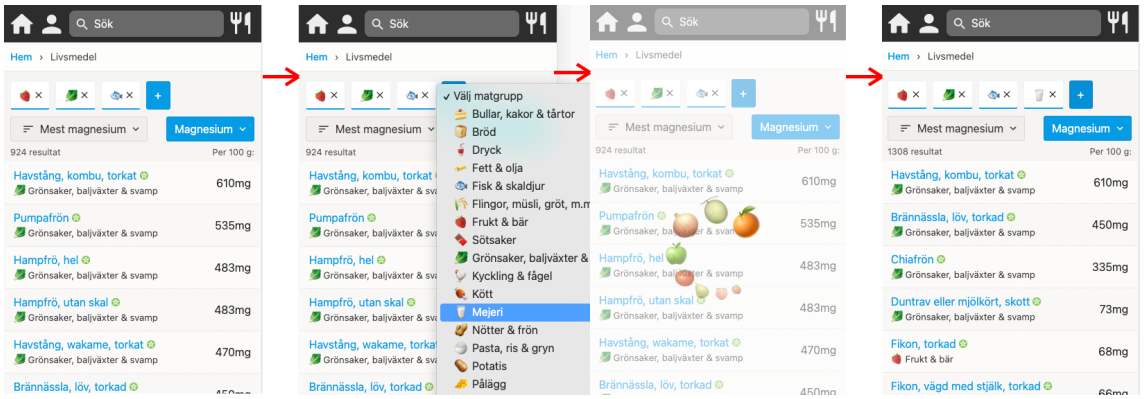


**Figure 8.15:** Dynamic queries allow users to filter out the foods that they are interested in. By allowing access to all foods and multiple filters, the interface helps the user find what they are looking for. When the query change, a request is sent to the server and a spinner is indicating that new content is loading.

In this project, user feedback from both questionnaires (see Section 7.1.4.1) and interviews (see Section 7.4) had suggested that there were issues both with the search and sort functionality, so clearly these were important functionalities to people. Responding to these, search functionality was improved and filtering functionalities were implemented. Filtering functionality meant that there was now only one page where all foods where listed (rather than one for each food category) and items could be filtered out according to user needs (see Figure 8.15). This was clearly an improvement in terms of exploration, and it meant that users were less likely to get lost in a confusing hierarchy (see Section 7.5.1).

By combining all different list pages into one and making it accessible from various page, the resulting browsing page worked like a hub. Visitors would get there by clicking breadcrumbs on the food pages, searching, or clicking "show more" on the home page. This allowed users to more quickly become familiar with the system, thus improving presentation; but it also allows users to more easily identify and find information according to their needs, thus improving on exploration.

### 8.2.4 Direct Manipulation

All of the input modals in the web interface provide *direct manipulation*, meaning they immediately communicate changes on screen (see Section 3.3.5). For instance, the user can modify the weight of a food (see Figure 8.16) and any charts or numbers will immediately update accordingly. Similarly, the user can search for different foods and the

drop-down suggestion reveals the top results in real-time (see Figure 8.17). These types of features makes it easy for users to learn the underlying functionality and better understand what effects their actions have on the interface. Ultimately, this is a type of feature that help facilitate situational awareness, mastery, and enjoyment (among many other things) (Shneiderman, 1997; Jones & Endsley, 2000).

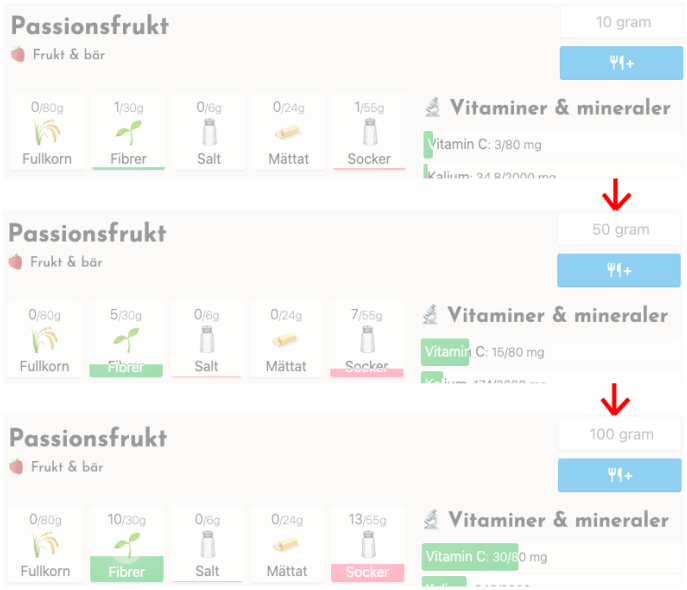


**Figure 8.16:** The user is changing the weight from 10 to 50 to 100 grams and, in the background, the different bars update in real-time.

The powers of direct manipulation were realized both through literature study (see Section 3.3.5) and by playing around with animation libraries (see Section 7.3.1, 7.3.2). Without the use of animation, the effect of direct manipulation would arguably not be as convincing. Furthermore, it was through understanding the different use cases of server- versus client-side functionality that it was understood how and when direct manipulation could be utilized. For instance, if new content was requested from the server (rather than manipulation on client-side) loading times would be involved and consequently the manipulation would not be direct (see Figure 8.8). Hence, it was because of the evaluation of SSG and SSR (see Section 7.1.2, 7.5.1) that direct manipulation was made possible.

There was not enough time to conduct a final evaluation with real users in this project. However, all of the participants of the usability study (see Section 7.4.3) were positively surprised by the direct manipulation on the food page (see Figure 8.16), and its hard to argue against its usefulness.

In summary, direct manipulation facilitates both engagement and exploration while maintaining the current context and demonstrating what effect the users actions have on the system. Indeed, Ware (2021) suggest that an interface should provide "a single unobscured screen to support essential monitoring tasks", and with direct manipulation this is possible. Furthermore, direct manipulation minimizes the number of steps that users have to take in order to achieve their goal, consequently reducing the cognitive load (Tidwell 2020, p.133-134).

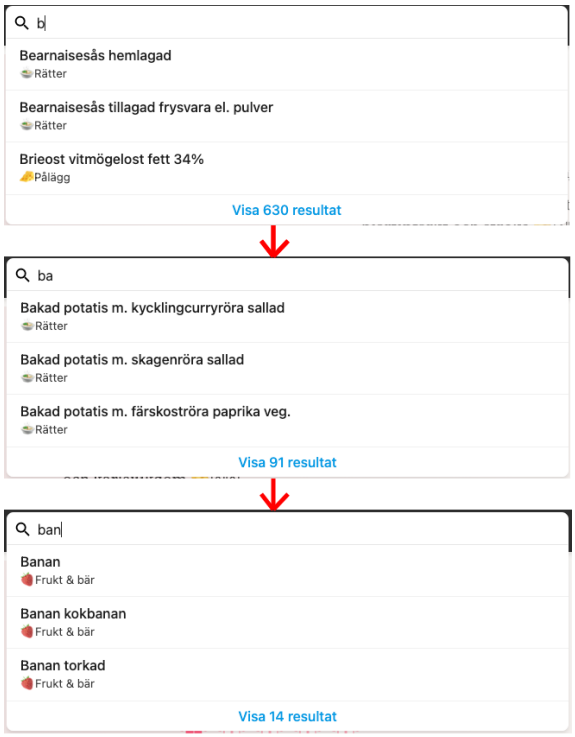


**Figure 8.17:** The search provides direct access to all foods in the database. On input, suggestions appear in real-time, helping the user to find what they are looking for.

## 8.3 Considerations

Two important considerations when balancing the act of presentation and interaction became apparent in this project: *technology* and *an iterative workflow*.

### 8.3.1 Technology

As opposed to papers, computers allow for invaluable interaction and manipulation that can help the user draw new connections (Tidwell 2020, p.433). The *user* can be seen as the person we are designing for, but this thesis arguest that the user can also be the *designer*. Most interactions today are made using technology, and as designers we can benefit a lot from improving our understanding of new technologies and tools. It is only by using and experiencing these tools directly, that we can understand their inherent potentials. For instance, in this project the author became familiar with concepts like SSG and SSR, and was introduced to various animation and visualization libraries. Different tools have different possibilities and limitations and thus directly impact how the final product will look and behave. If tools and technology had not been considered early on (see Section 3.5) the final web interface would arguably not be as sophisticated and dynamic as it is. Furthermore, it was only understood what direct manipulation could look like, and how dynamic queries would work, through experience with these tools and frameworks. Such understanding could not come from simply creating static low-fidelity prototypes.

Additionally, making a functional interface made it possible to publish the web interface and make it available to the general public (see Section 7.4). Because of this, it was possible to implement web analytics and observe issues that might not have been identified otherwise (see Section 7.4.2). A functioning interface meant that real interactions could

be observed and issues with functionality such as search and filtering could better be understood and improved (see Section 7.3.4, 7.4.3, 7.3.5).

It might be possible to prototype animations, transitions, and dynamic queries, but it would require a lot of time spent on creating representations that would not be used in the end. This is problematic because even though a solution might be deemed useful based on the test results of prototypes, it is not guaranteed that the designs are actually implementable. By programming these features directly in code, limitations and possibilities could be understood simultaneously to progress towards a final product. Furthermore, it was by testing out different libraries that it was realized that some libraries were not compatible with external features such as tooltips (see Section 7.3.2). Having realized this in later stages would make changes more costly.

Even after having decided on the framework for this project, more decisions had to be made that would directly impact what interactions that the user could have. For instance, it was decided to improve the structure on the website by adding category pages (see Section 7.3.5). This meant that SSG could be utilized (allowing for better performance), but it also meant that users had to manually explore different category pages to identify what food they were looking for. By understanding the underlying technology, it was realized that dynamic queries with a server-side approach would be more beneficial (see Section 7.5.1). In regards to technology, there are always more important decisions to be made and trade-offs have to be continuously be evaluated.

Indeed, a lot of considerations of modern web interfaces relate to what should be handled by the server versus the client (see Section 3.5). These decisions do not only affect what type of interactions will be used, but also affect how the interface responds, and how the website can be structured. Client-side logic means that pages are pre-rendered and made static, and all content is loaded instantly. No loading indicators or spinners will be necessary, and direct manipulation can be achieved. On the other hand, all calculations have to be done by the client device which can be costly. Furthermore, if a static page includes a global search functionality, the client needs to maintain a copy of everything that can be searched for and a lot of network traffic will be consumed. Such performance issues was identified and fixed in the later part of this project (see Section 7.5.1). Again, this was something that was only realized by working so closely with technology.

### 8.3.2 An Iterative Workflow

In this project, an iterative workflow meant stepping back from development and revising or reconsidering different theories; but it also meant to invite people in the role of designers and testers. Although these things depended on each other, they could not possibly be done simultaneously and therefore they had to be iterated. Maybe most importantly, an iterative workflow meant that everything could not be prepared for but must be understood through experience and exploration of various tools and applied theory. Only after having acquired such experience can informed decisions be made.

The initial user research gave an understanding of potential users along with their attitudes and goals (see Section 7.1.4.1). To understand how these needs could be met, technology had to explored and an understanding of nutritional data had to be gained (see Section 7.1.3, 7.1.2). This introduced new challenges in terms of how to present information and

what visualizations to utilize (see Section 7.2, 7.3.2). User needs had to to be re-iterated and re-evaluated through heuristic evaluation and user testing based on new understanding of technology and theory.

The heuristic evaluation was conducted to reflect on the structure of the web interface after initial development (see Section 4.3.10). Usability principles by Krug (2014) was considered and it was understood that the current home page was not clearly communicating what the purpose of the website was and what could be done. The importance of having a helpful home page was further emphasized after gathering of web analytics, revealing that many people did not reach the most important pages (see Section 7.4.2). Without external feedback, such issues would either take very long time to realize, or not be identified at all. Furthermore, both informal and formal feedback made it clear that the search functionality did not work as people expected (see Section 7.3.4, 7.4.1). To fix these issues another iteration of development had to be conducted (see Section 7.5.1).

What information to present cannot be understood without an understanding of what tools we have to work with, how the data looks like, and understanding of user needs. "Good designs often arise from trial and error in communities of users interacting on various tasks" (Riche et al. 2018, p.42). In this project, it was identified that some people expect search to work differently than it did and some people were confused with the meaning behind some of the icons (see Section 7.4). Furthermore, a hesitance to use the conventional blue color to indicate clickability seemed to come at the cost of people not knowing what they could interact with. It is simply impossible to predict all such issues without any user testing. Instead, we should strive to test early and maybe lower our standards on who we test with, the important thing is that we get as much feedback as possible (Krug 2014, p.222).

In summary, any development requires iterative work in order to gain perspective and understanding on the various aspects that will impact the artifact. As designers we learn by doing and often times the right solution comes from testing out many different alternatives. Humans are complex and unpredictable, their behaviours have to be observed and understood within each context. Arguably, good websites can best evolve through playful interaction with tools and consideration of useful theories and techniques.

# 9
# Discussion

This project revolved around answering the following question:

*What are some useful techniques and important considerations when balancing the act of presentation and interaction, to facilitate engagement, in data-driven web interfaces?*

Answers to these questions emerged through the process of creating a functioning web interface. Many things affected the outcome of this project, and these are expressed and emphasized through a contribution of techniques and considerations. The project touched upon multiple disciplines such as data analysis, programming, interface design, and information visualization; and the insights are therefore general and broad rather than specific and detailed. Because of this more broad and overarching approach, considerations and techniques are deemed to be helpful and applicable in general for teams and individuals that want to create engaging, data-driven web interfaces.

## 9.1 Results

### 9.1.1 Web Interface

The web interface presents the final artifact and contextualizes the insights and techniques utilized in this project. The techniques and functionalities are chosen based on realizations relevant to this specific project and are not necessarily the best choices for other projects. However, in addition to the web interface some specific techniques were picked out, and they are deemed applicable in general.

Given the time limit of the project, and because of new challenges that emerged, it was not possible to conduct a final evaluation as planned. Instead, with the resulting interface, evaluation and conclusions about the effectiveness and efficiency of the results depend on the authors personal opinions. However, the web interface got mostly positive feedback from the usability study, and changes made after that are based on issues identified from user testing. Furthermore, most of the techniques and design decisions came in response to identified issues and were inspired by either up-to-date technology and theory.

One important design aspect in this project was the usage of animation and transitions. Unfortunately, this is something that cannot be communicated fully through the static images in this paper.

### 9.1.2 Techniques

For this project, the focus was on engagement and balancing presentation with interaction. Therefore, a lot of focus was put on making the interface feel playful and easy to use by utilizing visual narratives. This might not be the right approach for more professional use cases with expert users. In those cases, users might possibly feel that features like emojis and saturated colors are disrespectful and disregard their professionalism. However, most of the other techniques are arguably useful in general since they simply make for more effortless interactions, utilize modern technology, and are based on relevant theory.

The project was guided by a literature study on up-to-date theory in, for example: data-driven storytelling, interface design, and information visualization (see Section 7.1.1). Some realizations, such as the importance of home pages were realized in the later stages of the project but still lead to the identification of useful techniques such as entry points. Although applied in a context, the proposed functionalities have their specific roles in general, which make them portable and adaptable across different subject areas.

### 9.1.3 Considerations

The considerations are based on reflections and findings from this project. Though they might seem general, they aim to underline important considerations when trying to balance presentation and interaction in data-driven web interfaces. Consideration of technology and an iterative workflow is argued to be especially important under these circumstances, and the hope is that the underlined insights from the process can help emphasize that. Though the considerations are based on personal experiences and opinions they are indeed an outcome of this project, not determined prior to it. Prior to this project there was a want to explore technology, but it was through experience that it was realized how much technology impacted the final product. Similarly, it was known that iterations are important to creating useful products but not that they were *this* important. The considerations can therefore be seen as lessons learnt and be relevant for any practitioner planning on creating data-driven web interfaces in the future.

## 9.2 Process

Many things affected what the final product came to be. For example, some of the charts from ideation were challenging to implement and what tools or visualizations to utilize had to be revised. Similarly, user analytics and usability studies revealed structural issues that had to be fixed. Hence, it was difficult to predict the process, and adjustments often had to be made according to the insights that continuously emerged.

### 9.2.1 Research

Through the research on data-driven storytelling and information visualization, it was determined that projects often start with a topic of focus (see Section 4.2.3, 4.2.4). In this project, the focus was initially solely on literature and the topic of nutrition was decided three weeks in. Having decided a topic at the start would have made it easier to determine what theory was relevant, made the literature study more efficient, and the process

of creating the web interface could consequently have been initiated earlier.

Data gathering lead to the identification of patterns and characteristics that had to be evaluated in accordance with what information that could interest the user. It was not easy to translate "what needs to be heard" into "what the users want to hear", because many users want to hear different things. Therefore it was decided to focus on general information that are based on authoritative data and applicable to most people. "Why?"-questions were helpful in finding these main sources. For example, "Why eat wholegrain" lead to "Because it prevents cancer", lead to "Why does it prevent cancer" lead to "Because it contains X, Y, Z".

Having a broad focus audience was also a way to increase participation and to identify broader attitudes during user research. Indeed, many general attitudes was identified, but it can be argued that a questionnaire would not be required to determine that money and time affect what people choose to consume. The exploration of general attitudes and goals were inspired by the goal-oriented approach, where discussions are steered away from talks about implementation in early user exploration (Cooper et al. 2014, p.14). However, the most useful insight came from answers regarding helpful and unhelpful characteristics of a potential interface (see Section 7.1.4.1). On the other hand, it was perhaps because of the initial goal-directed approach that participants had so much to suggest regarding this question.

### 9.2.2 Ideation

More focus on implementation meant less time on ideation such as sketching or creating storyboards. Mainly, sketching was done as a tool to collect the thoughts from research and communicate ideas to the participants of the co-creation workshop. Arguably, more paper sketching would have allowed for more exploration, and even though some solutions might not be feasible or used in the end it would cost little time to design them. Furthermore, alternative low-fidelity prototypes could have allowed for more early user involvement where ideas could be discussed and evaluated. Anyhow, spending any more time on any such things would directly have impacted the time available for development, and it was through development that many of the possibilities and limitations was realized. Clearly, the trade offs are not always obvious, especially when conducting multi-disciplinary work.

Because of the covid-19 pandemic, the co-creation workshop was done remotely and this introduced some challenges in terms of facilitation. For example, it was harder to have the participants sketch on paper rather than their computers, and it was hard to monitor how the participants were doing when working on their own. Overall the workshop was productive and resulted in many suggestions that inspired the process forward. Some ideas would not be feasible but all ideas gave insight or perspective to the problem.

### 9.2.3 Development

According to Ware (2021, p.2), most cognitive work happens in interaction with tools; and without aspects such as "Change", "Choose", "Combine", "Construct" and "Modify", the highest level in Bloom's Taxonomy cannot be reached (Armstrong 2016). Technology was deemed necessary to create a product truly interactive, but also to explore what interactivity could mean and look like. Working closely with the technology was deemed cost-beneficial as it meant exploring data sets while simultaneously getting an understand-

ing of the possibilities and limitations of visualization techniques.

Some challenges occurred that had not been expected. For example, translating data into information meant that careful efforts had to be taken when choosing the right words and deciding what information to show. Furthermore, some data had to be manually copied and pasted with carefulness (e.g. nutritional recommendations). Furthermore, careful calculations had to be made to convey the important information. For instance, different macronutrients have different energycoefficients, one gram protein equals four calories while one gram of fat equals nine. These calculations became more challenging when allowing visitors to combine foods, mainly because the combined foods where allowed to have different weights.

The charts used was not very experimental (pie chart, progress bars, and bar charts), however "just aiming for something different (or even worse, something "cool") is not a good enough motive in itself" (Kirk et al. 2016). Furthermore, making use of the most basic visualization resulted in visuals that the audience was probably more familiar with. The used charts were therefore deemed to be efficient in conveying what they are meant to convey, and (except the pie chart) they were also very easy to implement. The pie chart got a little more attention, but that was because creating it also meant learning a lot of invaluable things about D3. For instance, it was realized that patterns could be applied, consequently adding more encoding and improving on accessibility.

### 9.2.4 User Testing

All of the feedback from users were helpful because they gave their own type of insight. To combine informal feedback, analytics, a questionnaire, and a person-to-person usability study was useful and is recommended. The informal feedback gave initial insight into issues that had not been considered, such as search problems and that vertical bars were misinterpreted. Questionnaire gave insight on motivations, goals, and opinions of what a successful web interface could look like. Lastly, the usability study gave further insight into some general structural issues.

Certain demographics, such as people with less education, eat unhealthier in general.[1] It would have been more beneficial to focus specifically on these types of people, since those people could potentially gain most from the website. Instead, only people with higher education was part of both workshops, interviews, and usability studies. This was simply because these were the type of people that was available for this project, something that had an impact on all parts of the project. However, the first questionnaire did reach around 60 people, and it is probable that many of those people did not have higher education. There was no question regarding demographics to verify this.

## 9.3 Ethical Concerns

People have different preferences and allergies. Just during this project, concepts such as wheat protein allergy (a milder type of gluten intolerance) were introduced to the author. The website does not currently recognize the needs of such allergies, and it does not recognize gluten intolerant people or vegans and vegetarians either. Consequently, such

[1] https://www.folkhalsomyndigheten.se/publicerat-material/publikationsarkiv/oe/oppna-jamforelser-folkhalsa-2019/

groups might feel excluded, unhelped, or (worst case) be convinced to eat things that are not good for them. Given the time limit and limited expertise, it was simply not possible to accommodate for all different groups. However, on the browse page, the user can filter foods according to food groups and vegetarians and vegans have the ability to sort out foods that they can eat. Future work could include more filters that could accomodate for more people by giving filters such as "gluten-free" or "lactose-free".

Another drawback with the suggestions in the web interface is that it focuses mostly on specfic recommendations, not communicating the importance of a balanced diet more in general. Even though the intent behind a product is well-intended, it should be considered if it can be used in a bad way. For instance, if suggestions are followed blindly and religiously, is it possible that they cause more harm than good? Indeed, it has been suggested that the composition of a diet as a whole that is the most important aspect of a healthy diet.[2] However, the goal was to put light on, and present, recommendations that are already suggested by authoritative sources in a more accessible and engaging way. Hence, the recommendations are not provoking or

## 9.4 Future Work

First of all, a more formal evaluation should be conducted to validate and evaluate the outcome of the project. The web interface is very visually driven which could prove helpful for people with less than average language or numeracy skills, but this has to be evaluated. It would be interesting to test the website specifically on younger people or people with lower education because these types of people (at least in Sweden), tend to have worse dietary habits than the rest of the population. It would of course also be beneficial (and maybe necessary morally) to let a professional evaluate the website.

The project focused on the broad audience of general non-expert Swedish people. An issue with this approach was that information had to be generalizable and would consequently exclude the needs of certain types of groups such as allergic people. More expertise might be necessary to accommodate for these types of people. Future work could include discussion with experts and inviting minority groups into the design process to better understand their needs and wants. Adding more filtering parameters, such as gluten-free and vegan foods, is a quick way of making sure that more people could be helped by the website.
Of course there are also many features that would could be further worked on to improve the website, some of them include:

- More recommendations, for instance, regarding caloric intake
- Weight, height, and activity settings to calculate caloric recommendations
- Textual summaries for each food page
- Facilitate for pregnant and women in their menstrual cycle
- View for comparing foods, in addition to combining

## 9.5 Further Reading

During the process of this project, a relevant book has been published that might be relevant to anyone interested in these types "interactive story"-interfaces. Dougherty &

[2] https://www.folkhalsorapportstockholm.se/rapporten/riskfaktorer/matvanor/

Ilyankou (2021) presents "Hands-On Data Visualization", and ways of creating *interactive stories* "from spreadsheets to code". Similar to this project, they utilize HTML/CSS/JavaScript but instead of using D3 they went for Chart.js.

# 10
# Conclusion

Making important and authoritative data more available to more people is a big challenge in our rapidly evolving data-driven society. This thesis has attempted to respond to these challenges through a multidisciplinary *research through design* approach. By focusing on the specific topic of nutrition, it has been demonstrated how various methodologies and theories; such as data gathering, co-creation workshops, usability studies, interface design, and modern web technology; are maybe best combined and can complement each other. The process lead to insights relevant to the posed research question of:

*What are some useful techniques and important considerations when balancing the act of presentation and interaction, to facilitate engagement, in data-driven web interfaces?*

The suggested techniques include: *visual narratives*, *entry points*, *dynamic queries*, and *direct manipulation*. Furthermore, considerations should be taken, especially regarding *technology* and an *an iterative workflow*. The final web interface is demonstrated and some of the techniques are contextualized.

It must be noted that there are many ways to engage a general audience with important data, and this thesis only demonstrates a subset of these. Additionally, the results are based on personal opinions and depend on insights relevant to this project. Furthermore, the final product has not been evaluated formally by anyone outside of this project. Still, it is the authors opinion that most of the contributions are applicable in general, and the hope is that they can lessen the struggles of future practitioners.

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# A

# User Research Survey

Hey there. I'm exploring attitudes towards food and nutrition. I would love your input.

**1. How old are you?**
- Below 18
- Between 18 and 30
- Between 31 and 63
- Above 64

**2. How important important is eating healthy to you?**
1. Not at all
2.
3.
4.
5.
6.
7.
8.
9. Very important

**3. How healthy do you think your current diet is?**
1. Very unhealthy
2.
3.
4.
5.
6.
7.
8.
9. Very healthy

**4. What is the thing you would like to improve in your diet?**

**5. How would you rate your knowledge about nutrition?**
1. Low
2.
3.
4.
5.
6.

7.
8.
9. High

**6. Do you think more knowledge would positively affect your diet?**

1. No, not at all
2.
3.
4.
5.
6.
7.
8.
9. Yes, very much

**7. Is there something specific that you would like to better understand or explore?**

**8. What do you think you'd find most helpful on a website that lets you explore and compare different foods?**

**9. If any food could tell you how healthy/unhealthy it was, how would that affect what you choose to eat?**

Thank you very much for your time and input!

# B

# User Feedback Survey

Hi! Do you have time to answer 6 quick questions? Your feedback is valuable.

**1. How old are you?**
- Below 18
- Between 18 and 30
- Between 31 and 63
- Above 64

**2. How would you grade your current eating habits?**
1. Very unhealthy
2.
3.
4.
5.
6.
7.
8.
9. Very healthy

**3. Do you think the website can affect your eating habits positively?**
1. Not at all
2.
3.
4.
5.
6.
7.
8.
9. Yes, very much

**4a. Do you have any recommendations for how to improve the website?**
This question occurred if the answer for Q3 was 5 or lower.

**4b. Is there something specific that you like about the website?**
This question occurred if the answer for Q3 was above 5.

**5. Do you trust the website?**

1. Yes

2. No
3. I don't know

**6. What do you think about the recommendations (such as eating less salt and more wholegrain)?**

1. Helpful
2. Interesting
3. Surprising
4. Expected
5. Coercive
6. Irritating
7. I'm skeptical

# C

# Usability Study

The structure of the usability study was insipred by Steve Krug's sample test session (Krug 2014, p.273-291).

**Introduction**

My name is Oskar and I will be texting a website with you. The purpose with this session is to see if the website is working as intended and, just to be clear, I'm testing the website I'm not testing you. In fact, it would be very good if we could identify some points of improvements.

If you could talk aloud as you use the interface that would be really helpful for me. I would like to know exactly what you think, so please don't worry about hurting my feelings, the main goal is to improve the website. If you have any questions you can ask me, but I might not be able to answer them during the observation. I want you to think of it as if you are visiting the website by yourself.

I'm going to start a recording and I want to make sure that this is ok with you. The recording will only be used by me, so I can focus less attention on taking notes. It will be deleted after a transcript has been made.

**Warmup Questions**

- Do you have any food preferences or any allergies?
- What did you eat for breakfast?

**Observation**

The participants where shown the startpage of the website. They were asked what they thought the website was about, and later on they were given a task.

- What do you make of the website, what strikes you about it and what do you think it is and what can you do with it?
- Can you find and combine the foods that you had for breakfast?
- What you make of the information that is displayed.

**Discussion**

The observation has now stopped and the participant is encouraged to give their general impression of their visit. The facilitator asks any questions that might have occurred during the observation.