Use of colours on websites

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Nowadays, almost anyone can create a website. As a result, the importance of the appearance of a website has increased over the years. Websites are expected to function well, but also to be aesthetically pleasing. This study focuses on the colours of websites, because colours are perceived immediately, and colour is a property that can be easily modified.

Colours are one of the first things you notice on a website. The colour design of a website affects aesthetics, decision-making, and usability, which is why it is a good idea to understand colour theory when choosing colours for your website. It is also good to know if certain colours are particularly popular in website design.

There has been previous research on the subject, but this study aims to delve deeper. In particular, the research focused on how the geographical location and type of website can influence which colours are used in its colour scheme. In connection with this research, a colour analysing tool was developed to calculate how many of each colour are present on the homepages of different websites.

The results of the study show that certain colours are most commonly used on websites, regardless of the geographical location and type of website. These colours are white, gray, light blue, and dark blue. White is mainly used as a background colour, while light blue and dark blue are used as accent colours. Gray, on the other hand, can be used for both purposes.

Keywords: colours, websites, website design, colour analysis

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Nykyaikana verkkosivujen luominen onnistuu lähes keneltä tahansa. Tästä johtuen verkkosivujen ulkonäön tärkeys on korostunut vuosien varrella. Verkkosivujen odotetaan toimivan hyvin, mutta myös olevan esteettisesti miellyttäviä. Tämä tutkielma keskittyy verkkosivujen väreihin, koska värit havaitaan heti ja väri on ominaisuus, jota voi helposti muokata.

Värit ovat yksi ensimmäisistä asioista, jotka verkkosivulta havaitsee. Verkkosivun värisuunnittelu vaikuttaa estetiikkaan, päätöksentekoon ja käytettävyyteen, minkä vuoksi verkkosivun värejä valitessa on hyvä ymmärtää väriteoriaa. Lisäksi on hyvä tietää, ovatko jotkin värit erityisen suosittuja verkkosivujen suunnittelussa.

Aiheesta on tehty aiempaa tutkimusta, mutta tämän tutkimuksen on tarkoitus syventyä entistä tarkemmin. Erityisesti tutkimuksen kohteena oli, miten verkkosivun geografinen sijainti ja sen tyyppi voivat vaikuttaa siihen, mitä värejä sen väriskeemassa käytetään. Tämän tutkimuksen yhteydessä kehitettiin värianalyysityökalu, jolla laskettiin, paljonko mitäkin värejä eri verkkosivujen aloitussivut sisältävät.

Tutkimuksen tulokset osoittavat, että verkkosivuilla käytetään eniten tiettyjä värejä riippumatta verkkosivun geografisesta sijainnista ja tyypistä. Näitä värejä ovat valkoinen, harmaa, vaaleansininen ja tummansininen. Valkoista käytetään pääasiassa taustavärinä, kun taas vaalean- ja tummansinistä käytetään tehosteväreinä. Harmaata sen sijaan voi käyttää molempiin tarkoituksiin.

Asiasanat: värit, verkkosivut, verkkosivusuunnittelu, värianalyysi

Contents

1 Introduction

Colour is one of the first things that a website user notices. Today, the appearance of websites, in addition to functionality, is one of their most important features. The topic of the thesis is the use of colours on websites. The thesis separately discusses colours, websites, and colours on websites. Topics include what properties and effects colours have, how websites should be designed in terms of both appearance and functionality, and how to successfully design website colours.

The purpose of this thesis is to gather more information about what good website design is like. More specifically, the goal is to investigate the use of colours on websites: how to choose colours and how they should be used.

1.1 Research objectives

Website colour schemes have evolved a lot over the years, and efforts are being made to develop websites that are beautiful and aesthetic. The aim of the research carried out in the thesis is to find answers to the following research questions:

RQ1. What colours are popular in website design?

RQ2. Do geographic location and website type affect what colours are chosen for a website?

Colours have different meanings in different cultures, and for some countries, the colours of the flag or coat of arms may be important and even represented on

websites. The purpose of corporate websites is to inspire trust in customers, while e-commerce websites aim to get consumers to buy their products and services. Based on the previous information, the hypotheses of this thesis are as follows:

H1. Geographic location has an impact on the most used colours on a website.

H2. Bank websites and medical websites mainly use neutral colours.

H3. E-commerce websites use a lot of bright colours.

H4. Blue is the most used accent colour.

1.2 Methods and information retrieval

Chapters 2 and 3 of the thesis consist of a literature review, the purpose of which is to introduce the topics of the thesis. The search engines used during the research were Google Scholar and the University of Turku's electronic library Volter. The search engines were used to search for papers related to the research topics.

The search terms used when searching for papers varied slightly, as chapters two and three dealt with different topics. The most important search terms were *colour*, *website*, *web* and *design*. The search took into account plural forms of the search terms and different spellings of the word *colour*.

1.3 Structure of the thesis

Chapter 2 focuses on colour. We will find out what colour actually is and what attributes it can have. Then we will explore the effects that colours can have on people and emotions. After that, we will consider what colour preferences are and where they come from. Finally, we will look at how colours can be used in design.

Chapter 3 discusses website design. We begin by looking at how websites originated, what the first websites were like, and how the development of websites has

progressed since then. We then examine the role of colour in website design. First, we consider how colour affects the appearance and aesthetics of websites. Then we examine the impact of colour on website users' emotions and choices. Finally, we find out what kind of role colours play in the usability and accessibility of websites.

In Chapter 4, we review the objectives, practices, and implementation of this study. We begin by recalling the research questions, followed by a discussion of the rationale for the chosen methods. We then explain how the data needed for the study was collected and how it was processed. We then introduce the colour analysis tool developed for the study and how it works. Finally, we review what kinds of miscalculations were identified and how they were corrected manually.

Chapter 5 presents the results of the study and discusses them. First, the results are reviewed by country, meaning how website colours are selected geographically. Then, the results are presented based on website types, meaning how the type of website affects the choice of colours. Finally, the results are examined overall, meaning what kinds of colours are universally chosen for websites.

In Chapter 6, we discuss the results of the study and compare them with each other. We also consider issues that should be taken into account in the study. We then examine the limitations that affected the implementation of the study. Finally, we thought about what things could be done in future research.

Finally, Chapter 7 draws conclusions based on the results of the study.

2 Colours

Colours are an everyday thing, but there is much more to them than what they look like. In this chapter we will study what colours are, what attributes they have, how they can affect humans and how they can be used in design. We begin with a discussion about the essence of colour. That is then followed with different colour-emotion responses and how they can be modified. After this, we will look at what colour preferences are, how they arise and what things affect them. Finally, we discuss the role of colours in design, such as the possibilities of the context colour and the object colour, as well as colour trends.

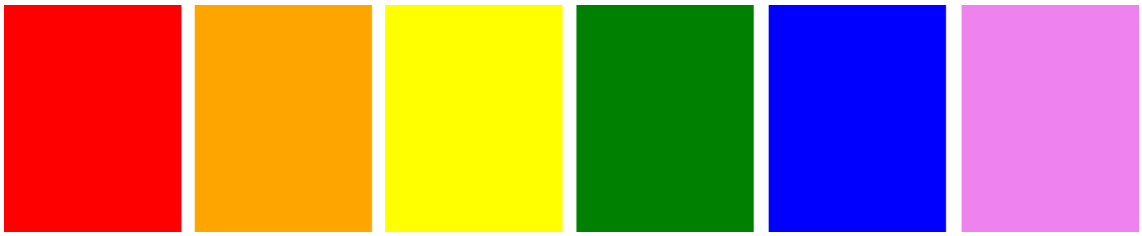
2.1 What is colour?

Colour can be explained scientifically as: it is an alteration in light's spectral power distribution that the human visual system can distinguish. Light is energy carried by electromagnetic field distortions. Therefore light has properties, such as a wavelength, a frequency and a speed. The usual visible wavelength of light is around 530 nanometres. This wavelength appears as bluish-green. [1]

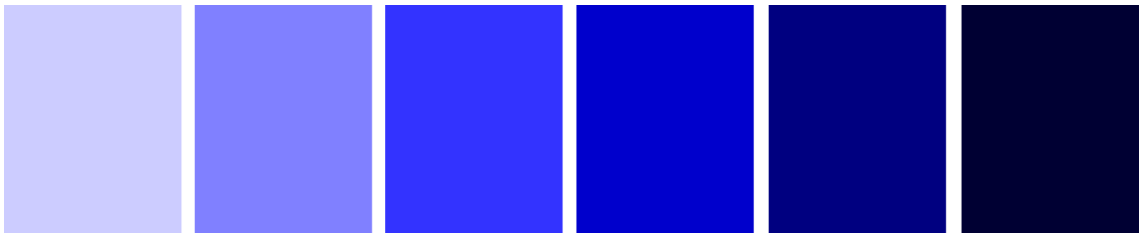
The following points concerning the attributes of perceived colour are from [2]. Perceived colour can be described using three different attributes:

- Hue distinguishes whether a given colour is similar to red, yellow, green, or blue, or is a mixture of some of these colours. (Figure 2.1a)

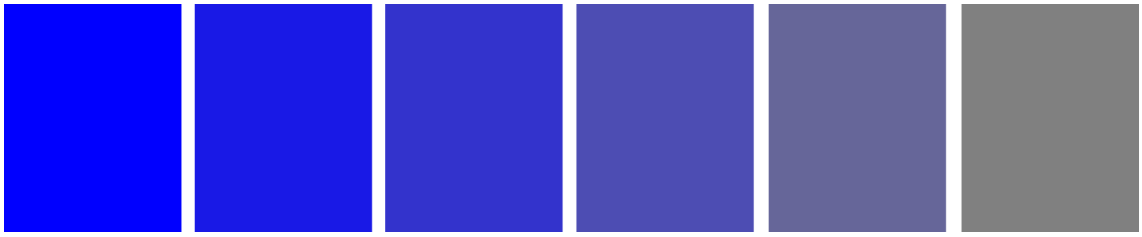
- Lightness tells whether the area emits or reflects more or less light. (Figure 2.1b)
- Saturation is how colourful the area is compared to its brightness. (Figure 2.1c)



(a) An example of different hues, in this case red, orange, yellow, green, blue and violet.



(b) Different lightnesses of blue hue.



(c) Different saturations of blue hue.

Figure 2.1: Examples to illustrate the attributes of perceived colour.

2.2 Colours and emotions

Colours can be associated with different things, as elaborated in [3]. Colours can be thought of as having a role, for example, as a symbol or sign. As a symbol, colours reflect either objects or experiences (e.g., in China, the colour red is a symbol of good luck). As a sign, colour may be used as a means of visual communication to convey information (e.g., in traffic, the colour red is a sign to stop). In either case,

the colour may evoke different emotions in the viewer, for instance, receiving a red envelope brings joy to Chinese people during Chinese New Year. Colour can also convey emotions by sending a signal that describes the affective quality of either the colour in question or the environment or the product (e.g., bright red can be interpreted as warm and stimulating).

According to Ou [3] three of the colour appearance attributes – hue, lightness and chroma – are closely related to the background factors of colour-emotion responses. The factors are hue-related factor, lightness-related factor and chroma-related factor.

Hue-related colour-emotion models (warm/cool)

The warm/cool effect is considered the most important factor when it comes to colour emotion. Hue has a strong influence on whether the colour is considered warm or cool – basically, red colours are perceived as warm and blue as cool. It has also been noticed that if the chroma of a warm colour is raised, it feels even warmer, and conversely, when the chroma of a cool colour is raised, the colour feels cooler.

Lightness-related colour-emotion models (heavy/light)

The heavy/light factor is strongly related to how bright the colour is. Associated with lightness-related factor is that colours with high lightness appear soft and light, while colours with low lightness appear hard and heavy.

Chroma-related colour emotion models (active/passive)

The active/passive factor has been thought to be a factor clearly related to chroma, but now it is known that it is also strongly related to lightness. For example, white and black are considered more active than medium gray, even though each has a chroma value of zero, i.e. they are achromic. Highly saturated colours seem dynamic, clear and active and they affect the viewer strongly on a psychological level, while

unsaturated colours have the opposite effect.

The term “colour emotion” is usually associated with only one colour at a time, while the term “colour harmony” evaluates how different colour combinations work together in the name of aesthetics. The exact definition of “colour harmony” is difficult to determine, but the following keywords can be found for it: “completeness”, “complementary”, “analogous”, “order”, “balance” and “unambiguous”. Thus, it can be said that colour harmony means when two or more colours are in neighboring areas, and they create a pleasant effect. Alternatively, colour harmony also means using colours in a way that pleases or satisfies the viewer. The previous terms “pleasing” and “satisfying” are related to emotions, which again suggests that colour harmony and colour emotion are strongly related to each other.

Colour harmony has key principles that have been established based on psychophysical data. Colour harmony is affected by:

- Equal hue: colours of the same hue are perceived as harmonious.
- Equal chroma: colours of the same chroma are perceived as harmonious.
- Unequal lightness values: the harmony of colour pairs may decrease due to small differences in lightness between the colours
- High lightness: the higher the lightness values of the colours of a colour pair, the more likely the colour pair is harmonious.

However, it is worth noting that psychophysical models are created based on colour patches that have no context. Thus, little is known about how context affects harmony between colours.

2.3 Colour preferences

Colour preferences are also essential when it comes to exploring colours and emotions. According to research, colour preferences are systematic and at least somewhat predictable. A universal model has been found for colour preferences, where the most popular colours are bluish and bluish-greenish colours, and the least popular are greenish-yellowish colours [1]. More precisely, the order would be blue, red, green, violet, orange, yellow [4]. Best [1] also says that the preferences remain the same regardless of the saturation values of the colours; blue at high saturation is more liked than yellow at high saturation, and the same when both saturations are low. In addition, there is a general tendency to prefer more saturated colours.

Humans are one of the few animals that have the ability to add colour where there would be none naturally. Artificial colours can be seen everywhere these days, and many products and objects are extremely colourful. These colours have no biologically evolved meaning and are also arbitrary, but humans strive to give them meaning. [4]

According to neurophysiological studies, certain neurons are able to represent colours as they are, not attached to any object or surface. Thus, a colour can take on an emotional meaning regardless of where it came from [4]. Because of this, colour preference has developed along with evolution. The colours of objects have been important, especially in survival-critical behavioral tasks. For example, the search for ripe food and attractive partners has developed a colour preference for those colours that convey information about desired characteristics. And since colours can be distinguished from objects, a preference for an object can develop into a preference for its colour. [1] [4]

The universal model of colour preference is influenced by many things, such as gender, age, geographical origin and culture [1]. For example, in many countries the colour black is associated with mourning, while in India and China the colour white

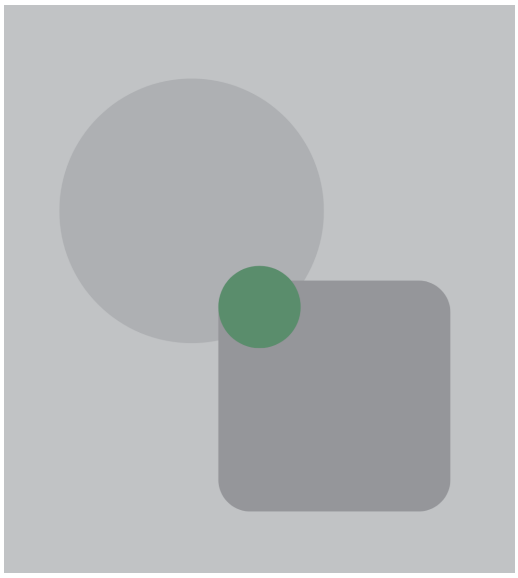
is associated with death, and in Taiwan gold and silver are used in wreaths made for the dead. It is also possible that differences in these symbolic associations also affect variations in colour preferences, or that symbolic associations have a direct effect on preferences. [4]

2.4 Colours in design

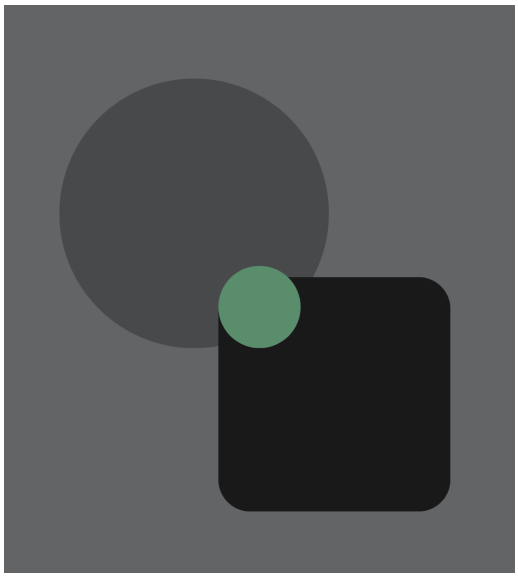
In design work, colour is the most important tool to influence the viewer's perception. Humans naturally react to colours, and therefore effective colours in design evoke a reaction in the viewer. The designer can even anticipate the reaction evoked by the colour by identifying which reactions each colour condition has. When it is known what kind of reactions each colour evokes, they can be used later in the design to achieve a similar reaction. [1]

A context colour creates a base against which all other design's colours are compared. For example, on websites, the context colour would be the background colour of the page and the object colour would be all other colours, such as coloured text blocks. The eye automatically compares colours where they meet and notes the most significant differences between them. The eye often prefers and slightly even exaggerates perceived differences between hues, lightnesses and saturations. Consequently, the more the object colour differs from its context colour, the easier it is to be noticed. It is clear that a darker object stands out against a very light background colour. Conversely, the same dark object is very faint against a dark background (see Figures 2.2a and 2.2b). The same effect also works by adjusting saturations and hues. A background with low saturation (neutral coloured) makes an object with high saturation (brightly coloured) stand out. Conversely, a high-saturation background makes a high-saturation object appear more faintly (see Figures 2.3a and 2.3b). The same effect occurs with colour temperatures. When the context colours are cool, the object appears warmer, while conversely, warm context colours

make the object appear cooler (see Figures 2.4a and 2.4b). Often the designer has the freedom to modify the context colour and object colour to achieve the desired amount of attention for the object; just changing the colour is enough, so there is no need to change the size or shape of the object. [1]



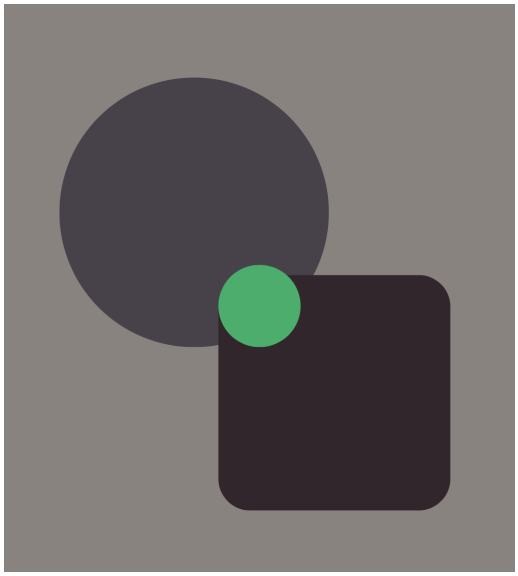
(a) A light context makes the object seem darker.



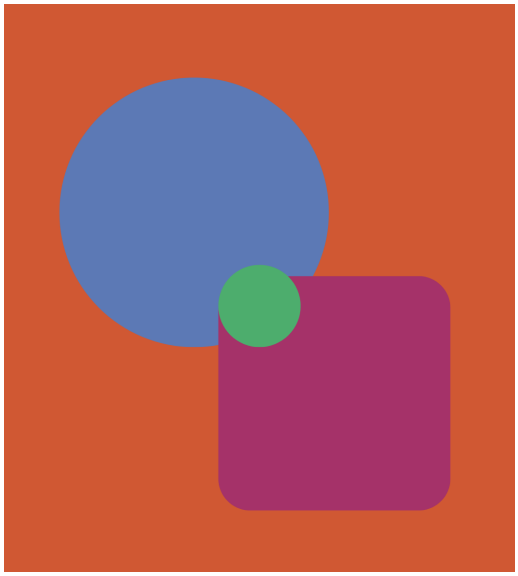
(b) A dark context makes the object seem lighter.

Figure 2.2: The effect of context colour's lightness on object colour.

Colour trend means changes in which direction colour families are moving or will move, in relation to the industry, product or material on the market. It can be harmful for brands to ignore trends, as it can, for example, seem like the brand is aging. Changes in colour and social trends are influenced by social changes, significant events and technological development. [1]

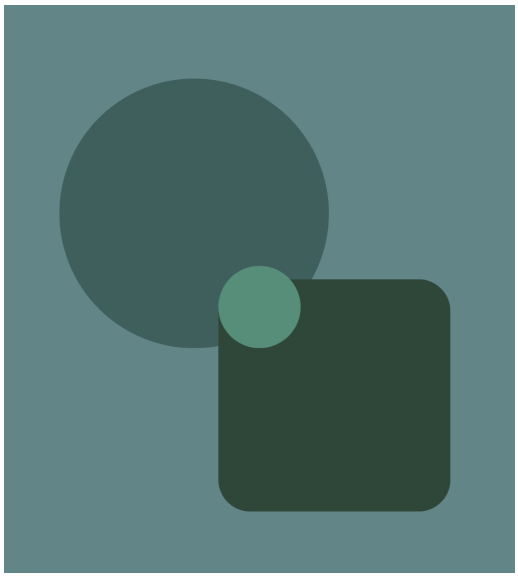


(a) A neutral context makes the object seem more saturated.

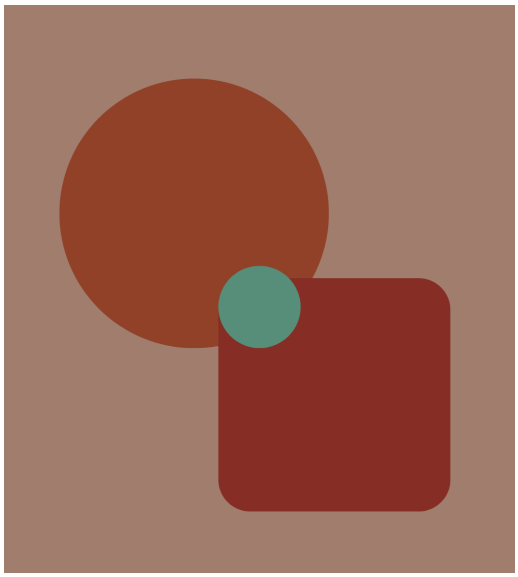


(b) A high saturated context makes the object seem neutralized.

Figure 2.3: The effect of context colour's saturation on object colour.



(a) A cool context makes the object seem warmer.



(b) A warm context makes the object seem cooler.

Figure 2.4: The effect of context colour's temperature on object colour.

3 Designing websites

This chapter examines how colours should be taken into account when designing websites. First, we will learn how websites should be designed, and what features good and effective websites contain. Then we take colours into account in website design, meaning what should be considered when using colours in website design. Next, we will go over why the pleasant appearance of websites is important, and how colour design can influence this. After this, we will examine the psychological effects of colours, which refers to how website colours can affect user behavior at the level of emotions and decision-making. Finally, we will learn about the usability and accessibility of websites and find out how the sensible use of colours can make it easier to use websites, both in general and for visually impaired people.

3.1 Website designing briefly

The first websites were made in the early 1990s. Sir Tim Berners-Lee developed the first graphical user interface Web browser in 1990 at the Organisation européenne pour la recherche nucléaire (CERN) [5]. In 1989, Berners-Lee developed Hyper-Text Markup Language (HTML), a modern standard markup language that uses common abbreviations, tags, that allow the creator of a web page to achieve the desired structure and layout. The first websites were quite basic and contained only text, because HTML tags for images and colours did not exist yet. Images were introduced in HTML 2 [6] and colours in HTML 3 [7]. At that time, there was no

general standard for designs and implementation. Expectations regarding the content and technical complexity of the websites, the number of users and the technical possibilities were limited. Since the websites mainly contained only text, not so much attention was paid to visual layout design, usability, or high-quality dynamic content provision. At that time, creating a website alone was already a technical leap, so design-related details were not a concern. Nowadays, it is a rapidly growing industry, and websites should meet a lot of commercial expectations, there are a wide range of technical and design options available, and websites should constantly be more and more interesting. [8]

With the development of web technologies and the availability of powerful software, almost anyone with IT skills can create a website. Nowadays, the appearance of the pages has become more important and noticeable, as more beautiful and pleasant websites have started to be demanded. [8] The development of the website appearance has been a subject of interest since the first websites were published. Authors wanted more control over the presentation of their pages, which led to the development of Cascading Style Sheets (CSS). A style sheet is a set of guidelines that tells the browser how the elements of a page should be displayed. CSS1 contains five different properties (i.e. types of presentation information):

- Foreground and background colours and background images
- Font properties
- Text properties, such as word spacing and letter spacing
- Boxes, such as floating elements, and margins and borders around block elements
- Classifications, for example control over formatting the elements. [9]

Every website has a purpose for using it. When the purposes of different websites are identical or overlap, there is competition between them. The goal of the website

is the number of users and usage time, and the competitive advantage is gained by choosing the content of the page carefully and delivering targeted purpose(s) in unique, effective and pleasant ways. In addition, good usability, high-quality aesthetics and good marketing can help the fulfillment of goals. [8]

According to Lawrence and Tavakol [8], poorly designed websites can at best be a waste of time, but at worst they can cause damage even financially. They recommend a structured and methodological approach to website design – balanced website design – which optimizes aesthetics, usability and purpose. Good website design includes the following:

- The website should have a clear purpose.
- The design and content should reflect the purpose of the page and the needs of the target audience.
- Design should create a visual layout and "mood" suitable for the page.
- Usability is extremely important and it usually aims for simplicity and clarity.
- User-centered design is efficient and good practice.
- Documentation must be maintained as part of the process.
- Appropriate navigation styles and relevant content are important features of a website.
- In the process, it is recommended to make prototypes and iterate.
- Using a structured and step-by-step approach is profitable.
- Designs and implementations must be tested.

3.2 Considering colours in website design

There are many reasons why colour is one of the most important design features. Tidwell [10] says that colours, shapes and forms are the first to be noticed in designs. In addition, a competent use of colours can enhance the aesthetics of a website. Lindgaard et al. [11] have shown that a user forms a first impression of a website in just 50 milliseconds, and the impression seems to remain the same over time. These first impressions create an aesthetic impression of the website for the user, which affects their subsequent navigation.

However, mere attractiveness is not always enough for the success of websites. According to Bonnardel et al. [12], when designing products, it should also be taken into account that positive emotions and feelings arise from its aesthetic properties and that colour choices in particular can influence users' feelings and reactions. It is also essential to note that colours are used a lot on websites: in the background colour, texts and imagery. That is why colours play such a big role in website layout. [8]

HTML colours are displayed using red, green and blue light. In addition, colours are defined either by hexadecimal notation (HEX) or by the number of red, green and blue colours (RGB). [1]

3.2.1 Appearance and aesthetics

Social scientists have emphasized the importance of aesthetics in everyday life. For example, a person's physical appearance affects their social interaction. Similarly, the aesthetics of the products is important in marketing and the retail environment. The attractiveness of the website also increases the probability that the user will return to the same page again later. Interactive systems should be aesthetic and also bring some fun and pleasure to the user. Pleasant systems are also perceived to work better, which leads to better user performance [12]. Gorn et al. [13] studied

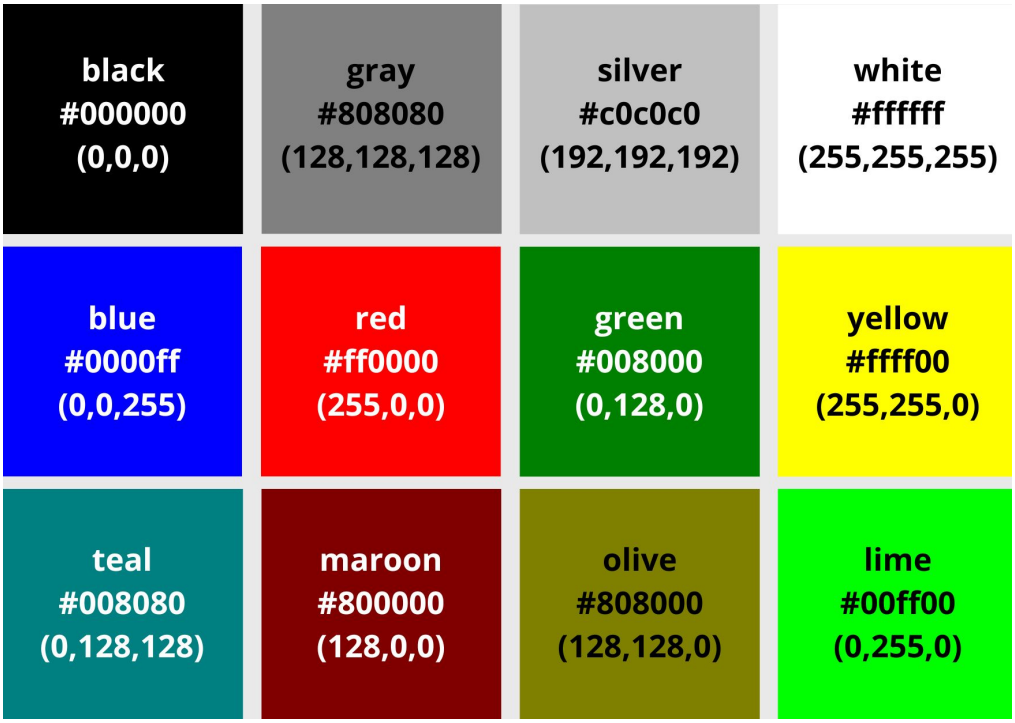


Figure 3.1: Some of the basic HTML colours. Each colour has a CSS keyword, HEX, and RGB, for example blue, #0000ff, (0,0,255).

the effect of the background colour on the perceived speed when loading a website, and noticed that colours that create relaxation made the loading feel faster. In addition, they noticed that the colours of the design affected what users thought of the website, and how likely they were to recommend the page to others.

The attractiveness of a website consists of both its appearance and usability. It affects whether the user wants to continue browsing the page. Aesthetic sensibilities are individual, that is, users' preferences influence the reactions that websites evoke in them [14]. Westerman et al. [15] report that, based on context-free colour studies, saturation may affect affective state more strongly than hue. Higher satieties have been found to be more pleasurable and arousing. On the other hand, this is not true in all contexts, such as background colours. For example, pastel colours are preferred in the interior of houses.

According to Liu et al. [16] the appearance of a website is one of the most

important non-functional features, because it affects the impression, feelings and behavior of users. When the appearance is pleasant, the user's impression is good, positive feelings arise and the website may be returned to again later.

According to Best [1] when designing a website, there should always be one primary colour and one or two secondary colours. The colours should be chosen with the target audience of the website in mind, so that they are attracted by the page. If there are more than two or three colours, the website is perceived as chaotic. Therefore, when choosing colours, you should keep things simple.

Lawrence and Tavakol [8] say that a website can have many types of externally created elements, such as text, images, animation and sound. An element can have subjective and objective aesthetic value, but if there are only a couple of these elements, the website cannot be aesthetically strong. Elements have properties such as colour, shape and position that affect how harmonious a site is, and choosing them poorly can lead to a negative outcome. Since websites are usually viewed as a whole, the selection and placement of elements, as well as the relationship and harmony between them, are very important. Lawrence and Tavakol [8] also state that websites are rarely used just because of how beautiful they are; it is usually noticed when something is wrong or very strong. Positive user experiences and emotional responses lead to user satisfaction, which increases the site's aesthetic value. Conversely, using too many or wrong colours can damage the user's experience and at the same time the aesthetics of the page.

Different companies have their own colour trends, which can either remain the same or change regularly. Gijsenij et al. [17] studied 15 paint companies' Colour of the Year from the past decade. Colour of the Year is a concept used by paint and coatings companies, introduced by a company called Pantone. The companies select their Colour of the Year each year based on research conducted by designers and trend experts. The study found that, in general, the Colour of the Year is off-white

colours, and most companies chose the Colour of the Year with high chromaticity. However, other factors may also influence the choice of colour, such as the varying geographies of paint markets or differences in colour preferences in architecture and consumer choices. While in 2015 the colours of the tear were yellowish red and greenish blue, in 2017 the shades have been mostly bluish, and in 2020 again a wide range of hues, indicating a distribution of colour preferences. There may even be a cycle in which the popularity of a particular hue varies from year to year. For example, the popularity of red and blue hues may have first decreased, then increased, and then decreased again.

3.2.2 Emotions and decision-making

In addition to the fact that interactive systems have functional properties, they should also evoke feelings in the user through visual sensory modalities. Emotions and cognition are considered information processing systems, but with different functions and parameters. Cognition is for interpreting the world and understanding it, while emotions give positive and negative values. [12] colour design takes into account things like excitement, temperature, harmony, and users' emotional preferences. [14] According to Spence and Velasco, the colours of a product convey the sensory properties of the product to the consumer. In addition, shades have a strong influence on emotions. For example, blue makes users feel relaxed, and light colours create feelings of calm and joy in users. Red and yellow are recommended for increased readability. [18] The colour black has a dual meaning. It can symbolize dignity, authority, sorrow, and classical, but on the other hand it can also symbolize opponent sensuality and modernity. [19]

Best [1] emphasizes that when designing websites, it is important to consider that colours evoke emotions in users, are associated with certain concepts, and have different meanings depending on the country. Therefore, colours can evoke both

positive and negative emotions in users. Below are listed common colour associations [20]:

- Red: passion, power, love, danger, excitement
- Blue: calm, trust, competence, peace, logic, reliability
- Green: health, nature, abundance, prosperity
- Yellow: happiness, optimism, creativity, friendliness
- Orange: fun, freedom, warmth, comfort, playfulness
- Purple: luxury, mystery, sophistication, loyalty, creativity
- Pink: nurturing, gentleness, sincerity, warmth
- Brown: nature, security, protection, support
- Black: elegance, power, control, sophistication, depression
- White: purity, peace, clarity, cleanliness

The hue of a website's background colour influences user behavior. Consumers spend more time and spend more on pages with a preferred colour. The phenomenon was studied by Westerman et al. [15], and according to them, the colours of the user interface affect users in two ways: the user's cognitive processing abilities and strategies, and aesthetic judgments. Contrary to the hypothesis, users' decision-making was found to be more comprehensive with a gray interface. They also found that colourful interfaces enable cognitive processing, which results in users making decisions with less effort. Bonnardel et al. [12] also confirm that although there is no theoretical rationale for the phenomenon that explains how colours affect emotions, colours do indeed influence user emotions, attention, judgments, and decisions, such

as purchase intentions and perceived usability. Their study proved that the interaction between a user and a web page is influenced by the colours that the user perceives. Furthermore, the effect of colour is not only valid during the interaction, but also afterwards, such as in text production from information read on the page.

Tidwell et al. [10] share approximate rules for using colours in user interface design:

- Red, orange, yellow, brown and beige are perceived as warm colours, while blue, green, purple, grey and white are perceived as cool.
- Light background colours (white, beige, and light gray) are more typical for computer interfaces and printed screens, while dark backgrounds can appear more edgier or more energetic.
- Depending on the background colour, elements on the page can have either low or high contrast against it. High contrast creates tension, strength, and boldness, while low contrast has a more calming and relaxing effect.
- Highly saturated or pure colours – such as brilliant yellows, reds and greens – create an energetic, bright and warm feeling, but when used excessively they can strain the user's eyes.

3.2.3 Usability and accessibility

In addition to being pleasing to the eye, websites should also be easy to use and accessible. According to Liu et al. [16], when designing websites, one should pay attention to aesthetic formality. The user's attention is initially captured by beautiful, creative, and interesting-looking websites, but the user experience may become poor if the user finds the pages illogical and less user-friendly. Text is harder to read on a monitor than on paper. This is why choosing colours when designing websites should be done carefully. Some colour combos create contrasts that are difficult for

the eyes, for example yellow text on a blue background. The most common combination is black text on a white background, because it is easiest to read on both paper and screen. [1]

According to Lawrence and Tavakol, good usability is when we use something to do what we want without being aware, almost or completely, that we are using the user interface. Noticing the user interface can therefore be related to the pleasantness of using it. Poor usability, on the other hand, is when the user interface just feels like an obstacle and hinders progress, which causes frustration. [8] Rubin and Chisnell [21] say that usability is only considered when there are problems with it, or the product is not usable at all. A product or service is fully usable when the user can do the things they want to do as they would expect to do them, without confusion or questions. Furthermore, Rubin and Chisnell summarize usability into six characteristics: useful, efficient, effective, satisfying, learnable, and accessible. Of these characteristics, accessibility is most relevant to the topic of this thesis.

Broadly speaking, accessibility means that the products required to accomplish a goal are accessible. However, accessible products are usually intended for people with disabilities. When a product is designed to be usable by people with disabilities, it often also benefits people without disabilities. When a product is designed to be accessible to people with disabilities, the design often becomes clearer and simpler. This makes it easier for users with temporary limitations, such as injury, as well as situational limitations, such as poor environmental conditions, for example poor lighting. There are many tools and guidelines for designers to create accessible designs. [21]

The World Wide Web Consortium (W3C) [22] develops international standards for the web, and The W3C Web Accessibility Initiative (WAI) develops standards and materials for developers and designers to understand and implement accessibility. The W3C website has the Web Content Accessibility Guidelines (WCAG)

international standard. They are currently working on WCAG 3, but it is not yet complete. You can view the existing standards in WCAG 2. WCAG 2 introduces four principles of accessibility. They create a foundation that allows anyone to access and use web content. Accessible web content should be:

1. Perceivable: information and interface components should be visible to users in ways that they can perceive. This means that the user must be able to perceive the visible information, meaning that the visible information must not be invisible to all of the user's senses.

2. Operable: user interface components and navigation must be operable. The user must therefore be able to operate the user interface, meaning that the user interface must not require functions that the user is unable to perform.

3. Understandable: the information and the use of the user interface must be understandable. Users must be able to understand both the information provided by the user interface and how to use it, that is they cannot be difficult for users to understand.

4. Robust: the content must be so robust that it can be interpreted well by different user agents, meaning that the content must be accessible to users as technologies develop.

WCAG 2 aims to ensure that colour is not the only way to distinguish information. In addition to colour, text or shapes can also be used. This benefits, among other things, users with partial vision, as they often also have limited colour vision. In addition, older users may not see colours properly. When information is also available in visual means other than colour, even users who are unable to distinguish colours can receive the information. WCAG 2.2 focuses on guidelines for making websites accessible to people with disabilities. Each principle listed above provides criteria and guidelines for making websites accessible to people with disabilities. [22]

When designing a user interface colour scheme, Tidwell [10] recommends eliminating anything that makes text difficult to read:

- A dark foreground should always be against a light background, and a light foreground against a dark background. This can be tested by adding the design to an image editing program and desaturating it, which means making it grayscale.

- When red or green is used to indicate essential differences, this should also be reinforced with form or text, as most colour-blind people do not perceive the difference between them. Statistically, about 10 percent of men have some form of colour blindness, while about 1 percent of women do.

- Some colour combinations should be avoided. For example, bright blue text against a bright red background can be tiring on the eyes. This is because they are complimentary colours.

- Black text on a white background is less tiring. On the other hand, white backgrounds often glow with light, which can also be tiring on the eyes. So it is a good idea to make the UI background darker if it is intended to be used on a tablet and there is a lot of empty space around the content or components.

Best [1] also emphasizes that when designing websites, information should not be conveyed solely through the use of colours. It is a common practice to mark errors in red, meaning the text is red. However, this proves to be inconvenient for colourblind people, as red appears dark to them just like black. Blue would appear differently to them, but red is the established colour for indicating errors. The easiest solution to this practice would be to make the red text bold, so anyone would notice it immediately. Contrast between foreground and background is also important, especially if the user is a person who cannot see all colours. At best,

low contrast is difficult to read. At worst, it is unreadable. The same problem in a different form occurs when content is presented in graduated colours in graphs and charts. If the objects that represent different things are not significantly different in colour, colour-deficient people will not be able to distinguish them from each other. Graduated colours contain elements of red and green. In this case, these elements are not visible to a red-green blind person and all objects appear only slightly lighter or slightly darker. Even then, the difference can only be noticed if the objects are next to each other, and if they are separated from each other, the difference is not noticeable. [1]

In user interface design, it is also possible to create different options for the view to choose from. For example, in Windows, the user can change the colour and font theme of the desktop. This feature is especially beneficial for visually impaired people who prefer high-contrast views and large fonts. If the user interface is intended to be used for long periods of time or at full size, design can help reduce user fatigue. In this case, the design should be quiet, not loud, so it is recommended to soften saturated colours, large text, high contrast, and strong textures. [10]

4 Experimental setup

The purpose of this chapter is to present a quantitative study conducted in the thesis, which aims to identify similarities and differences in the colours of websites. This approach provided insights into the colours used on popular websites. It also provided information on what factors may influence the colours chosen for websites, such as geographic location and type of website. This study was conducted with the aim of answering the following research questions:

RQ1. What colours are popular in website design?

RQ2. Do geographic location and website type affect what colours are chosen for a website?

The purpose of the colour analysing tool created for the study was to help find answers to RQ1. Six different countries from four continents and three different website types were selected for the study to allow for answers to RQ2.

4.1 Methodology

Primary data was collected for the study in order to obtain answers to the research questions while taking into account different cultures. Since the study wanted to find out how the colour designs of various websites were implemented, a qualitative approach was the most suitable option. Before the actual data collection, it was necessary to decide on the criteria for selecting the sites. The homepage is often the

first page of a website that a user visits. As such, it is also the page that receives the most attention when it comes to designing its appearance [8]. Since colours are an essential part of website design, and one of the first things people notice about a design, choosing them is of considerable importance [10]. To gain more understanding on the subject, the research needed to focus on what types of colours are generally used on websites, and how much.

4.2 Data collection

For data collection, six different countries (Chile, Finland, Japan, the Netherlands, Russia and the United States) were selected from four continents, with the aim of examining their most popular websites. This was done so that we could find possible connections between different cultures and website colours, or that there are no connections at all. Although the types of websites vary, their purpose is generally to keep the user on the same page and consume the products and services offered by the site. However, the study also aims to determine whether the type of website affects the colour palettes of the sites. colour associations can influence this; since the colour blue can be associated with calmness and trust [20], it could be a good choice for the appearance of a banking website when customers are looking for a reliable bank. Three different types of websites were selected for the study: bank, medical and e-commerce (see Table 4.1). Although these sites share the common goal of acquiring customers, their services and products differ greatly. The five most popular websites from each of the three website types were retrieved using a search engine called SimilarWeb [23]. Each of these sites was accessed, but not all were available or the domain was not associated with a website. Therefore, the sites selected for the study may not be among the top three most popular websites in the country in question. Screenshots were taken of three websites from each type based on whether the website was operational or displayed normally. In the end, a total of

54 websites (i.e. screenshots of their homepages) were examined. The screenshots were mostly taken on January 31, 2023, with a few exceptions. For example, the screenshot of John Hopkins Medicine's website was taken on October 25, 2023, as the page was not available on the earlier date.

Table 4.1: Nine Chilean websites from which screenshots were taken and analysed.

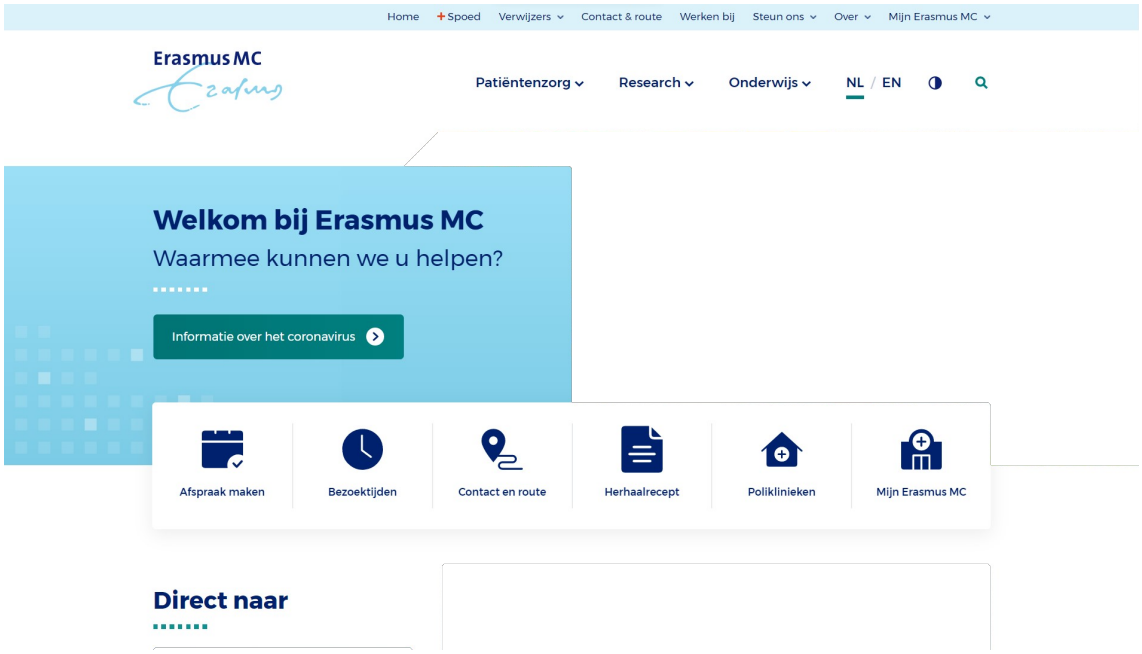
Country	Website type	Website
Chile	Bank	bancoestado.cl
		transkbank.cl
		bancochile.cl
	Medical	msdmanuals.com
		intramed.net
		clinicabupasantiago.nl
	E-commerce	falabella.com
		mercadolibre.cl
		paris.cl

The data as such was not ready for analysis, as more than just the design of the websites is visible in the screenshots. The screenshots were processed so that browser interface features, such as the browser toolbar and scroll bar, were cropped out. The browser toolbar bar was hidden from view by using full screen mode. To ensure that the screenshots remained the same size as I edited them, I took the final dimensions when cropping the first screenshot and cropped the rest of the screenshots accordingly. In addition, many websites contain advertisements or other images, such as product images or stock photos, which are not essential to the colour design of the websites and can distort the results of the study, so such images were cropped out, that is, their pixels were made transparent, as seen in Figures 4.1a and 4.1b. After this, the data was ready for analysis.

4.3 Colour analysing tool

Each screenshot was subjected to a colour analysis. For the colour analysis, I have created a Python program (colour analysing tool), which is given an image as input.

(a) The original screenshot.



(b) Screenshot after editing; scroll bar and images have been removed. The deleted images are actually transparent pixels, but appear white because the background colour of this document is white.

Figure 4.1: An example of how screenshot editing was implemented.

When the program is run, it goes through each pixel of the image and calculates, pixel by pixel, how much of each colour the image contains. After the program is run, the output is printed, which consists of the colours contained in the image and their percentages, in order of magnitude. For verification, the tool also prints the number of pixels, the number of non-transparent pixels, and the colour groups from largest to smallest and the number of pixels they contain. The program ignores transparent pixels and does not take them into account.

The program uses X11 colour keyword names according to CSS Colour Module Level 3, of which 147 are listed [24]. Since it is not always possible to determine from the colour names what kind of colour is in question, I have grouped each colour as belonging to a specific colour group, for example the colour teal belongs to the group Dark green. After grouping, there are a total of 26 colour groups. For most of the hues, there are usually three groups according to lightness; for example, light blue, blue and dark blue.

The program examines one pixel at a time. It identifies the colour of the pixel and assigns it an RGBA value. This is an RGB value that has been extended to also include an alpha value, which indicates the opacity of the colour. The alpha value can vary between 0.0 and 1.0. [24] For example, the value of completely transparent black would be rgba(0,0,0,0) and the value of opaque black would be rgba(0,0,0,1). The images have been removed from the screenshots so that the pixels in their place are transparent. For this reason, the program excludes pixels with an alpha value of 0 from the calculations.

When the program has received the RGBA value of a pixel, it searches for the closest match among the colour keywords. In this way, the colours contained in the screenshot can be named and counted. After this, the program searches for the colour group where the keyword in question is found for the keyword it has received, and counts the pixel as belonging to that colour group. When all pixels

have been examined, the program calculates the shares of the colour groups in the total number of pixels in the screenshot. Since transparent pixels are ignored, they do not affect the results. The percentages are therefore calculated only for those pixels whose alpha value is greater than 0.0. Finally, the program prints the results of the colour analysis so that one line shows the colour group and its share of the screenshot as a percentage, rounded to two decimal places. The results are in order of magnitude from largest to smallest. The program does not print colour groups whose rounded percentage value is less than 0.01.

Table 4.2: Results of colour analysis of one of the Chilean bank websites.

Land	Chile
Website type	Bank
Website	bancoestado.cl
Colours	white: 57.85 %
	gray: 21.75 %
	orange: 12.19 %
	brown: 1.67 %
	lightred: 1.2 %
	lightblue: 1.14 %
	lightbrown: 0.97 %
	darkgreen: 0.89 %
	lightyellow: 0.8 %
	lightgreen: 0.33 %
	darkyellow: 0.26 %
	beige: 0.22 %
	lightorange: 0.17 %
	black: 0.15 %
	lightpink: 0.12 %
	pinkorange: 0.08 %
	darkblue: 0.08 %
	red: 0.05 %
	darkred: 0.04 %
	blue: 0.02 %
	pink: 0.01 %

4.4 Data analysis

Data analysis began by running the data through the colour analysing tool. The analysis was carried out alphabetically by country (i.e. Chile, Finland, Japan, the Netherlands, Russia and the United States) and alphabetically by website type (i.e. Banking, E-commerce and Medical). The results of the colour analysis were saved in a spreadsheet, where they could be examined and compared with each other. For the list of the websites included in this study, see Appendix A.

When examining the results of the analysis, it was noticed that in fact, there are many different colour groups in all screenshots, but most of the colour groups in a screenshot comprised a very small portion, less than 1.0 percent, as can be seen in Table 4.2. Most often, 2–4 colour groups filled most of a screenshot. Since there are many colour groups with a size of less than 1.0 percent, and their share of the screen images is ultimately very small, they are not considered in the analysis. After all, the colour groups that are most present in the screenshots play the biggest role in this study. In addition, data editing may not have been done with pixel precision, which may result in some pixels from the cropped images remaining in the screenshots.

The results were analyzed in the following ways:

1. By country
2. By website type
3. Altogether

4.5 Manual error correction

When analyzing the results of the colour analysis, it was noticed that not all the numbers were always correct. For example, in the results of the Chilean e-commerce

website mercadolibre.cl, the majority of the colours were 43.39% light blue, even though it does not look like it. When looking at Figure 4.2, the unedited screenshot, you can see a lot of blue in the image. But after removing the images, the screenshot appears to be mostly yellow and light gray (see Figure 4.3). After re-examining the results of the colour analysis of the screenshot, I noticed that the screenshot had the most pixels matching the keyword "lavender". This may be because the gray background colour in the screenshot has an RGB value of (235,235,235), while lavender has an RGB value of (230,230,250) and the lightest gray of the X11 colour keywords, lightgray, has an RGB value of (211,211,211). In this case, the RGB value of lavender is closest to the value of the colour in question, and the colour analysing tool has calculated that the light gray background colour is lavender and belongs to the light blue colour group.

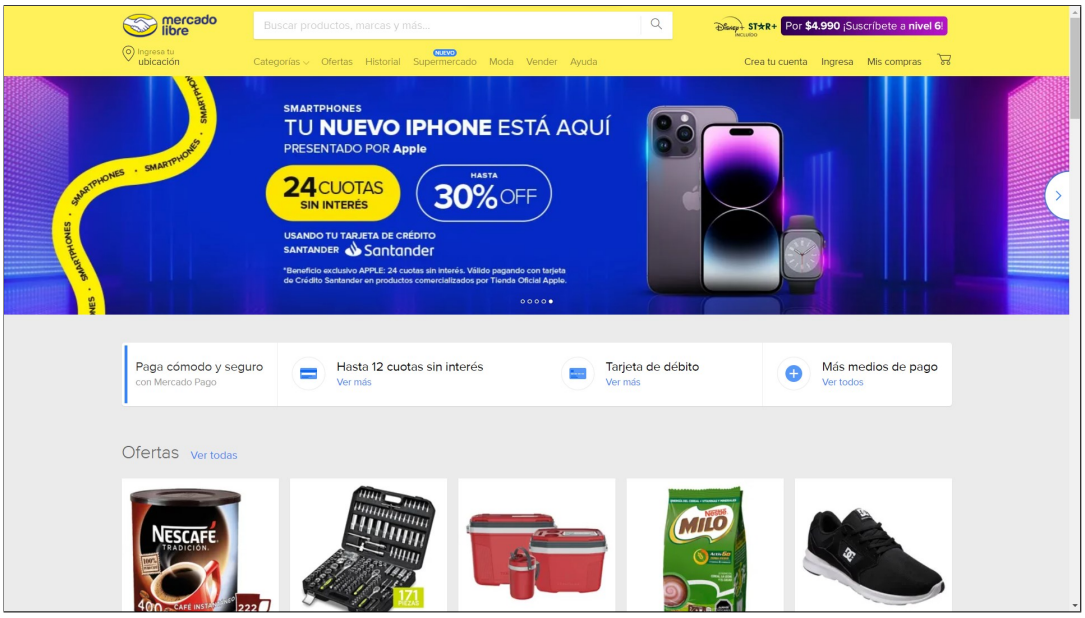


Figure 4.2: The original screenshot from the Chilean e-commerce website mercadolibre.cl.

Since the tool is based on X11 colour keywords, which are a significantly limited number compared to the number of HTML colours, I manually applied the corrections to the colour analysis results. This means that I went through the results and

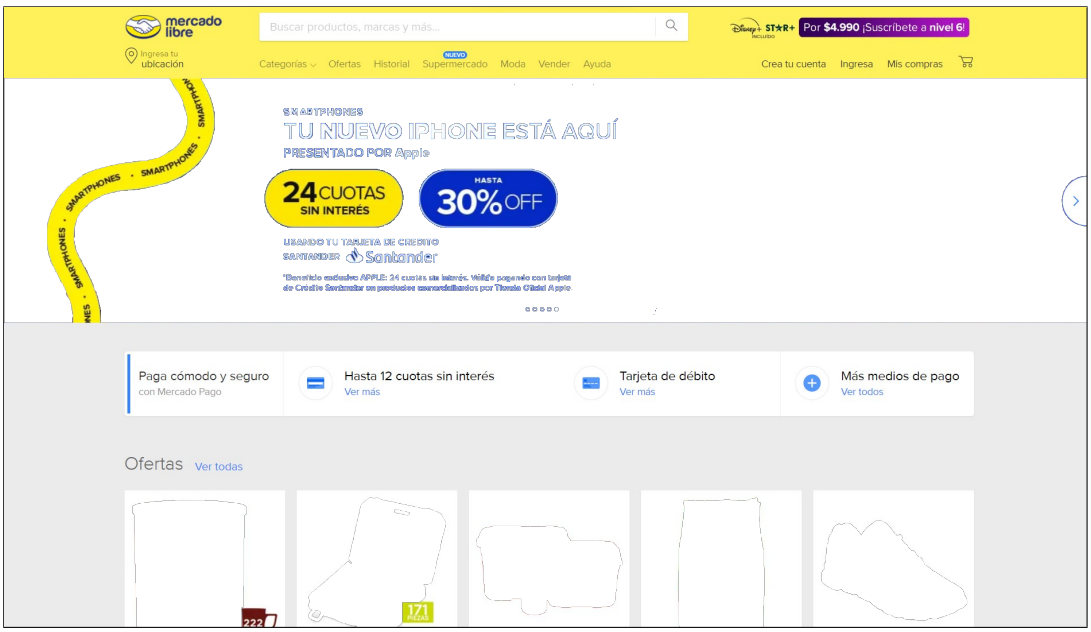


Figure 4.3: The edited screenshot from the Chilean e-commerce website mercadolibre.cl.

data and found out which of them might have been affected by the error. I re-ran the screenshots with the program, compared the results to what the screenshot looks like, compared the RGB values of the actual colours in the screenshots to the colours that the colour analysis tool claimed the screenshots contained, added any corrections to the spreadsheet and finally calculated new percentages for the colour groups affected by the error. For example, take mercadolibre.cl. According to the results, it contains 43.39% light blue and 487820 pixels of lavender. Since this is clearly not true, and the tool has calculated the gray background colour to be lavender, I counted the lavender pixels as part of the gray colour group, so according to the corrected results, the site would have 43.37% gray and 1.62% light blue. Corrections were made on eight website's results.

5 Results

In this chapter, we will review and discuss the results of the study. The aim is to get some idea of how the most popular colours are distributed across countries and website types, and to compare them all with each other. First, we look at how website colours are distributed across countries and compare them. Then, we consider whether geographic location or culture plays a role in website colours. Next, we examine the variation in colours across website types to draw conclusions about how website type affects colours. Finally, we look at all the results together to see if certain colours might be universally appealing.

5.1 Colours among the countries

The most popular colours by country are presented in pie charts. For these, the percentages of different colours were calculated per country. The pie charts do not include colours that were rounded to less than 1.0 percent of the colours in the country. The pie charts can also be thought of as a common colour palette for each country's websites.

The most used colour in Chile is white, which covers 42%. The next most used colours are dark blue and gray, which each account for 16%. From here on, the colours are clearly less; blue 6%, light blue 5%, orange 3%, light yellow, purple and red each 2%, and black, green, light red and brown each 1%. Apart from dark blue, the most used colours in Chile are mainly pure hues that are not dark, for example

blue and light blue. The popularity of the dark blue colour is significantly increased by bancochile.cl, whose design uses dark blue for about a third of the entire page. The colours and their distribution can be seen in Figure 5.1.

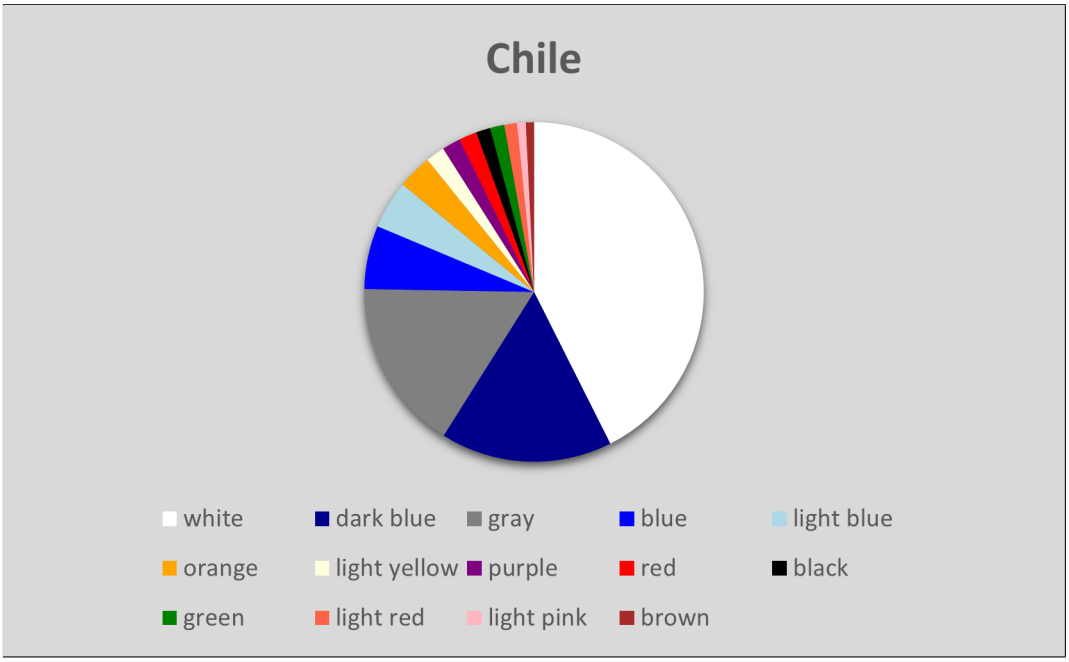


Figure 5.1: The colours of Chilean websites.

The most used colour in Finland is white, covering up to 49% of the country's websites. The second most used colour is light blue, which was 14%, followed by gray, which was found at 12%. Next is dark green, at 9%. What is remarkable here is that dark green was hardly found on other Finnish websites, but because it was used on the mehilainen.fi website by up to 79.64% percent, the colour reached the fourth most used colour in the Finnish colour palette. The next most used was dark blue, at 5%. Light yellow was used at 3%, light red at 2%, and brown and green at 1% each. The majority of Finnish website colours, more than three-quarters, are white, light blue, gray, dark green and dark blue, which can be perceived as cool colours. The Finnish colour palette can be seen in Figure 5.2.

The most used colour in Japan was also white, which was used by up to 53%. The second most used colour, gray, was used by 20%. From here on, the share of other

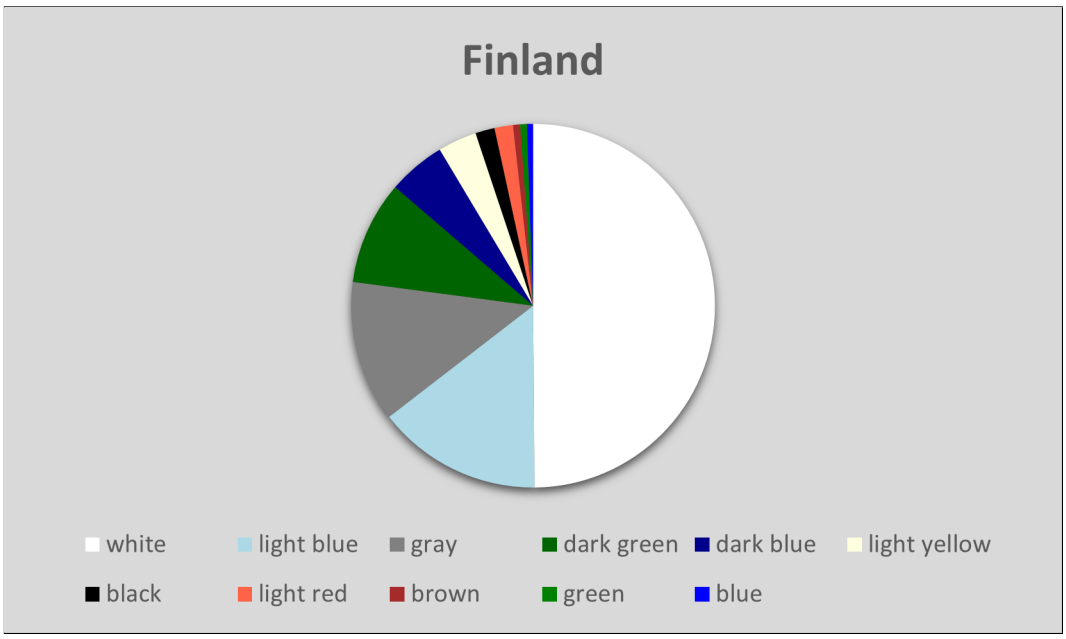


Figure 5.2: The colours of Finnish websites.

colours is significantly smaller, blue 6%, light blue 5%, light red 4%, dark blue 3%, light brown 2%, and pink, green, black, red, dark red and brown 1% each. Japanese websites use a lot of white background colour and accent colours in moderation. However, an exception is, for example, the Japanese paypal.com, where the accent colours blue, gray and dark blue take up about 58% of the page area, while the white background is 37.27%. The most used colours in Japan are mainly cool colours, and for example, light red, light brown, and pink can have cool or warm temperatures depending on their tone. The colour palette of Japanese websites can be seen in Figure 5.3.

The most used colour on Dutch websites is also white, but to a slightly lesser extent, 41%. Grey, on the other hand, is the second most used colour, with up to 26%. This is probably because a few websites use grey as a background colour, either with or instead of white. Compared to these two, other colours are used much less. Light blue is used by 9%, blue by 8%, dark blue by 6%, dark green and light yellow by 2%, and light pink, pink-orange, black, light red and orange by 1%. This means that a significant proportion of the colours on Dutch websites are cool, at

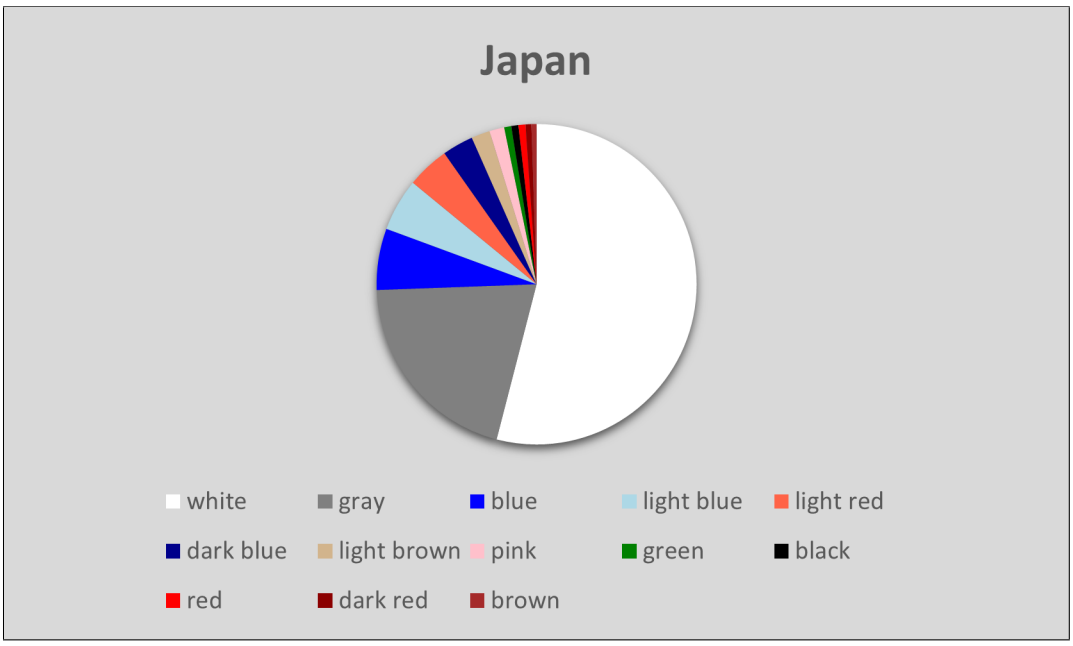


Figure 5.3: The colours of Japanese websites.

least 92%. The colour palette of Dutch websites can be seen in Figure 5.4.

White was also the most used colour on Russian websites, with 50%. Next was gray, which was used by 22%. The third most used colour was light blue, with 11%. The shares of the remaining colours are smaller; black 4%, light brown 3%, purple and blue 2% each, and pink, light red, dark blue, yellow and light yellow 1% each. In the Russian colour palette (see Figure 5.5), black is clearly higher than in other countries, even in fourth place. This is probably because black was the most used colour on the wildberries.ru website with 38.15%, while black was almost not used at all on other Russian websites. Thus, the colour palette of Russian websites is also mainly cool colours.

White was by far the most used colour on US websites, where it was used by 57%. There are significantly fewer other colours compared to white. This is because the most used colour on every US website was white. The second most used colour was gray, 12%. Next is dark blue, 9%, then blue and light blue, 6% each, green, 3%, red and light red 2% each, and black, yellow, light brown and beige 1% each. The

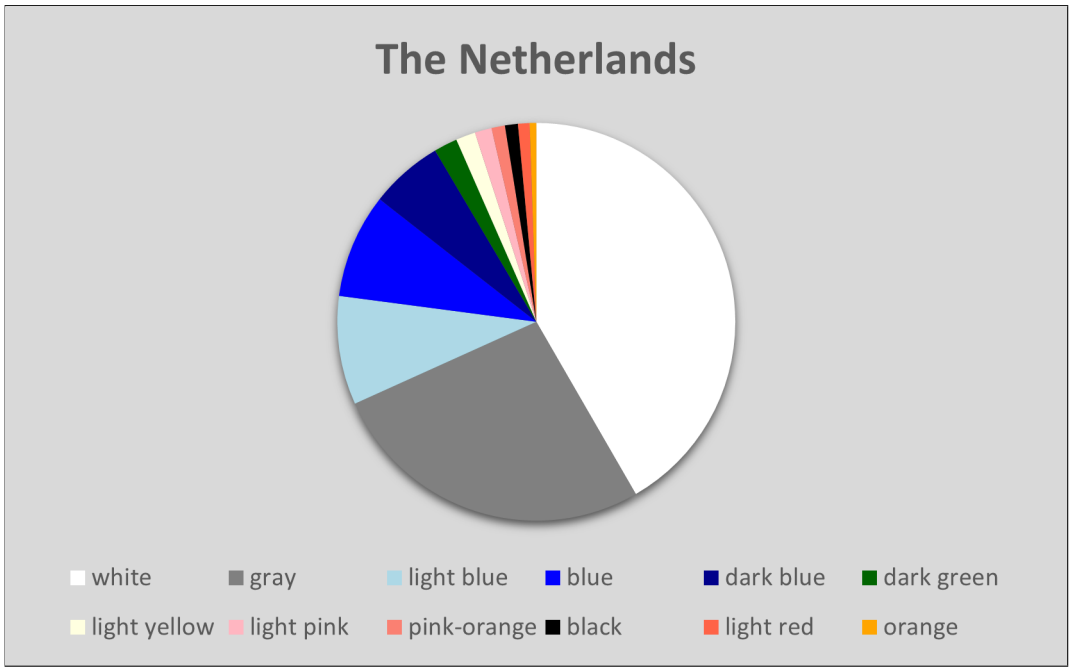


Figure 5.4: The colours of Dutch websites.

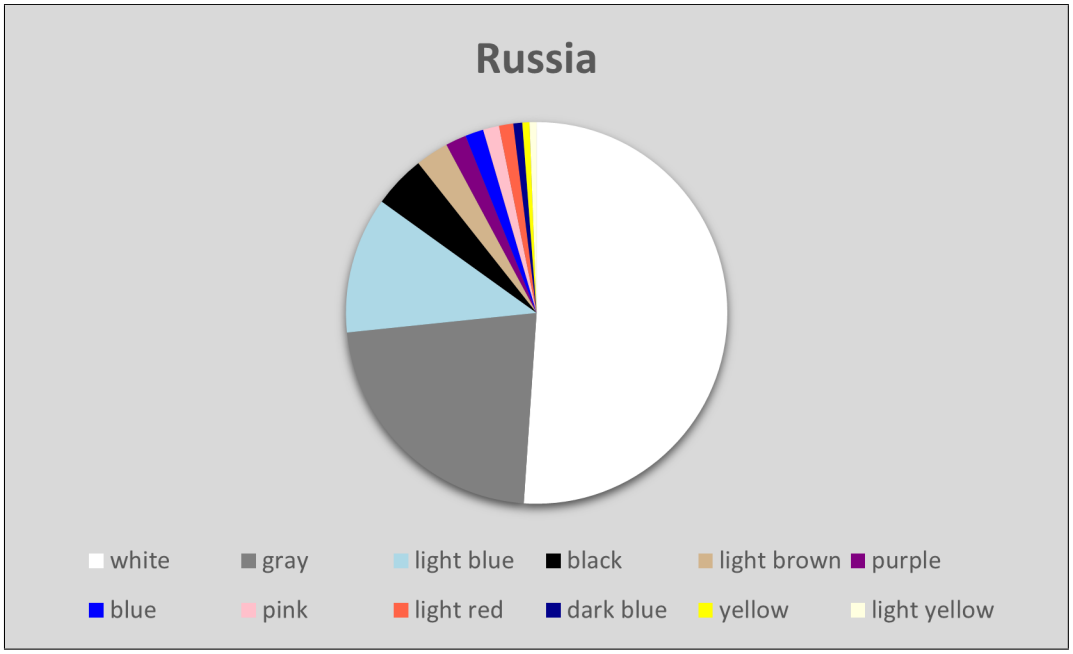


Figure 5.5: The colours of Russian websites.

colour palette of US websites (see Figure 5.6) therefore consists mostly of white, and less than half of it is other colours. This is probably because the colour design of US websites has been kept simple. In addition to the white background colour, all pages seem to use one or two accent colours.

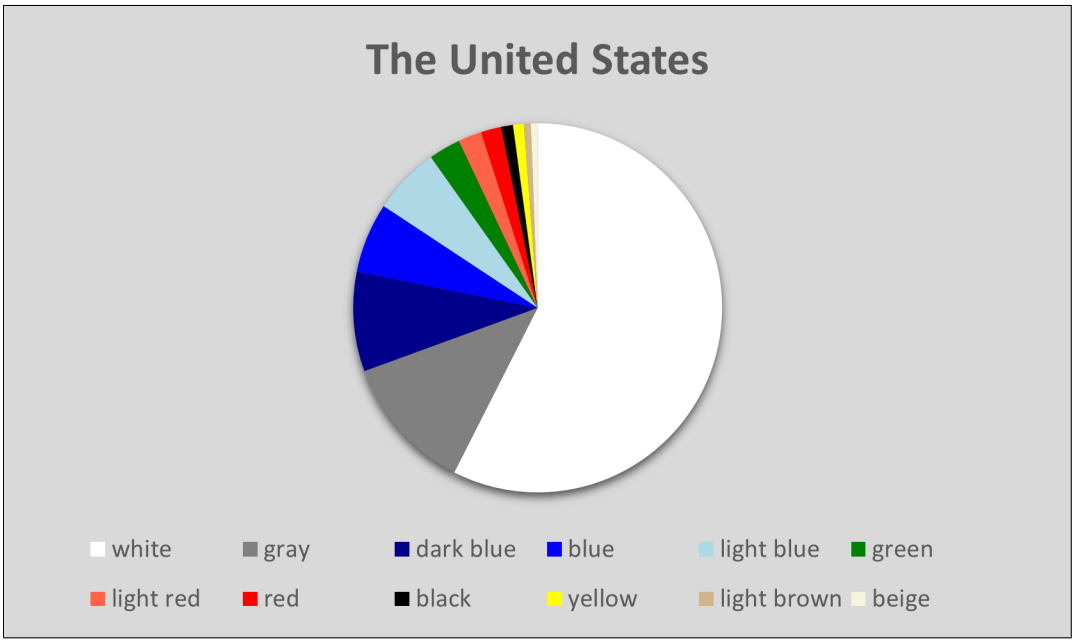


Figure 5.6: The colours of American websites.

Regardless of the geographical location of the website, it can be stated that the most used colour is white, which appears as the background colour on almost all pages. The second most used colour is most often gray, or alternatively it is either light blue or dark blue. These four colours seem to be in the top positions in every country. Blue is also among the most used colours in some countries, but not as high as light blue or dark blue.

5.2 Colours among the website types

The most popular colours by website type are presented in pie charts. For these, the percentages of different colours were calculated per website type. The pie charts do not include colours that were rounded to less than 1.0 percent of the colours in

the website type. The pie charts can also be thought of as a common colour palette for each website type.

The most popular colour on bank websites is white, used by 46%. The second most popular is gray, at 22%. Next comes dark blue, with 11%, then light blue at 9%. The number of other colours is clearly smaller; blue, light brown and light red each at 2%, and finally light yellow, orange, dark green, red and purple each at 1%. The majority of the colour palette on bank websites is cool colours (see Figure 5.7).

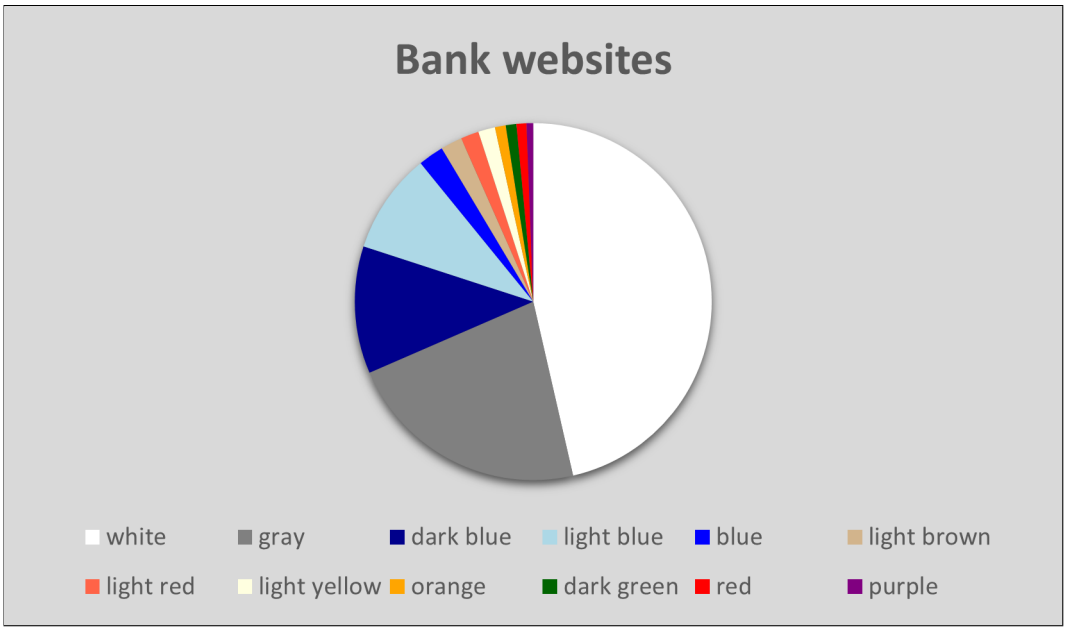


Figure 5.7: The colours of bank websites.

On e-commerce websites, you will immediately notice that there are more colours than on other website types. White is the most used colour also on these websites, it has been used by 48%. The drop from there to the next is quite large, as the second most used colour, gray, is used 16%. There are clearly fewer other colours; blue and light blue 7% each, black 5%, dark blue and light red 3% each, light yellow 2%, and red, light pink, pink, light brown, orange, purple, pink orange, yellow and brown 1% each. The colour palette of e-commerce websites (see Figure 5.8) differs from others in that there is no green at all, and there are also many light colours, such as light blue, light red, light yellow, light pink and light brown. Although there

are not large quantities of these colours, it is still significant that there are so many of them. The colour palette of e-commerce websites also seems to have the most warm colours compared to other website types.

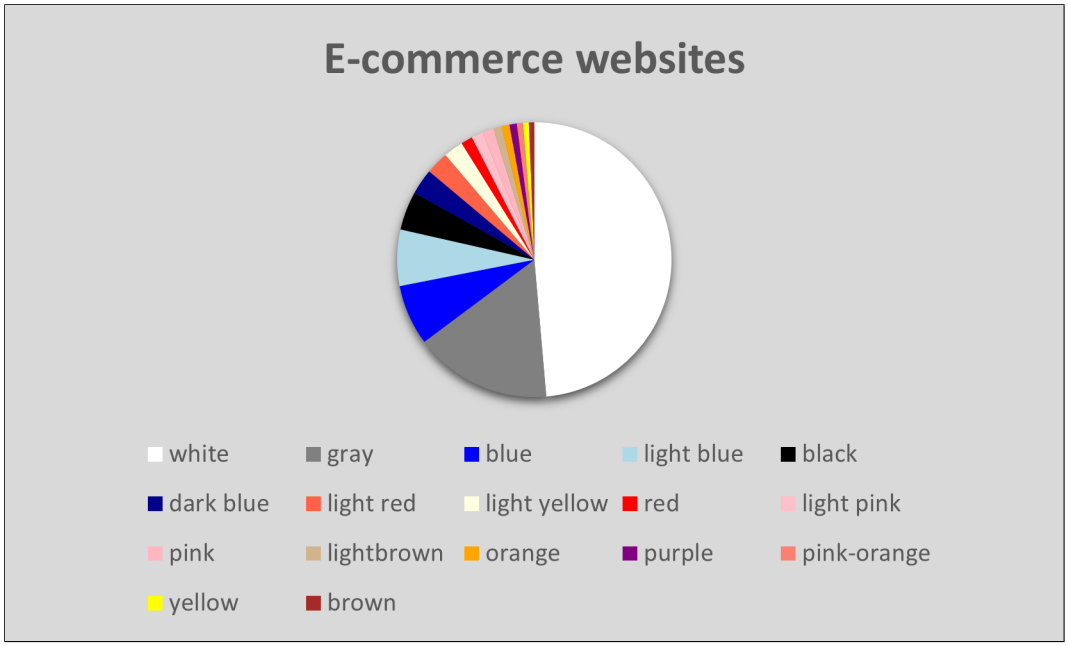


Figure 5.8: The colours of e-commerce websites.

The most used colour on medical websites is white, used 53%. The next most used colours are gray, 17%, and light blue, 10%. Then the most used are dark blue with 6%, blue and dark green with 5% each, green with 2%, and light red with 1%. There are clearly fewer colours than on other website types, only eight. From this, we can probably conclude that medical websites could have more consistent colour schemes compared to other website types. The colours in question are mainly cool, and even light red can be considered cool depending on its tone. The large share of dark green is mainly due to the fact that the Finnish medical website mehilainen.fi contains 79.64% dark green, while other medical websites hardly have it. Instead, the share of green is located on several websites in smaller shares.

When looking at websites, it is easy to notice that most often the colour scheme of a website comes from the logo of the company it represents. For example, if the

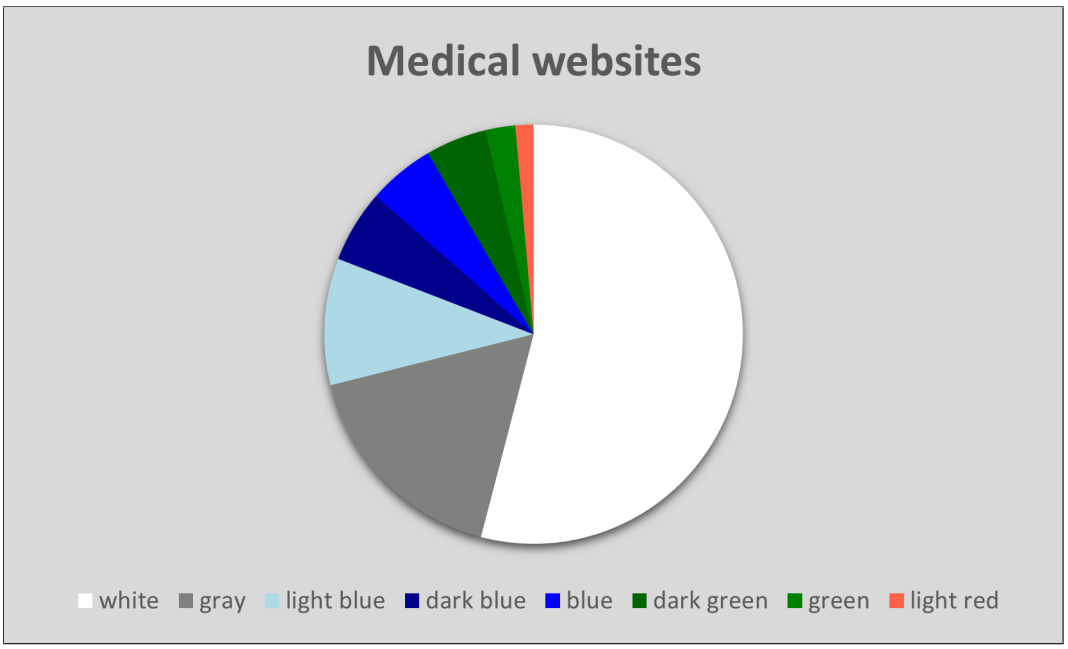


Figure 5.9: The colours of medical websites.

logo has two or three different colours, they are usually also used as accent colours on the website. The colours are not necessarily exactly the same, but also with different lightness or saturation. It is also noteworthy that, for example, Japan and the United States both had Paypal as the bank website under study. Both have shades of blue present in accordance with the logo, but the US version also includes a lot of yellow.

For some websites, a company's brand colours affect the overall results if they differ from the colour scheme of other websites. For example, the dark green featured on the Finnish medical website mehilainen.fi rose to sixth place in the colour palette of medical websites, even though the colour is barely present on other medical websites.

5.3 Colours altogether

Across all countries and website types, white was by far the most used colour. It was the most used colour on 36 websites, the second most used colour on 13 websites and

the third most used colour on five websites. This is most likely due to the fact that white is a very common and widely used background colour. It is a fairly neutral colour and can be easily combined with other colours without making the design look overwhelming. It should be noted that the "white" colour group only includes the "white" keyword. Keywords that resemble the colour white can be found in other colour groups, for example, "whitesmoke" belongs to the "gray" colour group. And despite this, pure white is clearly the most used colour. Figure 5.10 shows that the website could very well be almost completely white. Accent colours have been used sparingly, only in a few buttons and as text colours. Of course, the image also draws attention, although for the purposes of this study it has been cropped out when analyzing the image.

Figure 5.10: The original screenshot from the Japanese medical website fdoc.jp, which consists of 93.58% white.

The second most used colour was gray, which was the most used colour on 9 websites, the second most used colour on 17 websites and the third most used colour on 13 websites. This is likely because, like white, gray is neutral and works well as a context colour; objects of different colours next to or against gray are more

easily drawn to attention. Gray is also a common colour in icons, such as “menu” or “settings” icons. Gray is also used as a font colour to create a softer look, as black text against a white background can create a high contrast. In Figure 5.11, you can see that the large amount of gray is due to its use as a background colour. The gray used is very light, but it stands out clearly from the white at the top of the page, creating a clear boundary between the top menu and the rest of the page. In addition to make the difference clearer, a shading effect has been used between the top menu and the gray background colour, meaning a gradient colour utilizing slightly darker shades of gray.

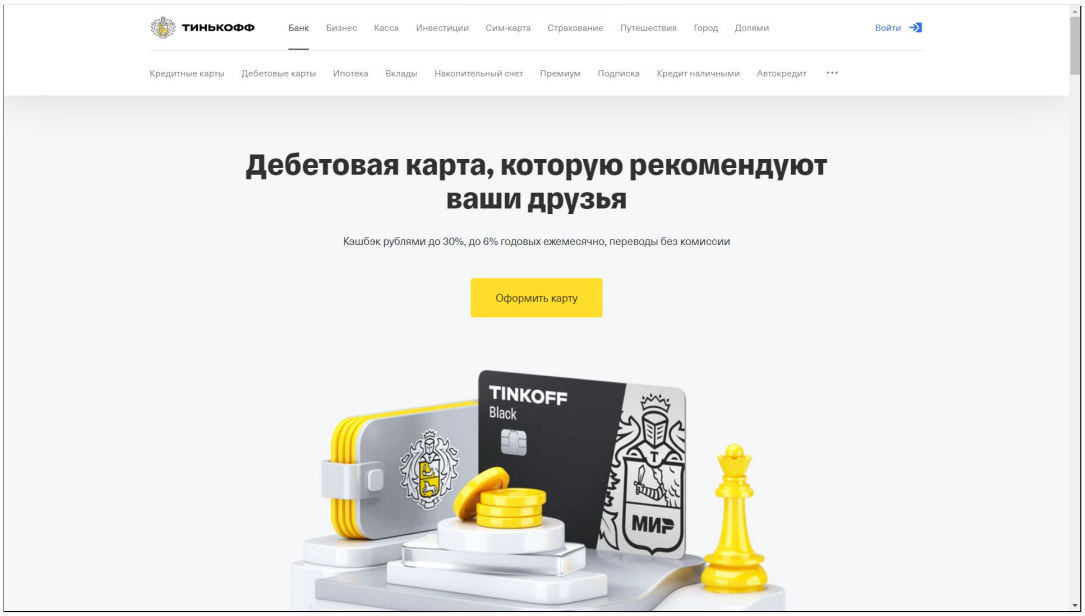


Figure 5.11: The original screenshot from the Russian bank website tinkoff.ru, which consists of 79.23% gray.

The third most popular colour was light blue, which was the most used colour on four websites, the second most used colour on six websites, and the third most used colour on ten websites. The popularity of light blue may be due to the fact that blue is a relaxing colour, and light colours create a sense of calm and joy in users [18].

The Finnish medical website hus.fi contained the most light blue, with 58.96% of

the colour. As seen in Figure 5.12, the website design uses mainly blue hues, which are mainly a light blue background colour and a dark blue accent colour and text colour.

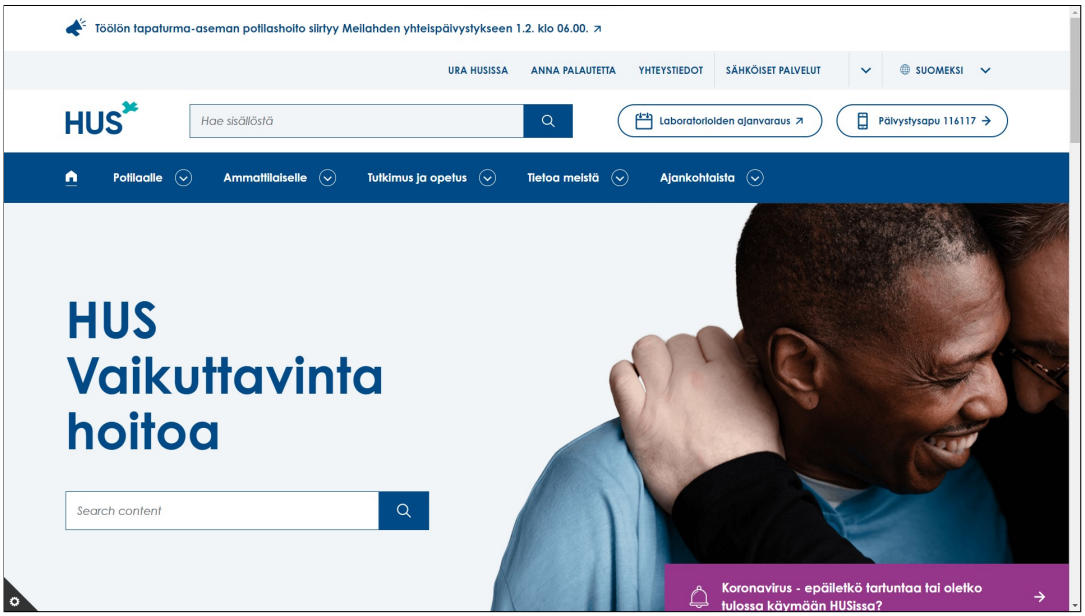


Figure 5.12: The original screenshot from the Finnish medical website hus.fi, which consists of 58.96% light blue.

The fourth most popular colour was dark blue, which was the most used colour on one website, the second most used colour on nine websites, and the third most used colour on six websites. Most often, dark blue is used with either white, gray, blue, or light blue. Dark blue is an excellent attention-grabbing colour in these cases to provide contrast to the light colours. It is also common for a website design to use a blue gradient that ranges from dark blue to light blue. The Chilean bank website bancochile.cl has the most dark blue on any website. The colour is used extensively on the home screen, with only a small amount of white background colour at the bottom (see Figure 5.13). The dark blue colour theme is also reflected in the website's images and text colour, and the colour palette also includes blue accent colours. The blue details are light enough to stand out against the dark blue background.

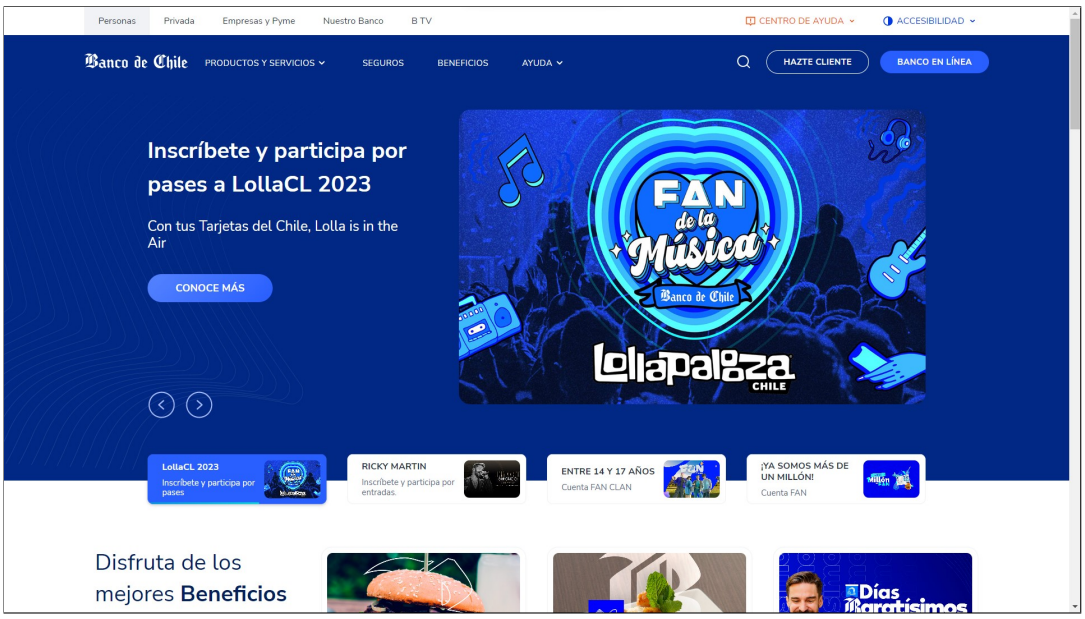


Figure 5.13: The original screenshot from the Chilean bank website bancochile.cl, which consists of 66.19% dark blue.

After white, gray, light blue, and dark blue, the popularity of other colours is clearly lower. The next most used colour would be blue, which was the most used colour on two websites, the second most used colour on four websites, and the third most used colour on one website. After blue, the most used colours are light yellow, dark green, light red, light brown, black, green, red, orange, purple, pink, light pink and beige, in that order. Each of these colours is one of the three most used colours on at least one website.

In general, it seems that the most popular colours on websites are white, gray, and shades of blue. White is the most popular background colour, which is why it appears the most on websites. Gray is widely used as a background colour, neutral accent colour, text colour, and various icon colours. The most popular hue, which differs from the previous two, is blue. Blue in various lightnesses has been used more than other hues. Its popularity may be based on the fact that blue evokes only positive emotions in the viewer, such as calmness, trust, peace, competence, logic, and reliability [18].

6 Discussion

The purpose of this study was to find out how colours are used on websites. Using qualitative methods, it was found that, regardless of the geographical location of the website or the type of the website, the colours with the largest percentages of the most used colours, seem to remain the same. This means that hypothesis H1 was partially wrong, as regardless of the country, the most used colours were mostly the same, but there were differences in the colours used less. The most used colour is definitely white, which is used as the background colour on the majority of websites. Gray is also one of the most used colours. Along with white, it is another neutral colour that can be widely used in different forms, such as a background colour, a neutral accent colour, a text colour, and an icon colour. Light blue and dark blue also emerged as one of the most used colours. They can be colours used by the brand, but they have also been used on websites in cases where they have not been in the company logo. With this in mind, hypothesis H4 was partially correct, the blue hue was a popular accent colour, but its light and dark versions were more commonly used.

The study shows that the geographical location of a website can affect the colours of websites, but certain colours are still popular regardless. Geographic location can have a greater impact on colours that are used in smaller quantities on websites, and most of the differences in colour palettes between countries are in those colours that play a minor role in colour palettes.

In terms of website types' colours, the hypotheses H2 and H3 were somewhat correct. Bank websites and medical websites have used a lot of more neutral and cool colours, while e-commerce websites have a wide range of colours. However, what all of these website types have in common is that white is the most used, gray is the second most used, and then at least two of the following are the most used: blue, light blue, or dark blue.

6.1 Things to consider

Although the answers from the study seem clear, there are some things to consider. For example, white is clearly the most used colour. This is because it is most often used as a background colour. To avoid overdoing the appearance of a website, there is usually a lot of background colour and fewer accent colours. White seems to be the default background colour, so to speak, even though some websites have used another colour for it.

Since the colour scheme of many corporate websites is derived from the company's logo or brand, when designing a website, it is not necessarily possible to choose colours based on aesthetics or colour preferences. In this case, the designer must find ways to use the desired colours in a way that makes the website overall pleasant.

Some websites may change their design within a year based on a theme. For example, e-commerce websites may increase their sales during holidays by emphasizing a theme in their design. In January, the website may be pink as Valentine's Day approaches, and in October, orange as Halloween approaches. Cultural differences may also affect these.

Finally, some websites had images whose colours had been changed to match the design by adding a colour layer. These could have influenced the results by increasing the amount of accent colour on each website. On the other hand, they

would have also increased the amount of other colours, because despite the colour layer, the images would have contained many other different colours that the designer did not necessarily directly intend to use. For this reason, these images have also been removed from the data.

6.2 Limitations

The research was limited by the low efficiency of the colour analysis tool. It took 20-30 minutes to analyze a single image, regardless of how many threads were assigned to work within the program. The tool might work faster if it were used on a more powerful computer. In this case, it would be more meaningful to study a larger amount of data.

The number of X11 colour keywords is very small compared to the number of HTML colours. This is why the colour analysis tool could make errors that were corrected manually. For example, in gradients the tool could make errors because there are many different colours between the closest colour keyword matches.

6.3 Future work

The most used colours on websites can be affected by the fact that a particular colour is used a lot on a single page. As the results of the study show, for example, the dark green on the Finnish medical website mehilainen.fi appears in both the most used colours on Finnish websites and the most used colours on medical websites, even though the colour is almost absent from other websites except mehilainen.fi. In such cases, a weighted average could be used to calculate the results.

The colour analysis tool could be modified to have fewer colour groups, so that colour keywords that are close to each other would belong to the same colour group. On the other hand, if the tool placed the colours it found into their colour groups

based solely on RGB values and not on colour keywords, there would be no error calculations. However, it could be difficult to define the boundaries between colour groups for RGB values.

7 Conclusions

The purpose of this thesis was to map a deeper understanding of how the properties and effects of colours can be utilized, how to design functional and attractive websites, how to choose colours for a website, and how to use colours in website design. This was carried out as a literature review by examining related works and previous studies. The aim of the research conducted in this thesis was to deepen knowledge about which colours are used on popular websites, and whether geographical location or the type of website affects what colours it contains. This was carried out with quantitative research methods, where the percentages of different colours were calculated from the homepages of the websites.

The thesis states that the colour design of a website is very important, as it affects many aspects of the website: appearance and aesthetics, usability and accessibility, as well as the website user's emotions and decision-making. The results show that the most commonly used colours on websites are white, gray, light blue, and dark blue. Moreover, the colours that are most commonly used on a website do not depend on the geographic location or type of website. On the other hand, the colours that are used slightly less on a website vary depending on the geographic location and type of website.

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Appendix A

Table A.1: The websites included in the study.

Country	Website type	Website
Chile	Bank	bancochile.cl
		bancoestado.cl
		transkbank.cl
	E-commerce	falabella.com
		mercadolibre.cl
		paris.cl
	Medical	clinicabupasantiago.cl
		intramed.net
		msdmanuals.com
Finland	Bank	danskebank.com
		danskebank.fi
		op.fi
	E-commerce	etuovi.com
		tori.fi
		verkkokauppa.com
		hus.fi

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Table A.1 – continued from previous page

First column	Second column	Third column
	Medical	mehilainen.fi
		paivamies.fi
Japan	Bank	americanexpress.com
		paypal.com
		rakuten-bank.co.jp
	E-commerce	amazon.co.jp
		kakaku.com
		rakuten.co.jp
	Medical	fdoc.jp
		m3.com
		msdmanuals.com
The Netherlands	Bank	abnamro.nl
		ing.nl
		rabobank.nl
	E-commerce	amazon.nl
		bol.com
		marktplaas.nl
	Medical	erasmus.nl
		radboudumc.nl
		umcutrecht.nl
	Bank	banki.ru
		sberbank.ru
		tinkoff.ru
		avito.ru

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Table A.1 – continued from previous page

First column	Second column	Third column
Russia	E-commerce	ozon.ru
		wildberries.ru
	Medical	invitro.ru
		rlsnet.ru
		vidal.ru
The United States	Bank	chase.com
		paypal.com
		wellsfargo.com
	E-commerce	amazon.com
		ebay.com
		walmart.com
	Medical	clevelandclinic.org
		hopkinsmedicine.org
		medscape.com