The Effect of Multi-Device Design on Website Efficiency and User Preference

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Abstract: Modern websites must accommodate many different devices with varying screen size without decreasing user experience or losing relevant features or content. In this thesis, three different multi-device design approaches, adaptive, responsive and mobile-dedicated, were researched on desktop, tablet and smartphone devices to ascertain whether one approach is superior to the others in terms of user preference and website simplicity and efficiency. A total of eight mock websites were created to represent the approaches on each device.

The mock websites were first evaluated with an expert analysis, wherein the individual page load times and aesthetic values of the sites were calculated. Then, a user study was performed, where 10 participants performed search tasks on each mock website, evaluating each site after completing the tasks. Additionally, a semi-structured interview was conducted after each study session and eye tracking data was collected during the study to identify possible differences in gaze behavior between the mock sites.

The results showed that no single approach was superior, as the results were very similar. However, it was discovered that participants disliked the mobile layout on the desktop device, even though it produced the highest efficiency. The results additionally suggested that mobile devices are preferred for their ease of use and accessibility, instead of for the layout design. Finally, a behavior where participants let their eyes rest while using the device to browse through a site was observed. Further study is suggested for the behavior, dubbed restful browsing, as it could have a strong influence on mobile web use.

Key words and terms: Multi-Device design, responsive web design, adaptive web design, mobile-friendly, website design.

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1. Introduction

Users access the Internet using numerous devices ranging from smartphones and tablets, all the way to desktop computers and even smart televisions. It is not uncommon for a user to have multiple devices capable of Internet access, which they use both simultaneously, browsing the Internet on a smartphone while watching a live video stream on a laptop, and sequentially, starting to read a news article on their desktop computer and finishing it on their tablet [Google, 2016]. Though the sites accessed with these devices are fundamentally the same, the requirements of each device are not. Therefore, to create a pleasant user experience with any device, web designers and programmers must consider different requirements, such as device screen size, methods of device use and usage environments. In response to these requirements, new design methodologies, which include scalable web elements and screen size recognition, are implemented in website design, allowing easy reordering of elements and navigation menus to fit the user's particular need. In this thesis, this method of design will be referred to as **multi-device design**.

In an ideal world, a website would support use with any device by offering unique layouts and functions to fit the device, be it a smartphone, tablet computer or the screen of a desktop computer. In reality, however, this kind of all-encompassing design is both time consuming and costly, making it an unattractive alternative. As most users use smartphones [Sterling, 2016], designers have shifted their focus away from traditional websites towards more mobile-friendly versions that are easy to scale and reorganize. This design philosophy has given way to websites that have a simple and minimalistic style, keeping content to a minimum and utilizing whitespace, typography and large images, among other techniques. From this philosophy, multiple multi-device design approaches have emerged. In this thesis, the following three design approaches are studied more closely: **mobile-dedicated web design**, **adaptive web design** and **responsive web design**.

These three approaches were chosen as they represent the extremes of multi-device design. Out of the three, the mobile-dedicated is not a recognized approach, but a phenomenon seen in some cases. In the mobile-dedicated approach, as the name suggests, a website is designed with mobile devices in mind, meaning that other devices must make do with the site as is [Patel et al., 2015]. The adaptive approach, on the other hand, attempts to achieve the state portrayed in the ideal world scenario by using set resolution boundaries. Each boundary corresponds to a different website layout, allowing developers to design separate websites for each device. [Gustafson, 2015] Finally, the responsive approach represents the middle ground. In the responsive approach, elements are built using a fluid grid system that is easy to re-scale and reorder to fit any screen. This method allows one layout to be used by any device regardless of screen size or orientation [Marcotte, 2010]. These approaches are described and compared in more depth in the second chapter of this thesis.

While most of these design approaches may fulfill the needs of mobile users, there are cases where sites fail to utilize the space larger screens offer, even though the responsive approach is used. These websites “cap” on a certain resolution, meaning that they do not expand past a certain point. In some cases, the desktop website is simply a larger version of the mobile website, with no responsiveness, such as relative font size. As mobile users outnumber desktop users, one would think that this is logical. After all, if users using dedicated desktop websites are in decline and mobile use is increasing, why bother creating full-scale sites at all, if mobile sites are just as effective and as popular? This question is relevant, as the results may alter the direction in which modern website design is heading. If desktop websites are not a viable alternative and mobile websites are preferred, website development practices should be changed to reflect this. Furthermore, this information may be of use to e-commerce, as the results may dictate whether companies need to invest in desktop website development and maintenance.

In this thesis, online newspaper websites designed with multi-device design approaches in mind are studied to ascertain the impact of the said approaches on website efficiency and user preference. Online newspapers were chosen as the focus of this study because they are commonly used by a large number of users in Finland [TNS Metrix, 2016]. Additionally, as online newspapers generate revenue from user activity on their website, user preference and efficiency are important factors. This thesis assumes that the reader has a basic understanding of the concepts of web development and the requirements of mobile and desktop Internet use, in addition to a basic understanding of usability, user experience and their measurement. This thesis was written to ascertain in which direction web development should focus, and will therefore be most useful for web developers.

This thesis will proceed as follows: theory and work related to multi-device design will be discussed and the main design approaches will be explored. Factors that affect user preference, such as visual complexity and first impressions, will be presented. After the theory section, the expert analysis and the study proper are presented, including information on the setup, volunteers and the mock websites created using the chosen design approaches. Following this, the results and analysis are presented. These results are discussed at length in tandem with the results, answering the posed research questions and analyzing their implications. The limitations of the study and suggestions for further study are discussed after the thesis reaches its conclusion, where all relevant information is summarized.

2. Previous work and theory

In this chapter, previously conducted research on the topic is presented and discussed. Additionally, concepts, such as different design approaches, are explained in depth and terms are defined in the context of this thesis. This chapter is divided into three sub-chapters: multi-device design, user preference and website efficiency. In the first sub-chapter, multi-device design is defined and discussed. The three design approaches introduced are presented in-depth and compared. In the second sub-chapter, the varying factors that affect user preference, such as visual complexity, are discussed. Finally, in the third sub-chapter, views on website efficiency and its measurement are presented.

2.1 Multi-device design

In general, the term design for multiple devices, or multi-device design, refers to the design and development of services and products that are usable and accessible regardless of the device used to access them. Depending on the context, however, there is some variation in the definition of the term. In the context of individual and sequential use, the term refers to the design of products, such as websites, that analyze and react to the device being used to access them, transforming the layout and elements to meet the needs of the device [Meskens et al., 2010; Bittencourt et al., 2015]. In the context of simultaneous and collaborative use, however, the term may refer to the design of products that can be used simultaneously on multiple devices, with changes made in one device synchronizing on the other. For example, Google Docs is a representative of the latter [Mikkonen et al., 2015]. As the focus of this thesis is on websites and their design, multi-device design will refer to the former definition of making products accessible regardless of device.

Previous research in the field can be divided into two categories: the development of tools and frameworks, and the design and research of multi-device products. The former category is not discussed in any depth in this thesis, as the varying frameworks and tools found were not applicable in the experiments to follow, though they were used as inspiration and as a guide. For example, a study by Mikkonen et al. [2015] on liquid web applications, which are applications focused on simultaneous and collaborative use, gives some insight into the differences between traditional “solid” and modern dynamic websites. Additionally, the study presents an example of the design of a dynamic application. The latter category presents case studies of multi-device products and their development, and gives insights into the techniques used and the benefits gained.

In multi-device friendly websites, the analysis of a device and the transformation of the website are controlled via cascading style sheets (CSS) [Vuotilainen et al., 2015;

Marcotte, 2009; Patel et al., 2015]. **Media queries**, which were introduced in the third version of CSS, can be used to inspect the physical aspects and class of a device. By using this information, a developer can set conditions that trigger a layout change when met [Gasston, 2011]. These conditions are commonly set to test the resolution of the device and are referred to as media **breakpoints**. With these breakpoints, the website changes according to the device by either using pre-defined CSS code or by loading a separate stylesheet for each breakpoint [Marcotte, 2010; Gustafsson, 2015]. A case study by Vuotilainen et al. [2015] shows how even traditional sites can be made multi-device friendly with relatively little effort by using existing multi-deivce frameworks and libraries. In addition to recognizing the differences between device characteristics, media queries can also be used to recognize different operating environments within devices, for example, differentiating between an android smartphone and an iPhone. As smartphone brands often have different style guides, it is important to use media queries and breakpoints to provide environment specific versions of a website. [Marcotte, 2010; Meskens et al., 2010]

The three design approaches chosen for further study in this thesis represent different levels of CSS, media query and breakpoint use. The mobile oriented approach represents the lowest level of use, with relatively few layout changes being performed beyond mobile phone resolutions. The adaptive approach, on the other hand, represents the highest level of use with each breakpoint signifying a complete layout change. The responsive approach is in the middle ground, as it features a relatively cohesive outlook and layout that changes only slightly for each breakpoint.

In the mobile-dedicated approach, a website is designed for use on a mobile device. As such, the controls, layout and features are optimized for touch-based interaction and a small screen. Though the website is designed for a mobile device, users of other devices can still access the site, although the layout does not change other than filling in the larger screen with blank space and possibly small amounts of text [Patel et al., 2015]. Alternatively, the mobile layout is stretched into the larger screen size. It should be noted, however, that some mobile-dedicated sites were created to work in tandem with desktop websites and are designed only for mobile devices [Soegaard, 2016b]. For example, the Twitter homepage, twitter.com, and the mobile version, m.twitter.com [Figure 2.1].

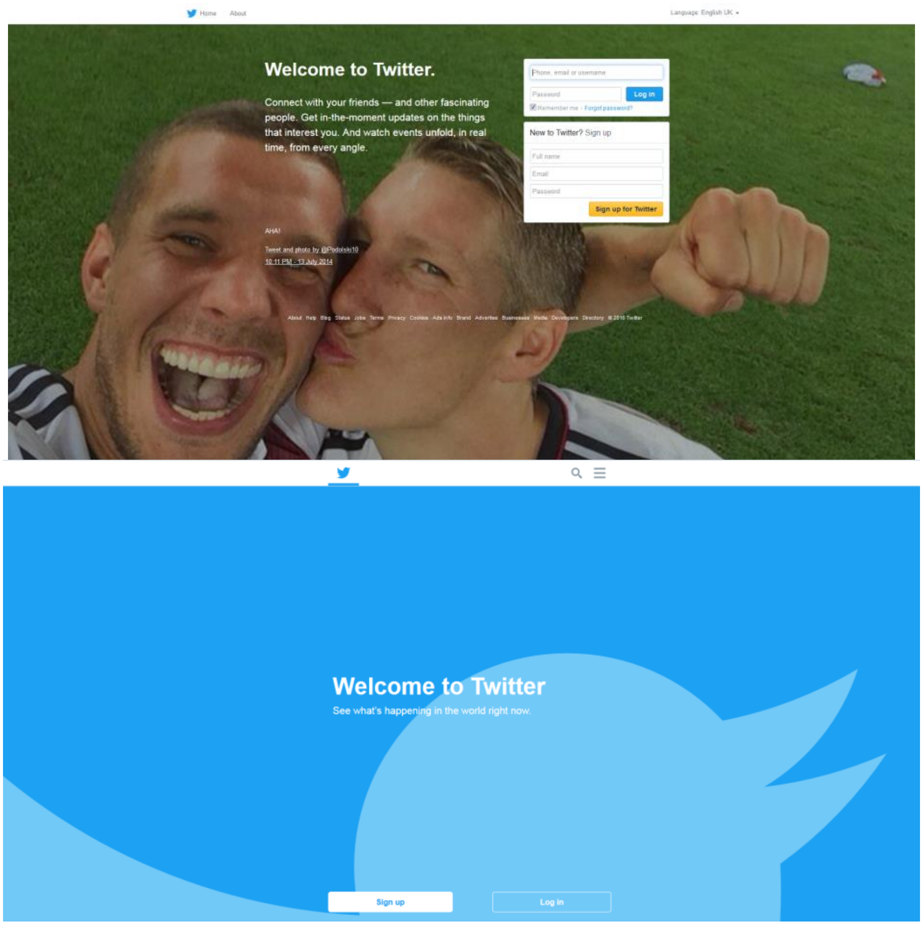

Figure 2. 1 Screen capture of Twitter Desktop homepage (top) and Mobile homepage (bottom). Viewed on a 1920x1080 screen. Accessed 30.11.2016

The main benefit of the **mobile-dedicated** approach is its simplicity [Maurer et al., 2010]. As mobile phones have a small screen and limited processing capabilities, mobile-dedicated websites often show only necessary content and hide options behind menus. For example, the navigation menu of a mobile application is often hidden from the user and only shown when the user presses the corresponding button. By eliminating unnecessary features and content, the application is naturally less cluttered, and therefore simpler [Vuotilainen et al., 2015; Hoehl and Lewis, 2011]. Additionally, one can assume that for mobile users a mobile-dedicated website would be the best solution in terms of efficiency and user experience. The main drawbacks of mobile-dedicated are its maintenance and exclusiveness.

When created to work in tandem with a desktop website, a mobile-dedicated site must be maintained and edited manually whenever the desktop site is edited and vice versa to maintain cohesiveness. Though mobile-dedicated approach was once a popular and effective practice, the amount of maintenance required has become a hindrance, when other approaches, such as the responsive approach, are much easier [Soegaard, 2016b]. If the site does not work in tandem, but instead is kept as is for all devices, the mobile-focused nature of the website excludes other users from gaining the full experience, as seen in the case study by Patel et al. [2015].

The key philosophy of **responsive** web design is fluidity. By using CSS, responsive sites shift and transform to fit any screen, like liquid being poured into a container. This fluidity, or responsiveness, allows responsive websites to maintain a cohesive outlook between devices without requiring excessive maintenance, and thus eliminate the need for multiple websites and stylesheets [Marcotte, 2010]. Flexibility, which can be thought of as a basic level of responsiveness, is achieved by placing website elements in a fluid grid, e.g., a container for website elements that reorganizes the layout according to the width and height of the screen.

Fluid grids use percentages instead of fixed numbers as units of measure for width in CSS to calculate the correct layout for each screen [Marcotte, 2009]. Though this responsiveness does support multi-device use, there may be issues in scaling images, advertisements and other elements, such as popups. To resolve this issue, responsive websites use media queries, breakpoints and CSS to dynamically change elements of the website to fit the current device, in addition to reorganizing and scaling the layout [Marcotte, 2010]. For example, in the case study presented by Vuotilainen et al. [2015], when a mobile device was detected, the website dynamically altered the navigation bar to be hidden behind a button, as in the mobile-dedicated approach.

This ability to adapt to almost any screen size without a large decrease in user experience is the main benefit of the responsive approach. This ability implies that a responsive website is "future-proof", e.g., it can be used by screens much larger or smaller than those currently available [Marcotte, 2010]. Additionally, as the layout and outlook of the website do not change drastically between devices, the website remains familiar and therefore easy to use. The adaptability of responsive websites in addition to the relatively ease of their implementation and the use of one universal outlook has made the responsive approach one of the more popular approaches currently in use. The result of this popularity has been that many existing frameworks and libraries, such as Bootstrap, have incorporated responsive elements and provided easy to use templates [Soegaard, 2016b].

The dynamic nature of responsive websites, however, can cause some issues. As the same website layout is used regardless of the device, the same amount of information is loaded each time the page is used. Though of little consequence to desktop or laptop users, mobile users may experience high load times because all the features are loaded even though they are not necessarily displayed [Soegaard, 2016b]. Although the universal layout provided by the responsive approach considerably decreases the workload of developing a multi-device friendly website, the outlook of the website on each device is not wholly under the control of the developer, as this is dependent on the device and its screen size. Elements may move and reorganize themselves in unforeseen ways. [Marcotte, 2010; Soegaard, 2016b]

The final design approach, **adaptive** web design, features the largest change in website layout between breakpoints. Whereas the responsive approach relies on flowing elements that can fit any screen, the adaptive, in contrast, divides each breakpoint into a separate stylesheet and layout [Gustafson, 2015]. When an adaptive website is accessed, the amount of space provided is checked and the corresponding layout is presented. After this initial check, the website is fixed and will not transform even if the website window is resized [Gustafson, 2015; Soegaard, 2016b]. Unlike in the responsive approach, the layout in an adaptive website can be vastly different depending on the device, as each layout is designed to be the optimal solution for the current screen size. For example, when viewed from a mobile device, an adaptive site may feature less visible content and a simpler navigation structure, as in the mobile-dedicated approach, but when viewing the same website from a desktop, the full amount of context and navigation is shown. [Soegaard, 2016b]

In theory, by providing a tailor-made layout for each kind of device, the adaptive approach provides the best user experience of all three approaches. Because each breakpoint is a separate layout, more focus can be given to the needs of the user in each case. For mobile users, for example, touch friendly navigation and functionality can be added, while desktop users can benefit from full use of their large screen and processing power [Gustafson, 2015; Soegaard, 2016b]. Finally, as adaptive websites have separate layouts and stylesheets for each breakpoint instead of the universal stylesheet of the responsive approach, the amount of content to load is smaller and therefore takes less time. [Soegaard, 2016b]

The main drawback of the adaptive approach is the considerable workload because each breakpoint requires a custom layout [Soegaard, 2016b]. As this is time consuming, not all developers or businesses have the resources to create them all, especially when other approaches, such as the responsive approach, offer similar functionality but require less time. In addition to high workload, the fixed number of breakpoints may not support all existing or future devices. For example, tablet users may suffer because their resolution is too small to fully encompass a desktop website, but too large for a mobile site [Soegaard, 2016b].

In summary, the three approaches offer similar, but unique methods for multi-device design. The responsive approach uses fluid grids and reorganizing content to make sure the site is viewable, regardless of the site used. The approach offers a universal layout for all sites and is theoretically future proof. The universal layout may cause issues in terms of long loading times and a layout that is not optimal for any device in particular, but satisfactory for them all.

The adaptive approach offers a tailor made layout for each device offering the highest user experience, in addition to lower loading times. The layouts used are fixed, however, meaning that once the layout is loaded, it will not change noticeably when a window is resized, for example. This may cause issues if a device has a screen size that does not have a preset layout. Additionally, the adaptive approach is the most cumbersome for developers, as it requires the most work. Finally, the mobile-dedicated approach focuses on designing the best experience for the smartphone, disregarding the other devices. The mobile-dedicated websites are often the simplest, suggesting higher efficiency and faster loading. The drawbacks of the mobile dedicated approach are increased need for maintenance and the exclusiveness of being mainly design for, and sometimes only available on, mobile devices.

The benefits of each of the three design approaches depend on the device used and the usage environment. When using a smartphone, a mobile-dedicated website may offer the best user experience. In the sequential use of multiple devices the responsive or adaptive approaches may be appropriate. The different perspectives these design approaches represent are a subject of interest in this thesis as they raise the question: “Are device-specific websites irrelevant?”. Is it more efficient and user friendly to use the responsive approach and create websites that fit any device, even though the devices cannot be used simultaneously to their full extent, or is it preferable to make tailor-made solutions for each device? A study by Maurer et al. [2010] showed that mobile-dedicated websites were not unanimously preferred over traditional websites when used on a mobile platform. Additionally, the study showed that even though users found the mobile-dedicated website to be more effective in terms of task completion time, the actual results were similar for both websites. Alternatively, a case study by Patel et al. [2015] presents a situation where a mobile-dedicated website is transformed into a responsive site. The change increased engagement in desktop users without decreasing engagement from mobile users.

2.2 User Preference and Visual Aesthetics

Preference is defined as the act of giving advantage to something over others [Merriam-Webster]. Although this is but one of many definitions, in the context of websites it is fitting. The Internet offers a vast number of websites, some of which offer similar products and services. Between these websites, user preference may be the difference between success and failure, as a website that is not preferred is often forgotten in favor of more attractive alternatives [Lee and Koubek, 2010; Tuch et al., 2012]. Preference is by its very nature subjective and, as such, the factors that affect it change from user to user. Regardless, common factors have been identified, such as **usability** and **visual aesthetics**, that affect all users [Lee and Koubek, 2010].

A study by Raita and Oulasvirta [2011] found that a user's expectations towards a website can affect perceived usability. In their study, participants were asked to rate the usability of a mobile device after being exposed to either negative, neutral or positive priming beforehand. The users performed tasks on the device to get a feel for the usability and then gave a review. The results showed that positively primed participants gave more positive reviews than neutrally or negatively primed participants. A study by Lee and Koubek [2010] found that perceived usability, e.g., the estimated level of usability of the website before actual use, had a larger effect on user preference than the actual measured usability of the website. These studies suggest that the usability of a website has a lesser effect on user preference making, when compared to the influence of expectations and user perceptions that, in turn, are influenced by visual aesthetics.

In the context of websites, visual aesthetics refer to the general pleasantness of the website – its layout and its outlook. Aesthetically pleasing websites combine the right amount of content, space, order and color to create a whole that is logically organized, easy to process and visually clear and simple [Moshagen and Thielsch, 2010; Sani and Shokooh, 2016]. In addition to being a factor in user preference making, visual aesthetics have been found to offer other benefits. A study by Moshagen et al. [2010] researched the relationship between perceived usability and visual aesthetics. The results of the study showed that visual aesthetics can increase user performance in cases where performance would otherwise be hindered by low usability, and indicates that visual aesthetics can be used to compensate for usability issues. Additionally, visual aesthetics influence the perceived trustworthiness of a website [Ferris and Zhang, 2016] as well as influencing the users' decision to purchase a product [Geissler et al., 2006]. Visual aesthetics comprise multiple factors and in the context of websites, Moshagen and Thielsch [2010] divided them into four main facets*:* **simplicity, diversity, colorfulness and craftsmanship.**

The **simplicity** facet refers to the consistency, balance and order of a website. A simple website offers a layout that can be easily processed and does not create a high cognitive load. A study by Sani and Shokooh [2016] combined Gestalt perception laws, which consist of the rules and ways the human mind processes visual information, and simplistic principles showing how the two can be used in tandem in website design. Though simplicity has a positive influence on visual aesthetics, it does not mean the best website is a blank page. Simplicity by itself can be dull to a user and may lead to a negative effect on visual aesthetics. To be considered pleasing, simplicity requires an amount of complexity to arouse and capture the interest of the user. The second facet presented by Moshagen and Thielsch [2010], **diversity**, represents this complexity, in addition to the novelty, creativity and dynamics of a website. Visual complexity has been found to have a strong influence on user preference and visual aesthetics, and it is therefore discussed in-depth in the following chapter [Tuch et al., 2012].

The third facet by Morthagen and Thielsch [2010], **colorfulness**, refers to the use of color on a website. In addition to selecting an appropriate color palette, the facet additionally encompasses color placement and combination. In addition to their aesthetic value, colors offer deeper meaning. For example, in some cultures, the color blue is associated with competence and white with purity, whereas the color black is received with negative reactions [Ferris and Zhang, 2016]. The final facet, **craftsmanship**, represents the skill of the developers of the website and the care with which the website is built. An aesthetically pleasing website requires harmonious design and skillful integration of the other facets. As websites, the devices used to browse them, and their underlying technologies are ceaselessly changing and progressing, websites with poor craftsmanship can easily become outdated and unusable if not maintained with skill and care.

Websites often belong to a group of sites, be it an online marketplace, business website or social media site. Each of these groups, or classes, has a recognizable style, which separates them from one another. The extent to which a website adheres to this general style is referred to as **prototypicality**. A highly prototypical website contains elements and style common to its group, and is therefore easily recognized [Tuch et al., 2012]. In the work of Moshagen and Thielsch [2010], prototypicality is incorporated into the facet of craftsmanship as a lesser influence. A study by Tuch et al. [2012], however, found that prototypicality has a noticeable effect on perceived visual aesthetics. In their study, a set of websites were chosen that represented varying levels of both prototypicality and visual complexity. Participants were asked to view a screenshot of the websites for a short duration, and then rate them. The results showed that websites with low prototypicality were found to be unattractive, regardless of visual complexity levels. However, visual complexity was found to have a stronger influence on user preference overall, with high complexity correlating with low preference and vice versa. The optimal website had low complexity and high prototypicality. Due to the findings of Tuch et al. [2012], prototypicality is considered to have a more significant influence on user preference than suggested by Moshagen and Thielsch [2010]. In the context of this thesis, prototypicality is considered a facet and will be treated as such, i.e., it will be given more attention in the design and development of the mock websites used in the experimental setup that will be described in chapter 3.4.

2.2.1 Visual Complexity

Miller´s [1955] magic number seven, plus or minus two, is a cornerstone of modern website design. The number refers to the limited amount of information a person can process at once and reminds website designers of the dangers of displaying too much or too little information at once. Visual complexity is formed from this balancing of content. No exact definition of visual complexity has been agreed upon [Tuch et al., 2012], therefore in the context of this thesis it will be defined as the amount of visual information in a website, be it in the form of images, text, color or other visual elements. Visual complexity comprises a number of elements, such as images, the amount and format of text and the colors used, to name but a few [Blanco et al., 2010; Deng and Poole 2010].

In the work of Moshagen et al. [2010], visual complexity is attributed to the facet of **diversity**. Visual complexity, in addition to novelty, website dynamics and creativity, captures the interest of a user and counteracts the low arousal caused by simplicity. In addition to increasing arousal, visual complexity has been found to have an impact in other areas. A study by Tuch et al. [2009] found that visual complexity has an impact on both the performance of a user and their ability to recall a website. In the study, participants were shown website homepages with varying levels of visual complexity and asked to perform a search task on the websites. After the task was completed, they were asked to rate the experience in terms of valence and arousal using the Self-Assessment Manikin (SAM). After the initial test, the participants were asked to return a week later and try to recognize the sites used. The results of the study showed that participants performed better in the search task when visual complexity was low. Additionally, low complexity websites were recalled more often than those with high complexity. Finally, the study showed that the participants preferred websites with low complexity, as seen in a later study by Tuch et al. [2012].

One could assume, based on the findings of Tuch et al. [2009], that to create a website that is pleasant, memorable and efficient to use, the website should be made with as low visual complexity as possible, showing only strictly necessary content. Therefore, it is logical to conclude that the mobile-dedicated approach, the design approach that uses simplistic mobile layouts on all platforms, is the correct choice. This idea, however, does not consider the needs of the user. For example, if a user wants very specific details on a product or service, a low complexity website may not be able to satisfy their needs because the specific details may not fall into the category of "necessary content" that is displayed. [Deng and Poole 2010; Blanco et al., 2010]

A study by Deng and Poole [2010] researched the impact a user's needs have on perceived visual complexity and valence in website use. Two approaches, or **metamotivational states**, were presented in the study that represented the needs, goals and wants a user may have. The first state, the **telic** state, represents a goal-oriented user who prefers to reach their goal without **diversion** or complication. The second state, the **paratelic** state, represents a user who uses websites seeking excitement, someone who values the activity over the goal. Deng and Poole [2010] found that the metamotivational state did affect the user's perceptions of visual complexity. Telic users preferred websites with high levels of order and low visual complexity, as these websites allowed them to complete their tasks quickly and easily. However, paratelic users found such websites boring. For paratelic users, higher levels of visual complexity correlated with valence because the increased amount of visual information increased their level of arousal. Similar results were found in a study by Blanco et al. [2010], where information presentation models were studied in the context of online product presentation.

As presented in the works of Moshagen and Thielsch [2010], simplicity itself does not guarantee positive visual aesthetics. A certain amount of diversity is required to increase arousal and to capture interest. The amount of diversity is not consistent, but varies on the needs of the user and the purpose of the website, as seen in the studies by Deng and Poole [2010] and Blanco et al. [2010]. A website that offers simple functionality, such as a search engine, does not need to display large amounts of information, therefore the website does not require high levels of visual complexity. A provider of electronic devices, however, must provide large amounts of specific information on products, requiring higher visual complexity [Figure 2.2]. To achieve positive visual aesthetics and gain user preference, a balance in the amount of content; i.e., visual complexity, and simplicity must be found.

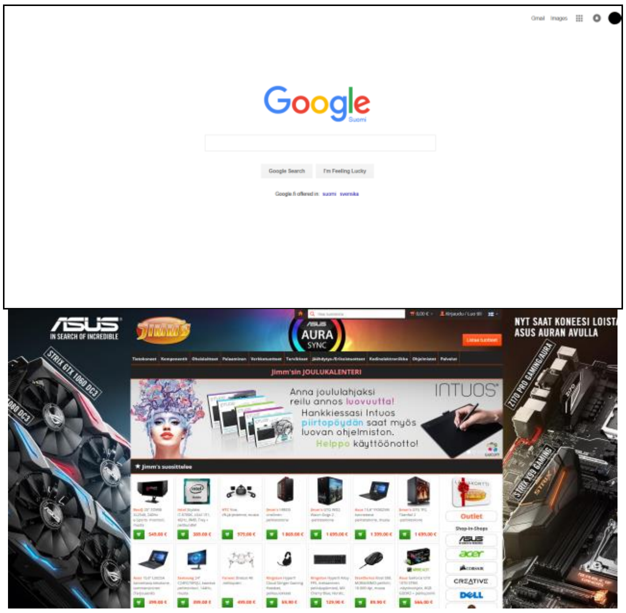

Figure 2. 2 Screen capture of Google.fi (Low Complexity) and Jimms.fi (High Complexity). Accessed 1.12.2016.

Because visual complexity has a strong influence on user preference, it is important that visual complexity is maintained. But how? One of the simplest ways to reduce visual complexity is to reduce the number of elements, such as images and text, being displayed at once, following Millers [1955] magic number seven [Huang and Zhou, 2016]. Additionally, Hick's law or the Hick-Hyman law, is another useful tool when designing a website [Seow, 2005]. The Hick-Hyman law, in general terms, states that as the number of options increases, so too does the time it takes a user to come to a decision [Seow, 2005]. By only displaying the necessary content, the number of options is kept to a minimum and the users do no become frustrated before reaching a decision [Soegaard 2016a; Seow, 2005]. It is important to note, however, that displaying only the relevant content does not mean the excess content must be cut from a website completely.

Instead of deleting all irrelevant information, elements can instead be hidden and organized. For example, information can be hidden behind categories or menus, or can be organized into logical groups according to their subject matter, so as to maintain low visual complexity. For example, menus often use general categories that reveal more specific content, such as navigational links, when selected [Soegaard 2016a; Leuthold et al., 2011]. By hiding content from a user, visual complexity is kept low, but users who require more information are satisfied, as the information is still easily accessible. In some cases, such as in menu design, a higher level of complexity can, however, be more efficient than a low complexity alternative. A study by Leuthold et al. [2011] found that a dynamic menu, where links were hidden behind broad categories, was found to be less efficient than a menu where all navigational links were presented simultaneously, but were divided into categorical groups. The dynamic menus were found to be less efficient because they required a larger number of clicks and more time to find a specific link.

In addition to deleting, organizing and hiding content, visual complexity can be controlled by manipulating the various factors that it is comprised of. Using lighter hues of color can lower arousal, whereas using bright colors such as accents can capture and direct the user's attention [Ferris and Zhang, 2016]. Gestalt visual perception laws can be used as a point of reference when designing the layout of a website [Sani and Shokooh, 2016]. By adhering to these laws, the grouping, organization and continuity of the site will complement the way users view the website and will therefore be less visually complex [Sani and Shokooh, 2016; Deng and Poole 2010]. Finally, the way textual information is presented can affect visual complexity.

A study by Blanco et al. [2010] researched the ways textual information presentation and the absence of images affect information processing and recollection in the context of online product presentation. In the study, two presentation modes and their relationship with the presence or absence of an image were examined. The two modes examined were **schematic**, i.e., presenting the information in a table, and **paragraph**, i.e., presenting the information as a paragraph of text. The results of the study showed that the optimal way to present textual information is not constant, but depends on the context. The schematic mode of presentation was found to be preferable when an image was present, whereas a paragraph mode was found to produce higher levels of product information recollection when the image was absent.

2.2.2 First Impressions

The Internet offers a multitude of similar services and websites, which is why the first impressions a user forms of a website is a decisive factor in either its continued use or abandonment in favor of another more attractive website [Tuch et al., 2012; Deng and Poole, 2010]. First impressions have been a popular topic of study, with multiple studies dedicated to researching its formation and influential factors. Though first impressions are not directly linked to the topic of this thesis, by understanding first impressions and the factors that influence them, insight may be gained into the reasons a certain design approach or platform is preferred over others.

The term **first impressions**, in the context of websites, refers to an evaluation conducted in a short time either during or before use [Shen et al., 2013]. The amount of time it takes to form an impression varies on the user, though a study by Tuch et al.

[2012] found that users viewing a website for as little as 17 ms were able to express preference, whereas an eye tracking study by Shen et al. [2013] found that, on average, a user would take approximately 2.7 seconds before they had processed a website as a whole. The studies suggest that although preliminary impressions are formed the moment a website is seen, users require additional time before the website is fully processed in its entirety. Regardless of the time it takes, first impressions have a noticeable impact on website use and preference.

The main impact first impressions have is on the decision to either abandon or continue using a website. A study by Deng and Poole [2010] found that if the first impressions of a website are positive, it is likely that a user will approach the website and continue using it afterwards, whereas negative first impressions may lead to the user abandoning the website or creating negative **expectations**. In addition to the immediate decision to either approach or abandon a website, first impressions have other, long term effects in terms of usability, performance and user preference [Lee and Koubek, 2010; Tuch et al., 2012]. For example, first impressions influence the expectations a user has toward a website. Negative first impressions lead to negative expectations, if not abandonment, and positive first impressions lead to positive expectations [Shen et al., 2013; Raita and Oulasvirta, 2011]. These expectations in turn have a noticeable effect on the perceived usability of the website as seen in the study by Raita and Oulasvirta [2011].

The study by Tuch et al. [2012] presented **prototypicality** and **visual complexity** as the main influences in the formation of first impressions, though **colorfulness** has been suggested as an additional important influence. In a study by Reinecke et al. [2013], computational models were created and used to calculate the colorfulness and complexity of a set of websites. The results of the study showed that the created models could be used to explain approximately half of the variance in first impressions, suggesting that colorfulness does have an influence on first impressions. Both studies found that visual complexity had a stronger influence on first impressions than prototypicality or colorfulness.

Prototypicality and colorfulness are related because certain color combinations may represent a certain class of website. For example, in the work of Shen et al. [2013], a participant found the combination of blue, red and white to represent an airline website. Figure 2.3 represents a website were all three influences can be seen. The website is simple in design and resembles other service providers in style. The color palette utilizes white and gray to produce a professional feel, while using green as an accent color, emphasizing important options. It is important to note, however, that both perceived visual complexity and colorfulness may vary according to the culture of the viewer [Reinecke et al., 2013].

Figure 2. 3 Screen capture of Geckoboard home page. Accessed 19.12.2016.

The first impressions formed during the first few moments of website use begin a flow, beginning from created expectations and perceived usability, flowing through task completion and website use, ending finally in preference making. So how does one improve their website to generate more positive first impressions? A study by Shen et al. [2013] used eye tracking to research the formation of first impressions and their relations to the different elements on a website. The study found six website elements that should be considered. The elements are as follows: **colors, images, navigation, text, position** and **space**, respectively. It should be noted that the study focused on university websites.

One of the first elements identified in the study was **color**, giving credence to the work of Reinecke et al. [2013]. Relaxing colors, such as yellow and lighter shades of blue and green, were preferred. Additionally, participants suggested that the main and background color of a website should be relaxing and should contrast the font color in an easily readable and pleasant manner. White font color on a light blue background is given as an example of bad color choices. The use of **images** was found to be equally important, with participants preferring professional, content-related images instead of meaningless images. Large numbers of images were found to be unattractive, whereas one participant found one large image to give a good impression.

Shen et al. [2013] found that, in addition to color, **navigation** was a commonly identified website element. The placement of the navigation menu, or navbar, was a point of interest, as users preferred it to be located either at the top or the left side of the website. The hiding of navigation links behind larger categories is suggested in the study. In addition to navigation, text was found to be an influential element. Participants found cohesive **text** size and font to be pleasant, whereas irregular font sizes, uncommon fonts and poor color choices lessened the readability and clarity of a website. The amount of text should be equally considered, as large amounts of text, especially in a small font size, can be frustrating to read.

The final two elements found by Shen et al. [2013] are **position** and **space**. Position is a higher-level element of sorts, as it refers to the positioning of each element in the website. By placing images and text in a way that complements the viewing patterns of users, first impressions can be improved. Gestalt visual perception laws can be used as a point of reference, as seen in the work of Sani and Shokooh [2016]. Space refers to the empty area between and around objects, commonly referred to as **white space.** By using white space to separate elements or groups of elements from one another, the website is given a more open feel, lessening perceived visual complexity. Additionally, white space can be used to accent the layout order of a website by using white space to group certain elements. One can, however, use too much whitespace. Because adding white space requires the lessening of content, a large amount of whitespace results in little content, which, in turn, is perceived as boring and visually unappealing [Moshagen and Thielsch, 2010].

2.2.3 Measuring User Preference

The difference between a successful and an unsuccessful website is user preference. Therefore, it is imperative to satisfy user needs and to provide a pleasant user experience. The task of predicting or measuring user experience, however, can be difficult. Methods used to measure user preference are commonly qualitative in nature, as the nature of user experience is subjective and can be difficult to operationalize. Questionnaires are common methods of discerning the opinions of a group toward a website, though interviews and user experience scales, such as the Self-Assessment Manikin, are additionally used [Tuch et al., 2009; Deng and Poole 2010; Shen et al., 2013]. For example, prototypicality can be measured with questionnaires, as seen in the study by Tuch et al. [2012].

An additional method for evaluating user experience during website use is the measurement of **physiological** information. Emotions, such as frustration, happiness and fear, can be monitored and analyzed by monitoring changes that happen within the interior and exterior of a user’s body. These emotions give insight into how a website makes a user feel [Tuch et al., 2009]. In the study by Tuch et al. [2009], the impact of visual complexity on physiology, along with experience, performance and memory, were researched. In the study, heart rate and electrodermal activity were measured, in addition to the use of electromyography, which measured muscle activity. The results of the study showed that visual complexity caused decreased heart rates and increased facial muscle tension. Additionally, reaction times, which were measured during a search task, increased with visual complexity. Higher reaction times resulted in increased heart rate and increased electrodermal activity. In addition to visual complexity, physiological measures can be applied to other factors such as colorfulness, visual aesthetics and user preference in general. As these factors are subjective in nature, they elicit different reactions in different users.

Eye tracking is a useful tool with which to gain additional insight into how users perceive a website. Eye tracking technology records the movements of a user's eyes as they view the screen, recording when and for how long the eyes focus or fixate on a position or element and how the eyes move in general. This data can be analyzed in various ways to gain both qualitative and quantitative data [Poole and Ball, 2005; Ehmke and Wilson, 2007]. Qualitative data can be acquired, for example, by analyzing the path of the user's gaze. Depending on the visual aesthetics of the value, the path of the user´s gaze will change. If the path is erratic or shows signs of repetition, the website may be too complex or confusing [Sorum, 2016; Shen et al., 2013]. In normal circumstances, a user's gaze often goes from left to right, spending more time in the left and upper segments of a website. Additionally, eye tracking gives insight into which elements of a website gain the most attention and which areas are left unseen, which can aid developers in positioning important elements [Sorum, 2016]. In terms of qualitative measures, eye tracking can be used to calculate a variety of measures. For example, the duration of time it takes for a user to fixate on an element or the number of fixations in general can give insight into the website [Shen et al., 2013].

Fixations, or the moments when the eyes stop processing information, give insight into which areas of a website are of interest, which areas are not receiving attention and how efficiently the website is organized. In Figure 2.4, fixations are represented with circles. The number and position of fixations show how a website is viewed and how its visual elements are perceived. For example, a large number of fixations may refer to poor website layout structure, which causes searching, whereas a dense group of fixations indicates interest and efficient searching. The lack of fixations indicates that an area of a website has not been given attention. [Poole and Ball, 2005]

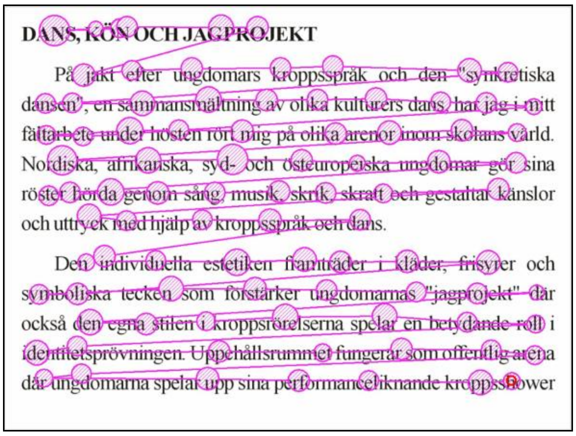

Figure 2. 4 Example Eye tracking data. Wikimedia Commons. Accessed 20.12.2016

The number of leaps between fixations, referred to as **saccades**, can additionally give information on the complexity of a website. The number of saccades represents how often a user shifts from one item of interest to another. If the number is high, this indicates that the user may be searching for something. If the saccades indicate sudden shifts in direction, it may indicate the users changing their goals or being confused by the layout [Ehmke and Wilson, 2007]. Additionally, saccades may indicate backtracking that may again indicate confusion or lack of visual cues [Ehmke and Wilson, 2007]. In Figure 2.4, saccades are represented by the lines between the circles.

The number of website visitors, in-website mouse clicks and page views are one example of a qualitative method for discerning user preference in the context of websites [Patel et al., 2015; TNS Metrix, 2016]. In addition to measuring user preference as a whole, there are methods with which the factors from which it is formed can be measured individually. Additionally, these methods can be used to form rough predictions.

In their work, Altaboli and Lin [2011] present objective, quantitative methods that can be used to measure visual aesthetics. In their study, the methods are divided into two categories: **simple count** and **formularized** methods. The simple count methods consist of calculating the number of elements visible. For example, the number of images, font size or objects. Another simple count measure presented by Altaboli and Lin [2011] is the size of the website in JPEG format. To acquire this measure, a screenshot of the website must be taken and then converted and compressed into a JPEG file. As a visually complex website has more content, such as images and text, it would therefore create a larger file size than a simple website. Though JPEG size has been found to be a valid measure [Tuch et al., 2009], it should be noted that the measure may not take into account modern dynamic website functionality such as hidden content or dynamic website alteration via javascript, for example.

The formularized methods presented by Altaboli and Lin [2011] measure visual aesthetics by calculating visual design features, such as balance and unity, using mathematical formulae. For example, one method is to calculate the average value of fourteen design features. The features are as follows: **balance, symmetry, equilibrium, unity, sequence, density, proportions, cohesion, simplicity, regularity, economy, homogeneity, rhythm** and **order**. This average value represents the aesthetic score of the website. In their study, Altaboli and Lin [2011] used both simple count and formularized measures to analyze 42 websites that had been evaluated via qualitative means beforehand. The results of the study showed that the quantitative results correlated with the qualitative results, signifying that the objective measures produced valid results. The work by Altaboli and Lin does not, however, consider the effects of colorfulness, though the work of Reinecke et al. [2013] can be used as a supplement.

The measures presented by Altaboli and Lin [2011] focus on the visual aspects of aesthetics and complexity, which is natural, as both are visual in nature. Wu et al. [2013], however, take complexity measurement one step further by analyzing the source code and website structure in addition to the web-page image. The method presented uses machine learning and web mining techniques to measure visual complexity in two phases. In the first phase, the website and its layout are analyzed, after which three classes of visual complexity features; i.e., HTML, structural and visual features, are extracted.

The HTML features are extracted directly from the source code of the website and consist of **count measures**, such as number of background colors, average font size and number of texts. Structural features are extracted via visual-based page segmentation in which the document object model (DOM) of a website is combined with visual cues, such as background color, to divide the website into blocks. These blocks are then organized into a tree that displays the structural order and hierarchy of the website. Visual features are extracted by analyzing the **brightness**, **hue**, **colorfulness** and **texture** of the website. Additionally, Wu et al. [2013] utilize the JPEG size measure in this calculation. In the second phase, after all three classes of features have been extracted, they are used to construct a vector. This vector is in turn fed into a measuring function created with machine learning techniques. The function produces the calculated visual complexity of the website.

It should be noted that while these measures can be used to predict the level of visual complexity, colorfulness and perceived visual aesthetics [Reinecke et al., 2013; Shen et al., 2013; Tuch et al., 2012], the results should be considered as educated guesses and not hard facts. Each website is different, and as such have their own requirements. Positive values in visual complexity or colorfulness do not make a website visually appealing [Moshagen and Thielsch, 2010]. For example, an online marketplace may have higher complexity scores than a search engine, but it does not necessarily mean the online marketplace is less preferable.

2.3 Website Efficiency

Website efficiency, working in tandem with visual aesthetics, plays an important role in user preference and website use. Efficiency is defined as production with minimal waste [Merriam-Webster] and in the context of websites this refers to being able to complete a task or tasks on a website without wasting time or energy. In this thesis, website efficiency is viewed from two perspectives: mechanical efficiency and user efficiency, with the former representing the programming of the website in terms of page loading times and the latter representing both the actual and the perceived efficiency of the user.

2.3.1 Mechanical efficiency

Mechanical efficiency is represented by how quickly a website loads when accessed and used, and is affected by how a website is programed in addition to how much information must be loaded [Work, 2011; Soegaard, 2016b]. If a website has a large amount of content, or needs to process a large number of functions, the load time will be longer. For example, in the context of multi-device design approaches, the responsive approach can be seen to be less efficient than the adaptive or mobile-dedicated approaches, as responsive websites generally load the highest amount of content due to the universal style [Soegaard, 2016b]. Though page load times may seem to be a trivial matter, studies have found that they have a noticeable effect on website use [Work, 2011]. Modern desktop users expect websites to load relatively quickly – around 2 to 3 seconds. If a website exceeds this time-frame, users begin to abandon the site because they lose interest or become frustrated. Even after the first second of loading, a small number of users give up on the site and move on. In addition, website load time has been found to be an important factor in user loyalty, in the context of e-commerce [Work, 2011; Jacob, 2011]. Mobile users, however, have been found to be slightly more patient, with users expecting mobile sites to be slightly slower than desktop versions. In general, mobile users allow for a period of six to ten seconds before abandonment [Work, 2011]. Internet connection speeds may have an influence on the expected load time, as mobile phones often have slightly weaker connections than desktop computers. Mobile phones additionally have less processing capabilities, further lengthening load time.

2.3.2 User Efficiency

In this thesis, **user efficiency** refers to both the perceived efficiency of a website and the efficiency of a user, or user performance. **User performance** refers to how well and how quickly a user performs a set task. In the context of websites, user performance represents how a user can process and use the elements of a website, be it the navigational structure or the process of ordering a product [Leuthold et al., 2011]. If a website is not efficient, e.g., easy to understand and clearly structured, a user will use more time to find the correct elements or links if they are able to complete the task at all [Leuthold et al., 2011; Soegaard, 2016a]. Perceived efficiency refers to the perceptions a user forms while doing the same task.

As with usability, aspects of visual aesthetics can influence how the efficiency of a website is perceived [Moshagen et al., 2010; Raita and Oulasvirta, 2011]. Visual complexity, for example, can decrease efficiency because high complexity increases the number of choices and therefore increases the amount of time it takes to come to a decision, as seen in the Hick-Hyman law [Soegaard, 2016a; Seow, 2005]. Simplicity, on the other hand, has an increasing influence. In a study by Maurer et al. [2010] in which desktop and mobile websites were tested on a mobile platform, users perceived that their performance was better on a simpler mobile website, even though the study found there was no difference in performance.

2.3.3 Measuring efficiency

Mechanical efficiency is measured by calculating the length of time a website requires to load a single page or to complete an action. Page load time indicates how efficiently this information is being loaded and the way in which the website has been programed to handle the flow of data. Several factors, including external file loading, image rendering and website redirects, in addition to the visual complexity of the site, influence the time a website requires to load [Jacob, 2011].

Page load times are calculated by measuring the time it takes for a website to fully load; i.e., all content is visible. While this can be done via a stopwatch, modern browsers offer more in-depth tools. Browsers, such as Mozilla Firefox and Google Chrome, among others, offer built-in development tools with which a user can view the source code and stylesheet of a website. Additionally, the tools can be used to view and analyze the way the website uses memory, what JavaScript commands are called and, most importantly, the timeline which displays the load time of a website and segments it to enable further analysis, as shown in Figure 2.5. In addition to built-in tools, multiple external applications and services exist, such as Google´s PageLoadTools, that analyze a website's load time and give feedback on possible ways to improve it.

Figure 2. 5 Screen capture of Google Chrome DevTools Timeline panel. Accessed 22.12.2016.

The methods used to measure user efficiency depend on which aspect, either perceived efficiency or actual user performance, is being measured. Due to the subjective nature of perceived efficiency, questionnaires often featuring Likert scales are a common and effective tool [Maurer et al., 2010; Blanco et al., 2010]. User performance is often measured with task completion times. Task completion times represent the amount of time it takes for a user to begin and complete a task, ranging from simple word searches to more complex activities, on a website. If a website is inefficient in terms of functionality or layout and visual cues, the tasks will take longer to complete [Raita and Oulasvirta, 2011; Moshagen et al., 2010].

Finally, eye tracking can be a useful tool in efficiency measurement, especially in the case of user performance. Eye tracking data give insight into how a user views a website and therefore on how effectively the visual cues and layout of the website function [Poole and Ball, 2005]. Fixation and saccade dispersal, length, shifting, repetition and amount are all indicators of a confusing or misleading layout that either does not match user expectations or does not offer meaningful cues [Poole and Ball, 2005; Ehmke and Wilson, 2007]. These layouts decrease efficiency because time is wasted on finding the correct option.

3. Research Methods

In this chapter, the motivations and goals of the thesis are repeated, research questions based on the materials gathered are formed and the expert analysis and the conducted study are presented. Additionally, the participants, measures, devices and mock websites are discussed.

3.1 Motivation and goals

The observed increase of desktop websites that featured mobile-dedicated elements, such as a fixed cap on width, large blocks of elements and generally simpler, easier to scale, designs were the main motivator in this thesis. As the use of the Internet on a desktop device is a daily habit, the question was raised whether this mobile-focused design was indeed the direction website design should take in order to accommodate the ever increasing amount of mobile users.

To answer this question is the main goal of this thesis. Additionally, a secondary goal is to study the effect each approach has on user preference and website efficiency depending on device is another point of interest. Finally, a goal of this thesis is to provide a guide for web developers in terms of deciding which design approach to adopt for a given project.

3.2 Research questions

A total of three research questions were formed based on the findings and material discussed in chapter 2. The first question focuses on the three different design approaches as one point of interest in this thesis is to discern if one of the said approaches is better than the others. The works of Soegaard [2016b] and Gustafsson [2015] depict the adaptive approach as providing tailor-made layouts for each device used without having to load a lot of data, giving it an apparent edge over both the adaptive and responsive approaches. Complexity may be an issue for the adaptive approach when compared to mobile-dedicated websites. However, the tailor-made designs across devices predict high preference overall. Therefore, the first research question is **“are online newspaper websites designed with the adaptive approach better overall in terms of efficiency, complexity and preference?”**, which will be referred to in the thesis as **Q1**.

The second and third research questions are related to how simplicity affects both preference and efficiency in websites. The work of Tuch et al. [2009], among others, has presented the important role visual complexity has on both first impressions and preference overall. Based on this statement, one could assume that the mobile-dedicated website for the desktop computer will produce higher scores in terms of preference than the representatives of the other approaches, as the mobile-dedicated website is the simplest. **“Is a mobile layout preferred for online newspapers on the desktop device?”** acts as the second research question and is referred to as **Q2**. Furthermore, as online newspapers often offer a large amount of information, it is a point of interest to see whether high simplicity is seen as a positive influence in this context. Finally, the third question asks whether the level of simplicity a website possesses correlates with efficiency both in terms of load times and task completion. One would assume websites with less content require less loading, in addition to being easier and faster to process. The third and final research question is: “**Does website simplicity correlate with efficiency in the case of online newspapers?”** and is referred to as **Q3.**

3.3 Participants

In total, ten participants, plus two for the pilot studies, were recruited during the study. Participants were recruited via two methods. Participants for the pilot studies, and the first three participants in the study proper were recruited by the researcher via spoken invitation. The seven other participants were recruited with the help of Alma Media. The goal of the recruitment process was to recruit a wide variety of users with different backgrounds and skill levels in both Internet use in general and the use of the Aamulehti website. A point was made to recruit both older and younger participants. Older participants would have used traditional sites longer and would have experienced the transition into modern responsive design, whereas younger participants would be accustomed to the more modern responsive and mobile-dedicated approaches. This difference in background was found to be of particular interest because it may affect user preference.

Data on the background and Internet use of the participants were collected via a short questionnaire (Appendix 3). Of the ten participants, five were male and five females, all of whom were Finns, resulting in a perfectly even split. The participants were divided into five age groups. Three participants were in the 16 to 30 years of age group, one was in the 31 to 45 years of age group, three were in the 46 to 60 years of age group, two in the 61 to 75 years of age group and one in the 76 and 87 years of age group. Each participant had at least a high school or vocational school level of education, with the majority having achieved a bachelor´s degree or equivalent. Interestingly, when asked how often they used the Internet, each participant, regardless of age, replied that on average they used the Internet multiple times a day, demonstrating how ubiquitous Internet use has become.

Among participants, the smartphone was the most common device used to browse the Internet, followed by the laptop, desktop computer and tablet. When asked what devices they used to browse the Aamulehti website, the participants generally gave the same answers as in everyday Internet use. However, there were a few cases were the participants reported using only a single device or a device they did not generally use to browse the Aamulehti website. Regardless, the smartphone was the most common device used. Finally, participants were asked how often they use the Aamulehti website. Most of the participants either used the site once a week or once a day. Additionally, one participant reported using the website multiple times a day and another did not use the site at all. A table containing the collected data can be seen in Appendix 7.

3.4 Description of study and procedures

The experiment was performed at the University of Tampere, utilizing their gaze laboratory facilities and equipment. The experiment used a 3x3 within-subjects design, wherein the variables are design approach (Responsive, Adaptive, and Mobile Dedicated) and device (Desktop computer, Tablet computer and Smartphone). In this design, the devices act as independent variables and the design approaches as the dependent variables. Additionally, perceived preference and efficiency act as dependent variables.

The general flow of the experiment was as follows. Participants were welcomed and informed of the purpose and methods of the experiment. After the informed consent and non-disclosure agreements were agreed upon and signed (Appendix 1, 2), general information was collected via a short questionnaire (Appendix 3). After the introductions, the participants were shown into the space where the experiment was held. Before the experiment began, the eye tracking hardware and software were presented and calibrated. To counter-balance the learning effect, each participant began the experiment using a different device than the previous participant.

After a device was chosen, the participant was presented with a set of two to three cards face down, each of which contained an address for one of the mock websites and two tasks to complete. The participants were asked to give a vocal signal when they had completed a task to aid post study analysis. The task cards could be completed in any order, though all tasks on one card needed to be completed before continuing to the next card. After a card was complete, the participant was asked to fill in a short questionnaire (Appendix 4) in which they gave their opinion on the complexity, efficiency and preference of the website. After all the cards were complete, the participant switched to another device and started again until all three devices had been used. Finally, a short semi-structured interview (Appendix 6) was conducted, in which the participant was asked to share their thoughts on the mock websites. When the study session was completed, the participants were presented with a small gift card provided by Alma Media. One study session lasted approximately one hour.

3.4.1 Devices

Three devices were used to test the mock websites during the experiment; a desktop computer, a tablet computer and a smartphone. The desktop computer used during the experiment had Windows 7 as the operating system and Mozilla Firefox acted as the browser. A 1600x1200 resolution screen was used. A Samsung Galaxy Tab 3 running Android 4.4.2 was used as the tablet computer and a LG G3 D855 running android 6.0 was used as the smartphone. Both the tablet and smartphone were used in the portrait view mode. These three devices were chosen because they represented the three most popular devices for Internet browsing and were easily obtainable for the study. Though the tablet device is less popular than the others, it was included in this study, as it was seen as a middle point between the desktop and smartphone devices, giving insight into the influence of a slightly larger screen combined with mobile-dedicated layouts.

The eye tracking hardware used during the test was the Ergoneers Dikablis Professional (Manching, Germany), head mounted binocular 60 Hz tracker along with its D-LAB analysis software. The Dikablis was chosen because it was head mounted, making tablet and mobile tracking easier, and due to its easy calibration. Additionally, the Dikablis offers the use of special tags that can be placed on the physical devices in any pattern and number. An example of the experimental setup can be seen in Figure 3.1 These tags can then be set as points of interest and can be analyzed individually with the use of the D-LAB software. Though the Dikablis can be used wirelessly via Wi-Fi, it was connected to a laptop during the experiment, as this assured higher quality material and allowed the moderator to analyze and make notes on the participant’s gaze during the experiment in real-time.

Figure 3.1. Experimental setup with tags seen on devices (left). Dikablis device being worn (right).

3.4.2 Tasks

There were two tasks for each website, making a total of 16 tasks. Each mock website had one task related to the main article and its headlines and another related to the content of the sidebar. The first of the two tasks was a mechanical search task that required the participant to browse through the website to find a specific article, column or other item. The other task presented the participant with a fictional situation simulating normal use of a newspaper website. For example, one situation established that the participant was given a device by a friend and asked to read the most recent article, as the friend had their hands full, but was interested in the contents. The tasks were written in Finnish, as it was the mother tongue of the participants. A full list of the tasks can be seen in Appendix 5**.**

3.4.3 Expert Analysis

The separate expert analysis followed the methods used by previous studies to gather objective data on website complexity and aesthetic value. Three measures were used: visual complexity, page load times and visual aesthetics. Visual complexity was calculated using JPEG file size, as used in the study by Tuch et al. [2009], whereas website efficiency was measured using page load times. The JPEG files sizes were measured by the author by taking full website screenshots of each mock website and compressing them into the JPEG format with GIMP (v.2.8.8), an image manipulation program. The default compression settings of the program were used, which optimizes for high quality. Discrete cosine transform based **lossy compression** is used as the default compression method.

The page load results were formed by calculating the average duration of 10 individual page loads for each mock site. As wireless Internet connections could affect the final scores and testing on other devices proved difficult, all mock websites were tested using a web browser, Mozilla Firefox Developer Edition specifically, on a desktop computer with a stable wired connection. Both a tablet and a smartphone device were emulated using the browser´s built in responsive design tools and were used to test the load duration of the mock websites designed for the said devices.

An objective evaluation of the visual aesthetics was performed by the author using both the simple count and formulized methods used in the work of Altaboli and Lin [2011]. In terms of simple count measures, the following were chosen: **number of objects, number of objects differing in size, file size** and **number of images**, which are similar to the parameters used by Altaboli and Lin, with the exception of the exclusion of number of different font types. Font types were excluded because all the websites used the same fonts, as they represented the same website. **Objects** were defined and calculated by referencing the div-elements on the mock websites. In general, div-tags are used to define sections or dividers on websites. They are also used to group a set of elements into one block, which is then modified or formatted via CSS [W3School, 2017]. A single div element, including its child elements, was seen as one object, excluding the first levels of the hierarchy, which comprise the layout as a whole. If an element was not the child of a div, object definition was based on the proximity of the element to another similar element.

Unity, **Simplicity**, **Density** and **Economy** were chosen as the formulized count measures for the mock websites. The four measures were chosen because they represent different aspects of a websites tendency to use space, be it in the proximity of objects to one another, the amount of white space used on the website or the shapes of the different objects on the layout. The measures were calculated using the formulae presented by Ngo et al. [2012]. The results of these calculations range from 0 to 1, with 0 signifying poor representation of the facet of visual aesthetics in question on the website and 1 signifying a perfect representation.

3.4.4 User Study

Preference, **efficiency** and **complexity** were the three main characteristics measured during the experiment. The characteristics were measured in two phases: during the actual experiment and during the separate expert analysis. During the experiment, a questionnaire was used to measure qualitative data on all three characteristics. The questionnaire featured a 7-point Likert scale for perceived preference, efficiency and complexity (Appendix 4). The user was asked to fill in the questionnaire each time they completed the tasks on a single page. The semi-structured interview held at the end of the experiment was used to gather additional information on the factors that affected user preference. Participants were additionally asked to express their opinions on the three characteristics and how they felt they affected their preference. The full list of interview questions can be found in Appendix 6. Task completion time was used as a separate quantitative measure for website **efficiency**. Task completion time was defined as the time, measured in seconds, between the participant finishing reading a task and the participant signifying that they had found an answer.

The eye-tracking data gathered during the experiment was similarly used for both quantitative and qualitative purposes. Each session was reviewed afterwards using D-LAB and the functionalities it provided. These include, but are not limited to, gaze path calculation, heat map generation and automatic saccade and fixation calculation. In terms of quantitative data, saccade and fixation amounts were measured as indicators of layout **complexity**, in addition to time until first fixation and average fixation length. In terms of qualitative data, the participants' gaze paths on each website were analyzed and compared to find common areas of interest, areas of disinterest and to find common themes in general viewing behaviors.

3.4.5 Pilot Study

Two pilot studies were performed using two participants. After the studies, the results along with notes and observations made by the moderator were analyzed. Based on this analysis, changes were made to the content of the mock websites, the tasks and the devices used. The biggest change was the replacing of the tablet device. Originally, a Microsoft Surface Pro 3 device was to be used, but during the pilot it was found that the device was uncomfortable to hold for long periods of time in portrait mode. Additionally, the device could not display the mock websites in the desired way. A Samsung Galaxy Tab 3 device, running Android 4.4.2, was used as a replacement device.

After the first pilot study, slight changes were made to the mock websites themselves. A large number of mock sites had a similar news article in the **most recent –** section, which, in short, conveyed recent threats made to the University of Tampere. As the study tasks had participants frequently viewing the most recent –section, the articles were changed to avoid causing discomfort and unease. Additionally, it was found that many tasks had the participant finding the exact same article, the first article in the **most recent** –section, on multiple websites. This was slightly changed to give more variety to the task by including other articles in the most recent –section.

After the second pilot study, additional changes were made to the tasks and the mock websites. It was found that the carousel method of portraying headlines was ineffective because participants could not recognize the functionality it offered. To correct this, the arrow buttons, which are used to control browsing between headlines, were made more prominent. Additionally, grammatical errors were corrected in task descriptions, as the original versions were slightly misleading.

3.5 Mock Websites

A total of eight mock websites were created for the experiment, each representing a certain design approach on a certain device, e.g., one mock website for an adaptive website on the desktop, another for responsive and so on. Each website used the current Aamulehti website as a base with only minor changes made to the layout and content to represent the different design approaches, while still maintaining the level of prototypicality found on the original website. The most notable change was how the main articles were presented in each website. Due to time restrictions, each website offered very little functionality and was hard coded to match the requirements of each device instead of true responsiveness. Additionally, a different article was chosen for each mock website to make the experiment more pleasant for participants, as the tasks had them reading through most of them.

3.5.1 Responsive Web Design

Figure 3.2. Responsive web design Mock websites

The current Aamulehti website uses responsive design elements, which is why the mock websites created to represent responsive design were almost identical to the original. Any differences between the mock site and the original were caused by the creation process, as each mock website was created from the ground up. As can be seen in Figure 3.2, the responsive websites are similar in design and layout, especially the tablet and the desktop computer. All three mock websites displayed the main articles in a full list, e.g., multiple items arranged in a column that comprised a title followed by a large image and an excerpt of text from the article. As is common in responsive websites, the image and font sizes scale with the size of the device or window and elements. The side column in this case were rearranged on smaller screens.

Though responsive websites use the same website with CSS differences for each viewport, separate HTML and CSS files were created in this experiment. This was done to increase the pleasantness of the experiment, i.e. each site could present a different article. In terms of efficiency measurement, a separate mock website was created using normal responsive practices. It should be noted that the Aamulehti website underwent minor layout changes during the experiment. These changes were not implemented in the mock websites, as the changes were made during the latter stages of mock website development.

3.5.2 Mobile-dedicated Web Design

Figure 3. 3 Traditional website on mobile (left), mobile-dedicated website on desktop (Right)

Two websites were created to portray the different aspects of the mobile-dedicated approach; a mobile-dedicated website that was viewed on a desktop computer and a traditional website viewed on a mobile device. The websites can be seen in Figure 3.3. The mobile-dedicated website was designed to be simplistic with only the relevant content displayed. Both font and image size are noticeably larger than the standard for most desktop pages and the page was presented in a “frame” similar in size to a tablet computer. The main headlines were presented in a simple text list, without images or excerpts, to increase simplicity. The mobile version of the Twitter home page and the example shown in the work of Patel et al. [2015] were used as a point of reference in the design. No mock website was created for tablet computers in this area.

The traditional website was designed to emulate websites as they were before the introduction of the mobile-dedicated and responsive approaches. In short, these websites were not able to read the dimensions of the device used and required manual zooming to be used on mobile devices. Additionally, the website takes up the full width of the page instead of leaving space on both sides as is common in modern web design. Otherwise the website was kept the same as the current Aamulehti website.

The two websites were viewed on the wrong device for two reasons. First, websites explicitly designed for both desktop computers and mobile devices can be found in the adaptive web design approach, making the testing of a mobile-dedicated website on a mobile device redundant. Second, the current setup offers insight into one of the points of interest of this thesis: the efficiency of mobile-dedicated website on desktop computers and the related user preference. Additionally, the setup mirrors aspects of the work of Patel et al. [2015] and Maurer et al. [2010], which can be used in the analysis of the results of the experiment.

3.5.3 Adaptive Web Design

Figure 3.4 Adaptive Web Design Mock Websites

The three websites created to represent adaptive web design are the most varied, as each website is tailor-made for the device on which it is viewed. Though each website adhered to the basic layout and elements of the original Aamulehti website, changes were made to both the way the main articles were presented and to the position of some elements so as to utilize the attributes of each device. The three websites can be seen in Figure 3.4.

The adaptive website designed for desktop computers differed from the original Aamulehti website in two key aspects: First, the adaptive website utilized all the width the computer monitors provide, similar to more “traditional” website. To accommodate the increase in width, font and image size were increased. The increased width additionally lessened the space requirements of the elements, such as the lists on the side column, because long article titles no longer required multiple rows of space. Second, the increased width permitted the presentation of the main articles in a table comprising two columns, and thus reduced the height of the website considerably. A single article was displayed in a block consisting of an image that was followed below by the title, category and time of publishing.

Similar to the desktop version, changes were made to the adaptive tablet computer website to better utilize the display size of the device. The side column was moved to the bottom of the website, as in a mobile website, to increase simplicity and element size. The navigation menu, however, was kept as it was in the desktop version because the width of the device was not so small as to require a separate toggleable menu. The main articles were presented in a single column list with each item comprising a small image that was followed on the right by the title, category and time of publishing, each displayed on top of one another.

The adaptive mobile website was very similar to the original, as responsive design, bootstrap especially, is mobile-friendly by nature. The most noticeable change in the adaptive website was how the main articles were displayed. Instead of the full list approach used by the original website, the adaptive version utilized a carousel; e.g., the articles are presented one at a time in a static pane with the article title, category, time of publishing and excerpt dynamically displayed below. The articles can be browsed using directional arrows found on either side of the pane.

In summary, the adaptive websites focused on using the full width of each device, in addition to offering tailor-made styles. The sites offered the widest variety of headline list styles and used a more mobile-dedicated style on the tablet device. The desktop mock site for the desktop computer was the most complex out of all the approaches. The responsive sites represented the online newspaper as they are now, utilizing rescaling and fluid grids to resize the site and using the same style of headline list for each site. Finally, the mobile-dedicates mock sites featured layouts designed for other devices, offering the simplest desktop and most complex mobile sites. Figure 3.5 presents all the mock sites arranged by approach into a grid.

Figure 3.5 Mock websites. Adaptive (top), responsive (middle) and mobile-dedicated (bottom).

4. Results and discussion

In this chapter, the results of both the expert analysis and the study itself are presented. As the analysis and the study were done independently, the presentation of the results are divided into separate sub-chapters. In the first sub chapter, the results of the expert analysis are discussed, including the website loading durations and the objective data on visual appeal found via count and formulized methods. In the second sub chapter the results of the study proper are presented. The results of the participant interview are divided into two sections to improve readability: The qualitative data collected during the experiment, in addition to the task completion times are presented first, followed by eye tracking findings and quantitative data.

4.1 Results of the expert evaluation

Table 4.1 presents the findings of the page load time measurement in seconds. Both the responsive and adaptive design approaches produced similar page load times, with the adaptive mock websites being only slightly faster than their responsive counterparts with a difference of less than a tenth of a second. As the tested websites are simple mock versions, the differences between adaptive and responsive sites may not have manifested because the difference in CSS file size and complexity are minimal. The mobile-dedicated approach is notable, however, as it produced both the fastest and the slowest load durations, 0.95 and 1.43, respectively.

Table 4. 1 Page load times (seconds)

Device/Design	Mobile-dedicated	Responsive	Adaptive
Computer	0,95	1,23	1,24
Smartphone	1,43	1,25	1,18
Tablet		1,25	1,21

The relatively fast loading time of the mobile-dedicated layout on a desktop computer can be attributed to the small number of images, 8 compared to the average 18 on other mock sites. Though the desktop layout on the smartphone had a similar number of images as the other mock sites, it produced the longest load time. The slight increase in loading time can be attributed to the zooming and scaling of the page. The page load times would suggest that website simplicity correlates with efficiency (**Q3**) as the simplest website, the mobile-dedicated site for desktop, also took the shortest amount of time to load. However, the similar load times between desktop sites and mobile sites, where the difference in simplicity should produce noticeable differences, make this assumption premature.

The values shown in Table 4.2 represent the results of both the simple count and formulized methods from the perspective of the three devices used. The scores were formed by calculating the average scores of the adaptive, responsive and mobile dedicated sites for each device.

Table 4.2 Simple count and formulized measures by device

Desktop		Min	Max	Average	Standard deviation
	Objects	19	25	21,667	3,055
	No of diff object sizes	15	19	17	2
	File size (mb)	4,4	11,1	7,090	3,54
	Images	8	17	13,333	4,726
	Unity	0,244	0,653	**0,476**	0,211
	Simplicity	0,059	0,075	**0,069**	0,009
	Density	0,765	0,901	**0,819**	0,072
	Economy	0,053	0,067	**0,06**	0,007
Mobile	Objects	18	24	21,333	3,055
	No of diff object sizes	16	17	16,333	0,577
	File size (MB)	4,09	11,5	7,03	4,17
	Images	14	15	14,333	0,577
	Unity	0,145	0,335	0,222	0,1
	Simplicity	0,06	0,075	0,066	0,008
	Density	0,567	0,697	0,637	0,066
	Economy	0,053	0,625	0,062	0,002
Tablet	Objects	24	26	25	1,414
	No of diff object sizes	16	17	16,5	0,707
	File size (mb)	9,42	12,5	10,96	2,178
	Images	15	18	16,5	2,121
	Unity	0,236	0,454	0,345	0,154
	Simplicity	0,055	0,061	0,058	0,004
	Density	0,172	0,063	0,492	0,453
	Economy	0,053	0,063	0,058	0,007

Before the specific results for the design approaches and devices were analyzed, the following general findings were noted: Regardless of design approach, device or any combination of the two, both the simplicity and economy formulized measures received very low scores, all below 0.1, even though one would assume the websites, especially the mobile layouts, would achieve positive scores on both, as the space between elements is relatively small. However, the large number of differently sized objects hindered both scores. Average density scores were relatively high overall, the highest being achieved by the mock sites for the desktop device. The lowest average density score was achieved by the tablet mock websites, suggesting that the combination of a slightly larger screen and the mobile layout had a positive influence.

In terms of simple count measures, the tablet device had the highest scores over all, though the absence of a mobile-dedicated mock website affected the results. Though the scores are relatively high, the standard deviations are low, signifying only slight variation between the two websites. The mobile-dedicated approach had a significant effect on desktop scores, particularly the standard deviation, as the design had few images and objects in relation to the other mock websites on the device.

The desktop computer received the highest scores in general from the formulized methods, scoring the highest in all categories, excluding economy. At first glance, this may be an indication of the desktop computers supremacy in terms of visual aesthetics. However, in addition to high scores, the desktop sites achieved the highest standard deviation. The high deviation implies fluctuation in visual aesthetic scores on the three desktop mock websites, which suggests that not all mock sites were equally aesthetically pleasing. It should be noted that even though the standard deviation was highest for desktop devices, the scores of both tablet and mobile devices were similar. Density and unity scores had the most deviation out of all formulized methods.

Table 4.3 presents the results of the simple and formulized count measures from the perspective of the three design approaches. Unlike in the previous results, no single design approach excelled in enough categories to be considered superior in terms of visual aesthetics. Instead, the adaptive approach received generally higher scores in simplicity, the responsive approach in economy and density, whereas the mobile-dedicated approach scored highest in unity. Standard deviations were similar between both the adaptive (AWD) and responsive approaches (RWD), with the responsive having slightly less variation in most categories. The mobile-dedicated (MWD) approach produced the highest variations, though the strong difference in layout and style between the two mock sites explains this in some regard. The mobile-dedicated approach does, however, have the lowest variation in simplicity.

Table 4.3. Simple count and formulized measures by design approach

AWD		**Min**	**Max**	**Average**	**Standard deviation**
	Objects	18	26	21	4,359
	No of diff object sizes	16	19	17,333	1,528
	File size (mb)	4,4	12	7,363	4,466
	Images	14	18	16,333	2,082
	Unity	0,186	0,454	0,296	0,141
	Simplicity	0,055	0,75	0,**068**	0,011
	Density	0,172	0,791	0,553	0,334
	Economy	0,053	0,063	0,056	0,006
RWD		**Min**	**Max**	**Average**	**Standard deviation**
	Objects	21	24	23	1,732
	No of diff object sizes	15	16	15,667	0,577
	File size (mb)	5,77	11,8	8,997	3,037
	Images	15	15	15,000	0
	Unity	0,236	0,529	0,366	0,**145**
	Simplicity	0,06	0,075	0,065	0,**008**
	Density	0,567	0,901	0,**76**	0,178
	Economy	0,063	0,067	0,**064**	0,**002**
MWD		**Min**	**Max**	**Average**	**Standard deviation**
	Objects	22	25	23,5	2,121
	No of diff object sizes	17	17	17	0
	File size (mb)	4,09	11,1	7,595	4,957
	Images	8	14	11	4,243
	Unity	0,145	0,656	0,**402**	0,361
	Simplicity	0,059	0,064	0,062	0,**004**
	Density	0,765	0,648	0,707	0,083
	Economy	0,059	0,059	0,059	0

As the results of the measurement were similar without any one device or approach being greatly better or worse than the others, no one approach can be considered completely superior. It should be noted, however, that the responsive approach received higher scores in more categories than the adaptive and mobile-dedicated approaches, in addition to having the lowest variation. Therefore, if one approach had to be chosen to represent high visual aesthetic appeal, it would have to be the responsive approach. Furthermore, in combination with the results of the simple count measures [Table 4.2], this would suggest that the optimal device-approach combination would be a desktop website designed using the responsive design approach. These results would suggest that the adaptive approach does not produce the highest overall rating by default (**Q1**), though the actual results of the study may prove otherwise.

4.2 Results of the study

In this sub-chapter, the results of the study proper are presented and analyzed. As there were many data sources, this sub-chapter is further divided into sub-chapters, with each focusing on one data source. The task completion times are analyzed first, analyzing the data in general and from the perspective of the design approaches and devices. Next, the participants perceived preference, efficiency and complexity are analyzed, followed by the results of the semi-structured interview. Finally, both objective eye tracking data and subjective observations made during eye tracking are presented.

4.2.1 Task completion times

Based on the results shown in Table 4.4, the following observations were made. Out of all the mock websites, the mobile-dedicated approach for desktop computers scored the lowest on average. The low score signifies efficiency, and implies that the simple mobile design had a positive effect on efficiency, though less information was presented. The shortest time was on the second task on the responsive site for tablet devices, with an average score of nine seconds. The highest time was achieved by the adaptive mock site on the smartphone with the longest average task completion times for both tasks. The relatively high score on the adaptive website for mobile devices can be partly attributed to the carousel methods of presenting headlines. The functionality and controls of the carousel were easily missed and a portion of the participants needed a hint or direction before they understood how it worked. In general, the optimal performance for each task was estimated to be approximately 30 seconds ± 10 seconds.

Table 4.4. Task completion times for each mock website in seconds.

Device	Approach	Task 1	Task 2	Average	Stdev.
Desktop	Adaptive	35,5	12	23,75	12,171
Desktop	Responsive	40	12,6	26,467	19,066
Desktop	Device	22,6	17,778	**20,189**	13,954
Mobile	Adaptive	83,3	30,889	57,094	**26,498**
Mobile	Responsive	55,444	28,3	41,872	**25,106**
Mobile	Device	**31,6**	17,2	24,4	14,758
Tablet	Adaptive	**43,2**	24,444	33,822	**22,699**
Tablet	Responsive	37	9	23	16,830

These results would suggest that website simplicity does correlates with efficiency (**Q3**) because the mobile-dedicated mock site for desktop scored the lowest in terms of task completion time. However, the relatively low score received by the mobile-dedicated site for mobile, which is arguably one of the more complex mock sites, along with the somewhat similar scores of the desktop adaptive site indicate that this cannot be confirmed at the current stage. This is further emphasized by the page load times seen in Table 4.1, which showed similar results.

Another finding based on the results is the effect the sidebar has on efficiency. Websites that have the sidebar on the side of the page, as in the responsive site for desktop for example, produced somewhat lower task completion times than similar pages with the sidebar at the bottom, regardless of device. For example, task completion times for task two, which had participants searching for data on the sidebar, on the desktop computer are lower on both the responsive and adaptive sites, whereas the mobile-dedicated site has a higher score. The same phenomenon can be seen in the mobile and tablet sites. The slight increase in completion time can be attributed to the scrolling of the website.

The only exception to this rule is the mobile-dedicated website on the smartphone, where the sidebar is on the right. The completion times for this site are the highest on the device, though this can be explained by the size of the website in relation to the device: When the website is loaded, the default zoom level conceals the sidebar completely and as the other mobile sites do not offer the sidebar, the participants do not expect it to be there. It should be noted that in the case of the adaptive approach on the tablet and the mobile-dedicated approach on the smartphone, the first task had the participant using the sidebar, instead of the second.

The adaptive and responsive mock site for the mobile device, in addition to the adaptive tablet site, produced relatively high variation between task completion times, suggesting that the tasks did not take as long for all participants. It should be noted that the high deviation reduces the credibility of the results, as the average may be skewed. However, the score averages for the adaptive and responsive approaches are high enough in relation to the other scores that they should not be completely disregarded either.

Table 4.5 presents the results from Table 4.4, where the average scores of all relevant mock sites from the perspective of the devices and design approaches used are calculated. The results of the table show that the mobile-dedicated approach produced the lowest task completion times overall, with the adaptive approach having the highest. The high completion times of the adaptive approach are to some degree caused by the exceptionally high scores produced by the adaptive mobile mock site. The low average score achieved by the mobile-dedicated websites contradict the effect of simplicity on efficiency, as they represent both spectrums, with the mobile-dedicated site on desktop devices being simple and the mobile-dedicated site on smartphone being complex. The high efficiency on the mobile-dedicated smartphone site can be attributed to the zoom functionality and quick browsing while completely zoomed out, i.e., having the whole mock site visible on mobile. On the mobile-dedicated desktop site, the larger font size and simpler design are helpful in search tasks, though additional research is needed to confirm this. Additionally, the scores for the mobile-dedicated approach produced the lowest standard deviation.

Table 4.5. Task completion time averages for design approaches and devices (seconds).

Averages	**Task 1**	**Task 2**	**Average**	**Stdev.**
Adaptive	54	22,444	38,222	20,456
Responsive	45	16,633	30,842	20,334
Device	27,1	25,275	**26,188**	14,356
Averages	**Task 1**	**Task 2**	**Average**	**Stdev.**
Desktop	32,217	17,833	**25,025**	15,064
Mobile	57,7	25,583	41,642	**22,121**
Tablet	42,111	15,85	28,981	19,764

In terms of device, the desktop computer achieved the lowest scores, followed closely by the tablet computer. The highest scores in both categories were received by the mobile device. The long completion times on mobile can be attributed to the increased needed to scroll through the mock site to find content. As the screen size is smaller than the tablet and desktop devices, the amount of scrolling needed is equally increased. Based on the results of both tables presented in table 4.5, the most efficient mock website was the mobile-dedicated site for desktop computers, which offered the most simplistic layout.

4.2.2 Participant reviews

Table 4.6 presents the results of the questionnaires presented to the participants after each of the tasks on one website were completed. The scores represent the averages of all participant Likert reviews and range from 1 to 7, with 7 representing a positive response, i.e. a very preferable site for example.

Overall, the adaptive approach for the desktop computer achieved the highest scores in each category, though in the case of efficiency, it shares the highest score with the responsive approach on desktop and tablet devices. Additionally, the relatively low standard deviation of the adaptive desktop site suggests that the participants were more unanimous in their opinion. The high efficiency scores achieved by the adaptive site for the desktop device contradict the task completion times presented in Table 4.4 as the site, and adaptive approach in general, did not achieve noticeably high scores. Regardless, participants found the site to be efficient, demonstrating how perceived usability and visual aesthetics may affect perceived efficiency [Raita and Oulasvirta, 2011; Koubek and Lin, 2010]. Similarly, the results of the task completion times indicated that the mobile-dedicated desktop site had the lowest completion times of all the mock websites, though the participant reviews give the site only slightly above average scores in terms of efficiency.

Table 4.6 Participant review averages for each mock website.

Device	**Approach**	**Preference**	**Efficiency**	**Complexity**	**Avg.**	**Stdev.**	**Min**	**Max**
Desktop	Adaptive	**5,2**	**5,5**	**5,9**	**5,533**	0,836	4,33	6,33
Desktop	Responsive	5,3	**5,5**	5,3	5,367	1,094	3	6,33
Desktop	Device	4,6	5	5,1	4,9	1,067	2,67	6
Mobile	Adaptive	4,5	4,3	4,1	4,3	**1,523**	2,33	6
Mobile	Responsive	4,8	4,9	5,2	4,967	1,172	2,67	6
Mobile	Device	4,5	4,7	5,2	4,8	1,185	3	6,67
Tablet	Adaptive	4,9	4,7	5,1	4,9	**1,498**	2,33	7
Tablet	Responsive	5,1	**5,5**	5,1	5,233	1,1798	3,33	7

The lowest scores of all were achieved by the adaptive approach on mobile devices, scoring lowest in each category. The low scores can again be attributed in part to the general negative impressions left by the carousel list, as the site does not differ greatly from the responsive site for mobiles other than the headline list. Although the carousel was used to improve efficiency by lessening the length of the website and therefore lessening the need for scrolling, the poorly visible controls and general uniqueness of the carousel negated any benefits that it may have offered. It is important to note, however, that even though the adaptive mock site for mobile did indeed receive the lowest scores, the difference between scores was not great. The relatively high deviation in scores for the mock site further emphasize the unreliability of this assumption.

According to Table 4.7, the responsive approach received the highest scores on average for design approaches, whereas the desktop computer received the highest scores for devices. The results of the table device suggest that the responsive website for desktop computers would be the ideal choice, contradicting the results for individual mock websites presented in Table 4.6, but confirming the estimate calculated in Chapter 4.1. Though the adaptive site for desktop devices did receive the highest score, the approach did not fare as well on other devices, explaining the disparity between the results and giving further evidence against the idea of the adaptive approach producing the highest scores due to its tailor-made layouts (**Q1**).

Table 4.7 Participant review averages from the perspective of design approach and device

Averages	**Preference**	**Efficiency**	**Complexity**	**Avg.**	**Stdev.**	**Min**	**Max**
Adaptive	4,867	4,833	5,03	4,911	1,286	3	6,44
Responsive	5,067	5,3	5,2	**5,189**	1,149	3	6,44
Device	4,55	4,9	5,15	4,867	1,126	2,83	6,33
Averages	**Preference**	**Efficiency**	**Complexity**	**Avg.**	**Stdev.**	**Min**	**Max**
Desktop	5,033	5,333	5,433	**5,267**	0,999	3,33	6,22
Mobile	4,6	4,683	4,833	4,706	1,293	2,67	6,22
Tablet	5	5,1	5,1	5,067	1,339	2,83	7

The scores for both the adaptive and mobile-dedicated approaches were similar with only a difference of approximately 0.05. In terms of devices, however, the mobile device scored slightly less than both tablet and desktop devices. Although the effect of the adaptive mobile mock site should be considered, the results of the individual scores seen in Table 4.6 show that the mobile sites received lower ratings in general. This is a point of interest because the mobile device is currently one of the most popular devices used to browse the Internet. This suggests that while the device itself is popular, users may not prefer the current designs used on the device. Alternatively, it may be that the device itself, with its generally small screen and long pages, affects user preference negatively. Because the mobile device is so easy to pick up and use on almost any occasion, even though one would prefer not to use websites on mobile devices, the preference of the site becomes less important. It is much easier and more discreet to browse the Internet on a mobile phone while commuting than it is on a laptop or tablet.

In the case of the adaptive desktop mock website, the site received the highest scores in all three categories (**Q1**). However, the slightly poorer results for the approach on other devices suggest that further testing is required before the approach is deemed supreme. Similarly, the results show that users do not prefer a mobile layout on the desktop platform (**Q2**), as the mobile-dedicated website was rated lowest of all the desktop websites, regardless of its simple layout. Finally, participant reviews show that simpler websites were not rated higher in terms of efficiency, suggesting that the correlation between simplicity and efficiency (**Q3**) cannot be verified either.

Though the concept of a “best” design approach and device have been mentioned in these chapters, it should be noted that the scores the mock websites received are very similar and cannot be considered valid in a statistical sense. No one site, device or approach received a negative score, as all sites received scores slightly above 4 on average. However, no one mock site received a noticeably high average score either, the highest being 5.5 out of a possible 7. The average standard deviation for the scores of each device and approach were similar, signifying a degree of unanimity in general. Although these results can be used to discern an approximate “best” mock website, the validity of this claim is questionable. As such, the half-structured interviews were used to gain more insight into the reasons behind user preference and website use to formulate a more competent answer.

4.2.3 Participant interviews, general preference

The first section of the interview dealt with the individual mock websites, asking participants to pick their most and least preferred site. In cases where participants could not come to a decision, they were asked to pick either an approach or device in general. As seen in Figure 4.8, the adaptive approach received the most votes with a total of seven, with both the desktop and tablet sites being specified. The desktop site was preferred because it utilized all the space of the screen and displayed a good amount of information at once, making searching easier. Additionally, for some older participants, the approach was reminiscent of the older style of website design, which they found nostalgic.

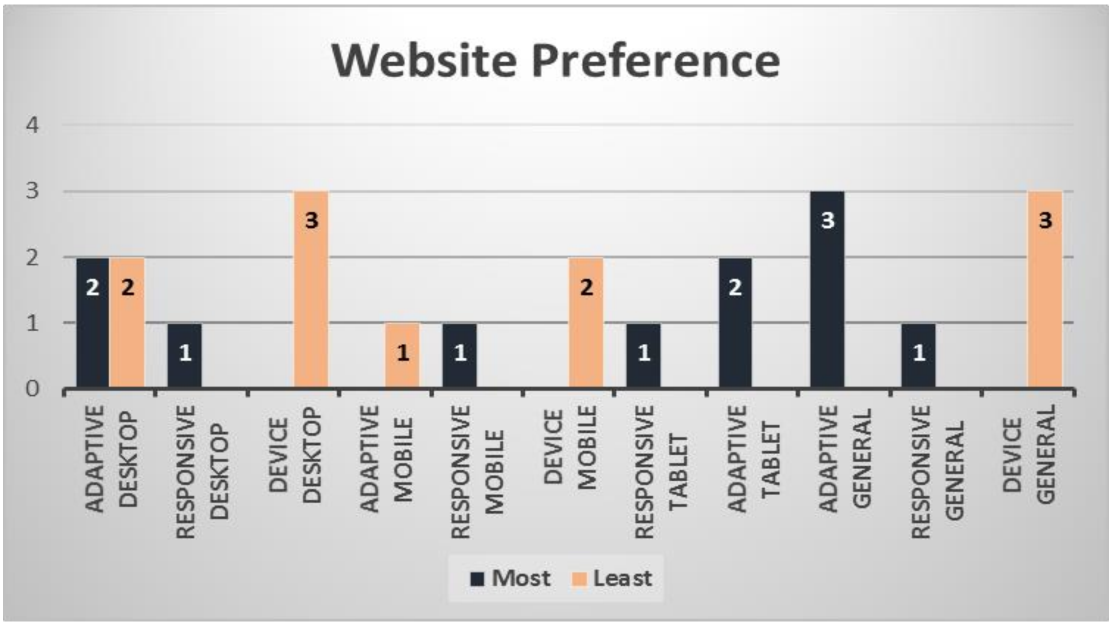

Figure 4.8 Participant Most/Least preferred mock websites

It should be noted that an equal number of participants found the site to be the least preferable. This was attributed to the dense portrayal of information, as the different section on the site had little whitespace between them. As the information was spread out onto a large area without any “breathing room”, browsing was cumbersome and it could be difficult to find specific data. This suggests that the use of all available space can be a positive influence, but the use of additional whitespace to give the site a more open feel is advised. The differences between the adaptive and responsive sites in this regard can be seen in Figure 4.9. In this example, adding white space between the main content and sidebar on the adaptive site could make browsing less cumbersome.

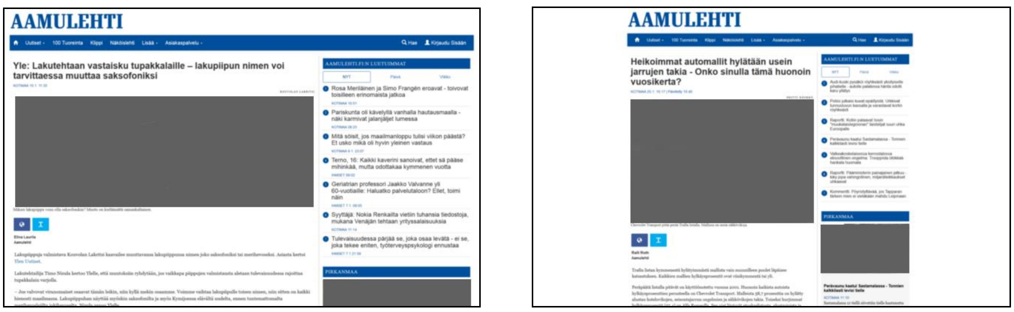

Figure 4.9 Adaptive website (left) and Responsive website (Right) space usage

The adaptive tablet site was preferred as it was simple, clear and easily understandable. The layout of the site was efficient, as the sidebar was positioned on the bottom of the page, leaving only the article visible at first. Participants felt this layout led them into reading the rest of the page after completing the main content. The slightly shorter page length, in relation to the mobile layout, was additionally perceived as a positive influence.

The responsive sites were a middle ground in terms of preference. They did not receive negative votes, they didn´t receive many positive votes either. This may be due to the responsive sites being very similar to the original site, therefore not creating as strong an impact on users as the more varied alternatives. Additionally, this may suggest that the responsive sites are adequate in that they are usable and not displeasing, but are neither especially noteworthy either.

The mobile-dedicated approach was the least preferred, receiving a total of eight negative votes, making it the only approach to receive exclusively negative votes. Participants observed that both sites felt like they were not optimal for the current device. The smartphone site required too much zooming and panning from one side to the other, in addition to having very small font sizes and poor usability. The desktop site was disliked due to the large amount of scrolling required by the mobile layout and larger font and image sizes. The results of the interviews show that the mobile-dedicated site for desktop was not preferred over the other version, confirming that users do not prefer the mobile-dedicated layout on the desktop device, even though it offers higher simplicity (**Q2**).

The results of the interviews give some credence to the supremacy of the adaptive approach in terms of supremacy (**Q1**), as many participants found the adaptive approach to be preferable. Although this does not mean that the approach is more efficient or simple, it does suggests that there is potential for further study. The results of the subjective ratings and the interview contradict each other in some regard: The adaptive smartphone site, the lowest rated site, received only one negative vote. Similarly, the mobile-dedicated desktop site was mentioned as the least preferable site by the majority of participants, though it received average scores in the Likert scale reviews. This difference can be attributed to the passage of time between the two situations. As the Likert scale review form was presented right after the site was used, the participant's current emotional state may have affected the reviews. During the interviews, the participants had had time to use other mock sites, allowing them to reassess their opinions.

The second section of the interview focused on discerning the most and least preferable headline listing methods. The column method received the most positive votes with a total of eight votes, as seen in figure 4.10. Participants found the method preferable because it listed the headlines in an efficient fashion. The font and image size were found to be optimal, with the images being large enough to capture attention, but not so large as to take up too much space.

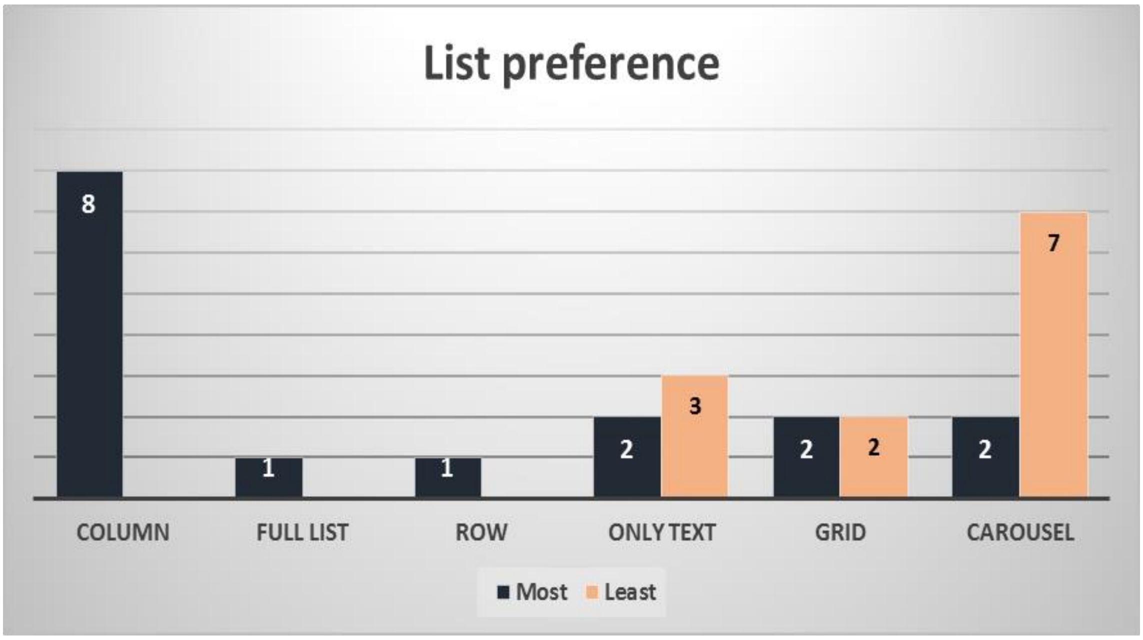

Figure 4.10 Participant Most/Least preferred headline listing methods

Out of the six methods, the carousel received the most negative votes with a total of seven. The two main reasons for disliking the method were its controls and the way content was hidden. As the method differs from the others used in this study, participants had difficulties noticing the controls and functionality of the element. In some cases, the element was not noticed even though it visually changed from one news article to the next via animation. This difficulty can be attributed to the users expecting the familiar lists instead of one dynamically changing article.

In addition to the difficulties seeing the element, participants did not enjoy scrolling through the articles. As only one article was shown at a time, the users could not know what articles were stored within and browsing through each was tedious. The carousel does indicate the number of items held within, though these indicators can be difficult to spot when on top of a background image. Some participants found the auto scrolling feature of the carousel to be frustrating, as the carousel section, which consisted of an image, title and excerpt, changed automatically.

The two listing methods seen in Figure 4.11 both represent different types of simplification, with the column relying on grouping and organization and the carousel on dynamically hiding content. One could assume that the carousel would be preferable, especially on mobile devices, as the method significantly reduces the amount of vertical scrolling necessary and allows the user to swipe through the articles at their leisure. However, the results of the study suggest that users prefer having all the articles visible at once, so that they are easily browsed through, similarly to the results of Leuthold et al. [2011], though with a slight difference: the tasks of the study had users looking for information, instead of browsing the website for leisure, which may have affected the metamotivational state of the participants. [Deng and Poole, 2010]

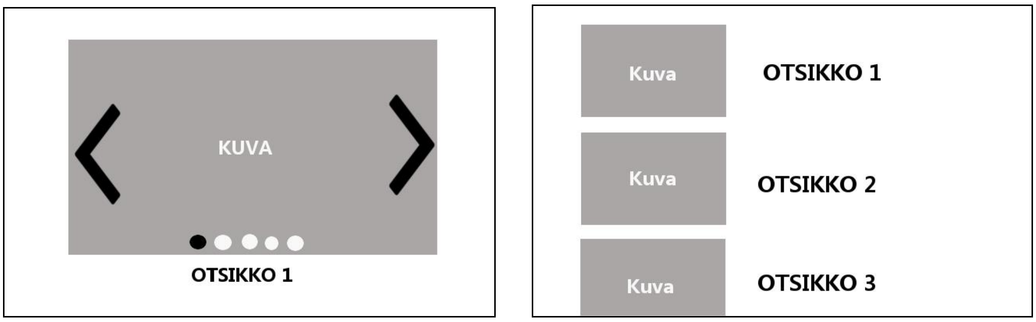

Figure 4.11 The Carousel (left) and Column (right) methods of headline presentation

In the third section of the interview, participants were asked what influences their decision when choosing an article to read in normal everyday use of the Aamulehti website in addition to personal interest. One of the most important factors mentionted was the topic of the article itself and its structure. If a topic had too much information, making it either overly long or complex, it was found tedious to read, whereas a topic with little information was not found engaging. A preferable topic would provide the main points of the topic without going into too much detail, acting as a summary. Some participants, especially those belonging to the younger age groups, mentioned **clickbait** topics as a source of irritation and negative preference, which they actively avoid. These articles often present interesting questions or situations to pique the user's interest, only to withhold any results or answers, forcing a user to read the article to satisfy their curiosity. In addition to the topic, images were found to be an important factor as they were said to capture the attention. An interesting image may be enough to get the user to choose an article, whereas the topic itself may not.

When asked if the participants used the content of the sidebar when browsing the website or looking for an article to read, approximately half of the participants reported seldom using it at all, with even active users admitting to only glancing through the content. Two main reasons were given for ignoring the sidebar: **position** and **content complexity**. On the desktop, the sidebar is placed abreast of the main content, meaning that extra scrolling is required if a user wishes to browse the whole sidebar after reading the article. The mobile and tablet layouts fare better in this regard, as the sidebar content is placed under the main content, making it easy and natural to keep scrolling after the article has been read.

Regardless of device and layout, the complexity of the sidebar had an influence on the lack of use in two ways. First, participants found the amount of content both in general and within the various lists to be high. The sidebar consists of multiple lists, each containing seven or more article topics, in addition to other blocks of content placed between the lists. On the desktop layout, the sidebar is narrow with little whitespace between the sections, making it densely packed and therefore uninviting. While the mobile layout is better in this regard, the sheer number of items can be deterring.

Participants felt that the topics within the lists were complex or overly long, making them unattractive and easily glanced past. This is a point of interest as the topics listed do not differ from normal article topics on the site. The proximity to other texts in addition to the general number of items combined with a lack of images may have influenced this perception. Finally, it should be noted that a small group of active Aamulehti users did not use the sites on which the mock versions were based, but instead preferred using a virtual newspaper, which is a simulated print newspaper without the functionalities offered. This acts as a partial explanation for the low use of the sidebar.

As a follow-up question, the participants were asked how they would modify the current layout, whether by adding, reorganizing or removing sections. As seen in Figure 4.12, a third of the participants found the current website to be satisfactory as it is. Another third of the participants suggested minor layout changes, such as reorganizing the layout and the rest suggested either the addition or removal of features.

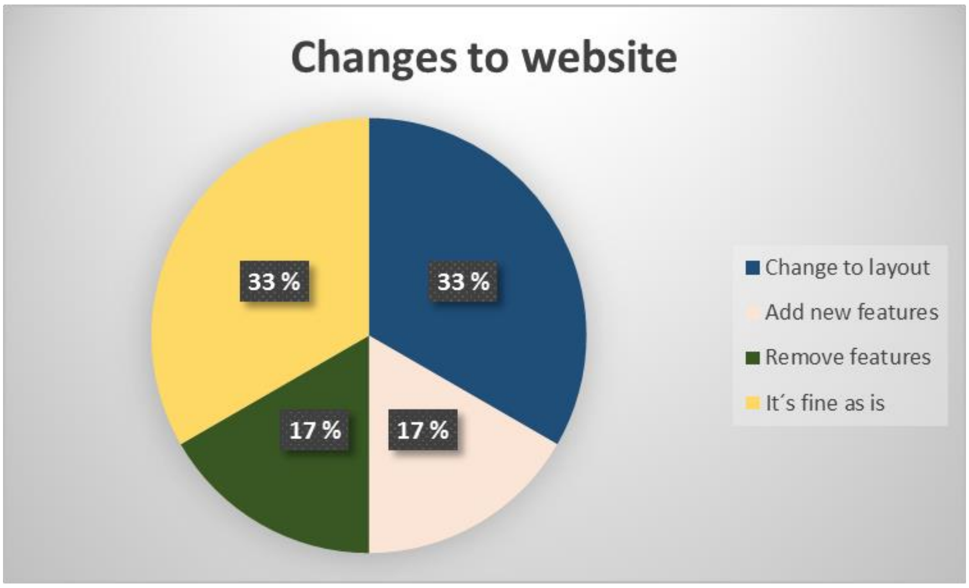

Figure 4.12 Participants´ website modification suggestions

The most frequent layout change suggested was placing the “most recent” section of the sidebar at the top, instead of the “most read”, as participants found the recent articles to be more interesting and relevant than the articles others had been reading. At present, the “most recent” section is somewhat low on the sidebar, making it less likely to be noticed. A slightly less frequent suggestion was the modification of the current article categorization.

In the mock website, each headline had a small label under the topic that indicated into which category of news the article belonged, i.e. culture, economy, global and so on. However, participants had trouble noticing this label due to its small font size and proximity to the topic itself. Participants suggested that the label be enlarged or positioned differently to make it more noticeable. In addition to these two specific changes, participants suggested an overall reorganization of the articles, but were unable to specify how it should be done or to which elements.

Slightly over a third of the participants suggested either adding or deleting elements from the current layout. In terms of deletion, the participants suggested either cutting the number of items in each list on the sidebar or removing the "most read" section entirely, as they felt the current sidebar was too complex. In terms of addition, three new elements were suggested: a **sticky navigation bar**, a **filtering** option and a "**recommended for you**" section.

The first addition is not adding a whole new element, but rather improving an existing one. A "sticky" navigation bar refers to a navigational menu that follows the user when they scroll down the page metaphorically "sticking" to the upper edge of the screen. The participant who made the suggestion thought this might would make navigating easier. As an alternative, a vertical menu positioned on the left of the screen was suggested. The other two suggested additions were thought of as features available for registered users, as the features either required knowledge of the user's preferences or a way for the website itself to save the options chosen by the user.

The second suggestion was a filter system, which allowed users to pick certain categories that were hidden from the headlines. For example, the participant who suggested the idea disliked news related to sports and did not want them cluttering up the news feed. The suggestion was thought to improve user preference, as they could affect which articles were shown and could pick from a list of interesting topics, instead of picking through undesirable items first. The final suggestion was a recommended articles section, which included articles picked out for users based on their browsing habits. It was suggested that the section be added to the sidebar, with three articles arranged in a column. With the addition of the "recommended for you" the participant thought the number of headlines in the headline list could be reduced.

4.2.4 Participant interviews, complexity and efficiency

The final section of the interview asked whether the complexity of the websites or the devices used affected their preference. The participants were asked if they noticed any differences in task completion and page load times during their use of the mock websites and if any single mock site stood out in either a positive or negative sense. In terms of page load times, participants reported not noticing any differences, which is understandable as the page load times differed very slightly. However, when asked about task completion times, they identified both the mobile-dedicated approach and mobile device in general as having low efficiency.

The mobile-dedicated smartphone website was found to be inefficient as the large amount of information presented at once paired with the small font and image size made searching for information tedious. The desktop version, while having far less content, was found to be inefficient due to its layout, which required a large amount of scrolling to browse through, making tasks take seemingly longer to complete. The perceived inefficiency of the mobile mock websites in general were attributed to the same layout issue as the mobile-dedicated desktop mock site.

In terms of the mobile device in general, the participant perceptions and task completion time results seen in Table 4.5 match with the mobile mock sites producing long completion times on average. However, a slight minority of participants found both the mobile-dedicated websites to be the least efficient out of all the mock websites. Additionally, none of the participants mentioning the mobile-dedicated approach in positive terms, even though the objective results show that the mobile-dedicated approach produced the lowest task completion times. This contradiction between perception and results can be attributed to negative perceived usability and visual aesthetics, as seen in the research done by both Raita and Oulasvirta [2011] and Koubek and Lin [2010].

Both the mobile-dedicated mock sites contain features that may act as negative influences on perceived efficiency, such as the large amount of visible content and small font and image sizes on the mobile site and a long layout and large font sizes on the desktop site. It should be considered, however, that the contrast of the two websites, when compared to other websites on the same device, may equally affect the participants' pre-use perceptions. As both websites represent a layout designed for another device, the low prototypicality may cause negative perceptions, as seen in the work of Tuch et al. [2011]. These results would suggest that simplicity itself does not lead to increased efficiency, though it may aid in creating the perception of efficiency (**Q3**).

When asked if the participants noticed any differences in mock website complexity and if the complexity affected their opinion on the website, a slight majority found the websites to be somewhat indistinguishable. No examples of either especially high or low complexity were reported, or the participants were unsure and therefore could not give an answer. It should be noted, however, that the similarity of the sites may be a positive attribute. For example, one participant noted how the similarity between websites made navigating easier after the initial learning period, making complexity less of an issue. This outlook may favor the responsive approach with its universal design.

The slight minority of participants who did notice differences in complexity found that complexity influenced their judgements, with more complex websites featuring larger amounts of content, requiring them to look around more and process more information. Participants did not, however, find low levels of complexity preferable either, as one could assume. Instead, in the words of one participant, neither too much content nor too much empty space would be optimal. This balance of content and simplicity, while vague, signifies the importance of organizing and filtering data to give users enough information so that they can perform their intended actions without too much trouble, but still having enough space and order so as not to make the website too cumbersome to browse through.

As a final follow-up question, participants were asked if the devices affected their judgement in one way or another and which of the three devices did they prefer after the study session. This data was then compared to the background information gathered at the start of the study to discern whether the device most **frequently used** by the participant to browse the Aamulehti website would still be their **preferred** device after the study session. It should be noted that a participant could have multiple preferences or most frequently used devices.

The most popular device, as seen in Figure 4.13, was the desktop computer. Participants felt that, again, the large screen size was the reason for their preference. The table shows that in everyday use participants seldom use the stationary desktop, favouring instead the more mobile laptop. Since both devices belong to the same category in terms of layout design, with the exception of pocket laptops and others more akin to tablets, the two can be seen as representatives of one device group. This combined group would therefore be more frequently used than mobile phones, which would coincide with the preference results. The tablet device was preferred for similar reasons, in addition to the mobility and slightly smaller size of the device. For the participants who preferred the tablet, the device represented a golden middle-ground between the large screen size of the desktop and the mobility of the smartphone. Additionally, it was found that often participants preferring the tablet device also preferred the simulated print newspaper to the normal online newspaper site, as the device was the optimal size for its use. It is notable that participants who reported using the tablet device frequently also preferred the device after the study. Participants did, however, specify that they preferred **their** tablet devices over the test device, which was relatively small in comparison to other tablet devices.

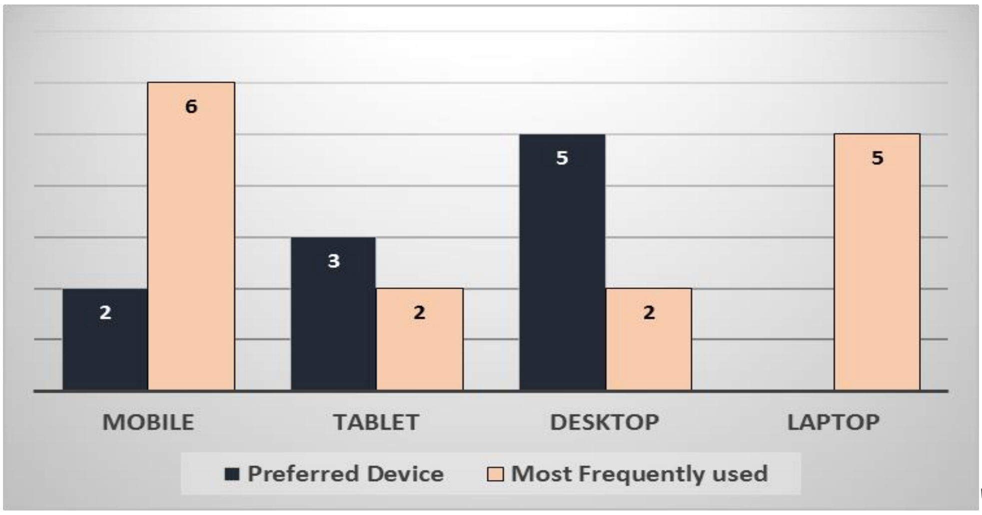

Figure 4.13 Preferred vs. Most frequently used device

The difference between frequency of use and preference of the mobile device is noticeable because the number of participants preferring the device is much lower. This would suggest that even though smartphones are frequently used, they may not be preferred. Because a smartphone is easy to carry around and use for small session regardless of the situation, be it during a morning commute or during a coffee break, it stands to reason that it would be used most frequently. This does not, however, suggest that the layout of the mobile website is preferred over the desktop layout. This can be seen in the Likert scale result for the mobile-dedicated site on the desktop and the interview results [Table 4.6, Table 4.8]. The influence of usage environment on which the device is used was best expressed by a participant who reported using all three devices. When they are sitting at a table, the desktop computer is the preferred choice of device. When they are sitting on the sofa, they use a tablet, but when they are on the move or somewhere other than at home, they use a smartphone. This utilitarian outlook on device use further implies the importance of convenience over preference during smartphone device use.

4.2.5 Eye tracking results and notes

Eye tracking data were collected in two ways. First, the DLab software was used to produce both a table of objective data on the number of saccades and fixations for each device, and heat map images of the gaze paths on each mock website. The default settings for the software (version 3.0) were used in terms of gaze threshold, minimum fixation duration and so on. Second, general notes on eye movement behavior were made during and after the study sessions. Before any data is presented, it should be not-ed that the circumstances of the study, i.e., the constant changing of device and issues with head position in relation to the device being monitored, resulted in somewhat inaccurate data. The data may however be used to gain a broad perspective on eye movement and gaze behavior in the context of each device. The heat maps used in this chapter are examples from single users that represented typical participant gaze behavior.

The objective eye tracking data produced by the DLab software, seen in Table 4.14, give insights into the numbers and durations of glances, fixations and saccades for each device used during the study. In terms of glances, the tablet device produced the largest number overall, although the mobile device had the most glances that lasted longer than 2 seconds. This would suggest that participants looked around the screen more on the tablet device, but focused on one spot for longer times on the mobile device. The desktop computer was a middle ground in both factors, having a large number of glances both under and over 2s.

Time to first glance represents the time it takes a participant to browse through a website and then focus on a single spot, instead of searching. The desktop computer produced a noticeably higher duration than the mobile or tablet, though this can be attributed to larger screen size. The data would indicate that, in terms of time to first glance, the tablet device has a slight advantage. This is possibly influenced by the slightly larger screen size combined with the simple mobile layout.

Table 4.14 Objective eye tracking data

Device	**No. Of Glances**	**No. Of Glances > 2s**	**Mean Glance Duration [s]**	**Time to first glance [s]**	**No. Of Fixations Left**
Mobile	65,497	590,389	122,197	166,778	252,137
Desktop	268,561	470,75	211,211	313,75	355,923
Tablet	318,222	250,778	68,838	124,667	268,599
Device	**No. Of Fixations Right**	**Mean Fixation Duration Left [ms]**	**Mean Fixation Duration Right [ms]**	**No. Of Saccades Right**	**No. Of Saccades Left**
Mobile	407,944	32,891	261,347	165,889	4,81
Desktop	572,25	37,669	384,775	220,875	5,04
Tablet	204,389	33,955	323,221	82,222	4,452

In terms of fixations and saccades, the results for the three devices were somewhat similar, with the desktop device generally producing slightly higher scores. The similar scores would suggest that the participants' gaze moved around the mock websites in similar amounts regardless of device, though this is influenced by the searching nature of the tasks of the study.

In addition to the objective data produced by the DLab software, notes based on the participants´ gaze paths were made during the study sessions and afterward by watching the recorded session with gaze path visualization. This provided insight into viewing behavior both generally and for each device and approach. In general, participants tended to focus on the left side of the screen, regardless of device, with the bottom or top half of the screen receiving attention depending on the direction the participant was scrolling. The websites were browsed from left to right as is usual [Sorum, 2016].

It was noticed during the analysis that, as the participants themselves stated, little attention was payed to the titles of each section in the sidebar, as participants focused more on the actual content. The tasks themselves may have influenced this behavior because the tasks had the participants looking for individual articles instead section titles. However, the tasks themselves required the participants to discern between similar lists, such as between the “most recent” and “recently read” sections, wherein the title was important. Additionally, no attention was paid to the category label that was under the topic of each article, regardless of the site unless it was specifically required.

In general, text was preferred over images, though this may have to do with the nature of the performed tasks. Images did, however, receive more attention in websites that featured zooming capabilities, such as the mobile-dedicated site for mobile and the tablet websites. When zoomed out, participants first browsed through the images to find one related to a task or category, such as sports, before zooming in to read the actual topic. Additionally, when zooming in, images were used as a baseline, e.g., participants zoomed in until the width of the current view matched the width of the image.

In addition to general observations, the different design approaches produced unique behaviors: It was noticed that while using the adaptive website for desktop computers, participants tended to move their eyes larger distances horizontally, taking slightly more time to switch between the main and sidebar content. This slight change in behavior can be attributed to the increased amount of space used and whitespace between the main block and the sidebar, making browsing through both at a glance slightly more cumbersome than on the responsive version. Additionally, the gaze paths on the adaptive websites showed more signs of search behavior, i.e., a large number of fixations spread out in a wide area. The fixations show that participants focused on the middle of the screen, reading through article topics on both the sidebar and main content, whereas on the responsive version the fixations are fewer, are formed in groups and are focused on the left edge of both the main and sidebar content, possibly indicating more efficient searching, but less attention to the actual content.

The differences between responsive and adaptive websites on the tablet and mobile device were less pronounced, with slightly increased fixation amount and spread on the adaptive mobile site as seen in Figure 4.15. The eye tracking data revealed that, as was assumed, participants did not notice the carousel list on the adaptive site for mobile devices, with one participant failing to notice it even while the menu was auto-scrolling onto another article as they were scrolling past. It was noticed that on the mobile-dedicated site for the smartphone, seen in Figure 4.15, participants did not expect to find any sidebar content, with the participants searching for the sidebar under the main content as in the other mobile layouts before looking elsewhere. Some participants needed to be given hints on the zooming functionality; i.e., the ability to increase and decrease the view size of the website via a pinch gesture. Participants often needed to decrease the view size until most of the mock site was visible on the mobile screen before noticing the sidebar. Similar behavior was observed on the mobile-dedicated site on the desktop, as a few participants began looking to the right side of the view to find the sidebar, before quickly realizing the mistake and browsing the site further.

Figure 4.15 Responsive (left), Adaptive (center) and mobile-dedicated (right) heat map for mobile device.

An interesting form of browsing behavior was observed on the mobile adaptive and responsive websites. When browsing through the site, participants tended to focus on the top or bottom left corner, depending on the direction they were browsing, letting their eyes rest on the said corner and scrolling with the site itself, moving their eyes only when finding a possible answer to the current task. It is possible, that this **restful browsing** is one of the reasons users find themselves "mindlessly" scrolling through mobile websites, such as image galleries or article lists, and may have an influence on general browsing behavior. If the behavior allows users to rest their eyes while browsing, they may browse for longer periods, going through more content. This behavior can also explain the high number of glances over 2 seconds seen in the objective data [Table 4.14]. Though it is beyond the scope of this thesis, restful browsing presents an interesting area for further study in terms of gaze behavior during mobile layout use.

The layout of a website and the ease with which a user can scroll through a website affect whether restful browsing is possible. To allow restful browsing, a layout should have all its content in one column. If the layout is divided into multiple columns, as in the other desktop sites, the users will have to move their eyes to browse through all content, as seen in the mobile-dedicated site for the smartphone [Figure 4.15]. Additionally, scrolling through a page should be effortless and not require much in the way of movement, i.e., swiping with a thumb or scrolling with a mouse wheel. The same behavior was observed on the mobile-dedicated website for desktop, seen in Figure 4.16, but not on either of the tablet websites. This can be explained by the slightly larger size of the device because the device is held in a way that does not allow for the same type of comfortable and effortless scrolling the mobile and desktop devices offer.

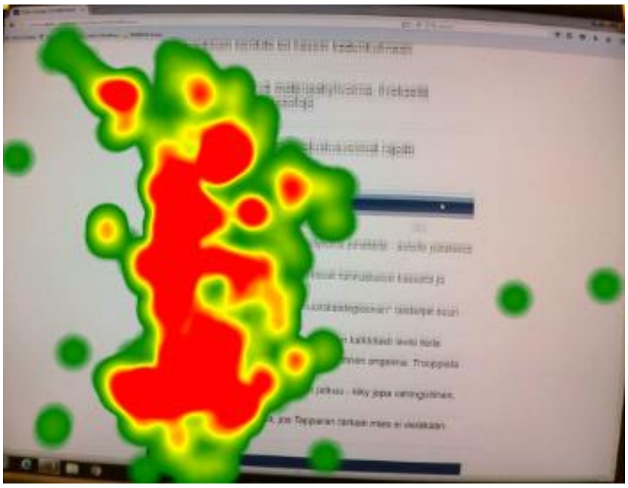

Figure 4.16 Mobile scrolling behavior on the mobile-dedicated site for desktop

5. Conclusions

In this thesis, three multi-device design approaches have been researched and examined with the goal of finding out how said approaches influence participant preference, website complexity and efficiency. An expert analysis and a user study were performed to discover if one of these approaches would be superior to the others, regardless of device used. Eight mock websites were created to represent websites designed using the three approaches on each device.

In terms of design approaches, the results of both the expert evaluation and the study showed that none of the design approaches produce significantly higher scores than the others. There were some single websites that produced relatively high scores, such as the mobile-dedicated site for desktop in terms of task completion times and the adaptive site for desktop in terms of participant Likert reviews, but the final results showed these differences to be insignificant. No single approach or device could be definitively elevated above the others. However, the study did reveal some factors and behaviors related to both approaches and devices that should be considered.

Though the Likert scale results favored the responsive approach very slightly, the interviews showed that the adaptive approach had potential due to the high number of participants who preferred the approach. The use of all available space was found to be a positive influence, though careful use of whitespace is required to make browsing less cumbersome. Additionally, the adaptive website for tablet devices was preferred because it resembled the mobile layout instead of the desktop, making browsing on the smaller device more enjoyable. It is difficult to say how strongly the design choices made during mock website development affected the end results, which is why additional research into the merits of adaptive vs. responsive design is needed. Out of the three approaches, the responsive approach can be seen as a “safe choice”, as the approach scored well in the Likert review and was generally liked in the interview, though to a lesser extent than the adaptive approach.

The mobile-dedicated approach was disliked on both the desktop and the mobile, as they both felt inefficient and featured design choices, such as unsuitable font sizes and low prototypicality that diminished user experience. Additionally, the perceived inefficiency of the two mock sites was noteworthy, as the objective results revealed them to be among the most efficient sites, at least in terms of task completion times. These conflicting results indicated the important role user perception has in website evaluation and preference, as seen in previous research: If a user expects a site to be “bad”, the site will feel worse than it objectively is.

In terms of devices, the use environment was found to be a key factor. Although the desktop computer was the most preferred device overall, the mobile device was still the most frequently used. This can be attributed to the ease with which the smartphone can be accessed and used, despite use environmental and situation, such as standing in a crowded bus. The desktop computer was the preferred device while sitting at a desk at home, whereas the tablet was used while relaxing at home on the sofa. The mobile device can be discreetly used while being on the move, commuting or being surrounded by strangers without causing much discomfort. The result suggests that the popularity of the mobile device in terms of web browsing is more to do with the accessibility and ease of use of the device rather than the actual website layout designs. This in turn indicates that mobile-dedicated design on desktop devices, while possibly efficient, is inadvisable.

The eye tracking data gathered during the study gave additional insight into device and design approach specific behaviors. The adaptive mock sites for both the mobile and desktop devices were shown to produce more searching behavior than their responsive counterparts. The mobile-dedicated sites showed how participant expectations may affect their viewing behavior, as seen in the position of the sidebar on both the mobile and desktop sites. Additionally, the adaptive and responsive mobile sites revealed an interesting form of browsing, where the users let their eyes rest, using the page's scrolling functionality to browse the site instead. This behavior, dubbed restful browsing, could be one of the reasons mobile devices are popular, as the behavior allows users to browse for longer periods of time without straining their eyes.

In terms of further study, this thesis has revealed multiple areas that require additional research. The first main area is the actual benefits of the adaptive approach when compared to the responsive approach. Second, the restful browsing phenomenon was not studied in any depth due to lack of resources, but has potential to advance our knowledge on mobile use behavior and the benefits of mobile use. Third, the column listing style should be researched, as the current study only used it in the context of the tablet device. The feedback of the participants would suggest that the style would be preferred on other devices as well. Finally, both the mobile-dedicated sites require additional testing to discern if they are more efficient than their adaptive or responsive counterparts. Additionally, the general dislike the mobile sites received raises questions on the role of modern mobile websites. Could they be improved so that the websites themselves are valued equally or more than just the accessibility of the device?

There were multiple limitations in the study that stemmed from both unforeseeable events and personal blunders. The first limitation in this study was the unnatural testing environment. Due to time constraints and the restrictions of eye tracking technology, the experiments were held in an enclosed space with participants having to wear the eye tracking device with the moderator sitting next to them. Additionally, the use of both the mobile phone and tablet computer differed from natural settings, as participants were required to keep the devices still and could not move about as freely as they would in normal circumstances. The use of mock websites was another limitation, as the design choices of the author played a large part in the results. A blunder in the design of one mock website could have possibly lowered the overall score of one of the approaches considerably, as may have happened with the carousel list.

The searching nature of the tasks may have affected the end results, as the tasks may not have reflected common use cases. Additionally, the difference between the tasks for each mock site could have possibly influenced results. Some opportunities were also missed in the interview. For example, the participants were not asked whether they preferred the same layout on all devices, or if it was preferable that the layout changes, as in the adaptive approach.

In conclusion, though no single design approach could be put forward as the best alternative, each approach has merit. The adaptive approach offered the largest variety in layout design across devices, with the use of all available space being a positive influence on preference. The responsive approach was an overall good choice, offering stable scores in all categories, though being slightly less preferred and efficient. The mobile oriented approach, while not preferred as such, offered the best efficiency. Regardless of approach, the strengths of all three approaches should be considered when creating a website for multi-device use.

Using all available space, as in the adaptive approach, was a positive influence. This use should not be overwhelming however, as page browsing may become cumbersome with too much space between elements. For example, using all available space as in the adaptive approach, but using whitespace between elements as in the responsive can create a working balance. Text size and position should also be considered, as seen with the ignored sidebar titles and category labels. Finally, although the mobile-dedicated layout is not advised, the idea of restful browsing should be considered when websites feature long lists of contents such as articles or images. By combining an appropriate listing style that allows users to quickly browse through items with simple, streamlined layout, it is possible to extend the browsing time of a user, in addition to possibly increasing efficiency.

This thesis has explored multi-device design in terms of websites and glanced through the different factors that influence users' preference. First impressions, prototypicality, expectations and perceived usability, among others, have been researched and discussed. Mock websites have been created and tested. The results of the thesis have discussed the features of three design approaches and has raised questions and observations that hopefully inspire future research and further advances in website design.

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Appendices

Appendix 1 – NDA Agreement

Salassapitosopimus

Tämän kokeen aikana esitetään verkkosivuja, jotka ovat rakennettu käyttäen Alma Median ja Aamulehden tarjoamia resursseja, kuten kuvia ja tekstiä. Verkkosivut eivät kuitenkaan edusta Alma Mediaa tai aamulehteä, vaan ovat yksinomaan koekäyttöä varten. Verkkosivuja ei saa mainostaa Aamulehden edustajina. Lisäksi, kokeessa käytettyjä verkkosivuja, niiden osoitteita tai käyttäjätiliä ei saa levittää tai käyttää itse koetilaisuuden ulkopuolella. Käyttäjätili ja verkkosivut poistetaan käytöstä viimeistään 30.6.2017.

Minä, allekirjoittanut, ymmärrän ja hyväksyn ehdot ja sitoudun niihin.

Allekirjoitus ja Nimen Selvennys Päivämäärä

____

Appendix 2 - Informed Consent Form

Päivämäärä:

____

Tallennussopimus

Minulle on selitetty tutkimuksen tarkoitukset ja kulku ja ymmärrän ne. Olen saanut tilaisuuden esittää kysymyksiä sekä osallistumisestani, että itse tutkimuksesta ja tutkielmasta. Osallistun tutkimukseen vapaaehtoisesti ja ymmärrän voivani keskeyttää osallistumiseni milloin tahansa ilman rangaistusta tai kysymyksiä. Minulle on selvitetty tutkimuksen luottamuksellisuus, kerätyn aineiston käyttö ja omien tietojeni käyttö ja anonymiteettini tutkielman tulosten analyysissä. Ymmärrän miten aineisto esitetään, keille se voidaan esittää ja miten se säilötään.

Annan Tutkijalle luvan tallentaa kokeen aikana otettua videokuvaa ja ääntä toiminnastani koeasetelmassa käytetyillä laitteilla ja mielipiteistäni haastattelussa. Annan myös tutkijalle luvan käyttää kerättyä kirjallista aineistoa, kuten perustietolomaketta, ja lainauksia tutkimuksen aikana tapahtuneesta keskustelusta. Suostun antamaani lupani sillä ehdolla, että Tutkija sitoutuu käyttämään kerättyä aineistoa vain tutkimuksen edistämiseen, säilyttämään anonymiteettini ja varmistamaan, ettei aineistoa esitellä kellekään tutkimuksen ulkopuolelliselle taholle. Tutkimukseen kuuluu Tutkijan lisäksi Tutkijan ohjaaja.

Tutkijan allekirjoitus

____

Osallistujan allekirjoitus

____

Appendix 3 – Background information form

Perustietolomake

Ikä: 16–30 ( ) 31-45( ) 46-60( ) 61-75 ( ) 76-80 ( ) 81+ ( )

Sukupuoli: Nainen ( ) Mies ( )

Koulutus: Peruskoulutus ( ) Lukio/Ammattikoulu ( )

Alempi Kork. Koulutus ( ) Ylempi Kork.Koulutus ( )

Mitä seuraavista laitteista käytät netin selaamiseen?:

Älypuhelin ( ) Pöytätietokone ( ) Kannettava tietokone ( )

Älytelevisio ( ) Älykello ( ) Pelikonsoli ( )

Muu, mikä ____________

Kuinka usein selaat nettiä (Valitse sopivin)?

En lainkaan ( ) Kerran viikossa tai vähemmän ( ) Useita kertoja viikossa ( )

Kerran Päivässä ( ) Useita kertoja päivässä ( )

Kuinka Usein käytät Aamulehden verkkosivuja tai sovellusta (Valitse sopivin)?

En lainkaan ( ) Kerran viikossa tai vähemmän ( ) Useita kertoja viikossa ( )

Kerran Päivässä ( ) Useita kertoja päivässä ( )

Millä laitteilla selaat Aamulehden verkkosivuja:

Älypuhelin ( ) Pöytätietokone ( ) Kannettava tietokone ( )

Älytelevisio ( ) Älykello ( ) Pelikonsoli ( )

Muu, mikä ____________ ( )

Appendix 4 – Mock website review form

Arviointilomake

Arvioi verkkosivu ympyröimällä yksi kohta jokaisesta asteikosta.

▢ **Uutisartikkeli oli minulle ennestään tuttu.**

Mieltymys

Sivusto oli mielestäni (1= Erittäin epämiellyttävä, 7= Erittäin miellyttävä)

1 2 3 4 5 6 7

Tehokkuus:

Sivusto oli mielestäni (1= Hidas ja vaikea käyttää, 7= Nopea ja helppokäyttöinen)

1 2 3 4 5 6 7

Monimutkaisuus

Sivusto oli mielestäni (1= Monimutkainen ja hämmentävä, 7= yksinkertainen ja selkeä)

1 2 3 4 5 6 7

Appendix 5 – Tasks

Desktop (6 tasks)
Avaa linkki R1

1) Milloin on julkaistu uusin KULTTUURI kategorian pääuutinen?
2) Olet kuullut, että Kari Pitkänen kirjoittaa kiehtovia tekstejä. Löytyisikö jokin hänen kolumneistaan?

Avaa linkki A1

1) Kuulit, että Jari Tervo on tehnyt merkittävän päätöksen. Onkohan aiheesta kirjoitettu vielä pääuutista?
2) Mikä on tällä hetkellä 5. luetuin artikkeli?

Avaa linkki D1

1) Milloin on julkaistu tällä hetkellä uusin URHEILU – kategorian pääuutinen?
2) Sinua kiinnostaa nähdä mikä on tällä hetkellä tuorein uutinen. Löytyykö tämä tieto sivulta?

Mobile (6 Tasks)
Avaa linkki R2

1) Kuinka monta MAAILMA kategorian pääuutista on sivulla?
2) Olet kuullut, että Planetcon on julkaissut videon työmahdollisuuksista. Löytyisiköhän se sivulta?

Avaa linkki A2
1) Ystäväsi kertoi lukeneensa koskettavan pääuutisen ”Kertusta”. Mikä pääuutinen on kyseessä?
2) Mikä on tällä hetkellä tuorein uutinen?

Avaa linkki D2
1) Mikä on tällä hetkellä luetuin uutinen?
2) Ystäväsi Johannes on hurahtanut täysin jääkiekkoon. Löytyisikö sivulta häntä kiinnostava pääuutinen?

Tablet (4 Tasks)
Avaa linkki R3

1) Ystäväsi ojensi sinulle tabletti-tietokoneen ja pyysi lukemaan hälle ääneen tietyn pääuutisen. Kysyttyäsi minkä, hän vastasi vain ”No se uusin!”. Mikä pääuutinen on kyseessä?
2) Mikä on tämän hetken 3. luetuin uutinen?

Avaa linkki A3

1) Ystäväsi suositteli Sinikka Pylkkäsen kolumnin lukemista. Löytyykö se kyseiseltä sivulta?
2) Milloin on julkaistu uusin KULTTUURI kategorian pääuutinen?

Appendix 6 – Semi-structured interview questions

General

1. Mikä verkkosivuista oli mieleisin sinulle? Miksi?
2. Entä vähiten mieleinen verkkosivu?
3. Mikä vaikuttaa artikkelin valitsemiseen?
4. Oliko jokin artikkeleiden listaustyyli erityisen mieleinen/epämiellyttävä?
5. Oliko jokin verkkosivujen suunnittelutyyleistä erityisen miellyttävä/epämiellyttävä

Complexity vs Simplicity

6. Vaikuttiko verkkosivun yksinkertaisuus arviointiisi? Miten?
7. Oliko käytetyllä laitteella vaikutusta?
8. Mikä on sinun mielestä oikea määrä sisältöä uutislehden sivuille? Mitä lisäisit, mitä ottaisit pois?

Efficiency

9. Huomasitko verkkosivujen välillä eroja sivujen latausaikojen suhteen?
10. Huomasitko verkkosivujen välillä eroja tehtävien suoritusaikojen suhteen?
11. Mikä mielestäsi vaikutti eroihin tehokkuudessa?

Appendix 7 - User background data

	Age	Sex	Education	Device used to browse Internet	How often do you browse the Internet	How often do you use the Aamulehti website	With what device
s1	1	2	2	1,2,3	5	2	2
s2	1	1	3	1,2,3,6	5	1	-
s3	5	2	3	1,3	5	4	1,3
s4	2	1	4	1,2,7(tab)	5	3	1
s5	3	1	3	1,2,3	5	3	1,3
s6	3	1	4	1,3	5	2	1,3
s7	3	2	3	1,2,3,7(Tablet)	5	4	7 (Tablet)
s8	4	2	4	1,3,7(tablet)	5	5	1,3,7(Tablet)
s9	1	1	3	1,2,3,6	5	2	2
s10	4	2	2	1,3	5	4	1,3

Age: 1 = 16-30, 2 = 31-45, 3 = 46-60, 4 = 61-75, 5 = 76+
Sex: 1 = Female, 2 = Male
Education: 1 = Primary School, 2 = High School/Vocational School, 3 = Bachelor's degree, 4= Master´s degree or higher
Devices (Columns 5,8): 1 = Smartphone, 2= Desktop, 3=Laptop, 4=Smart TV,5= Smartwatch,6= Video Game Console; 7= Other.
Frequency (Columns 6,7):1= Not at all, 2= Once a week/less, 3=Multiple times a week, 4=Once a day, 5= Multiple times a day.