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Visual Heatmaps in User Experience Design

Attitudes and Adoption Factors

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ABSTRACT:
Visual heatmaps, illustrating user behaviour and areas of interest in a two-dimensional graphical representation, have become widely utilized in the user experience (UX) industry. When appropriately utilized, visual heatmaps efficiently summarize and communicate significant volumes of user data to designers. They can even have the capacity to reveal the focal points of users' attention across specific emotional and cognitive states. Despite their benefits, heatmaps are susceptible to misinterpretation stemming from deficient data analysis or lack of focus.

Recent academic research has primarily focused on the technical aspects and potential benefits of the technology used in generating visual heatmaps, with a specific emphasis on eye tracking-related technology being prevalent in scholarly articles. In contrast to prior studies, the research objective of this thesis is on the attitudes of UX designers toward this technology and the factors that impact its adoption. This objective is explored through three research questions. To answer these questions, qualitative data was gathered through ten semi-structured individual interviews with UX professionals. The collected data was analysed through thematic analysis.

The findings reveal that UX designers are aware of visual heatmap technology but often limit its use in UX design. Attitudes among participants revealed a spectrum, ranging from more cautious, negative and sceptical to positive optimism. Thematic analysis revealed designers with technical background to favour more established methods, while those with visual or humanistic education seeing value in visual format and experimental nature of heatmaps. Heatmaps were considered most effective when complementing findings from other UX tools. Limited resources pose a significant constraint in the utilization of heatmap technology. Interviewees highlighted that recent industry establishment, resulting partially from legislative changes in accessibility and privacy, have further reduced the necessity for experimentation in UX evaluation.

The relevance of the results of this thesis may vary depending on e.g. the organizational structure and project scope. As the thematic analysis was conducted during the interviews, the variability of code frequency was observed to stabilize by the end of the final interviews. This indicated successful data saturation and consistency. Given the extensive variety encompassing both the spectrum of technology associated with visual heatmaps and the visual format they present, future research could investigate the effectiveness of specific combinations of heatmap and evaluation methods. Furthermore, additional inquiry could aim to elucidate the reasons behind the attitude gap identified between the technical and humanistic domains in UX design.

KEYWORDS: Human-computer interaction, User-centred design, Usability, User experience, User interfaces, Eye tracking

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TIIVISTELMÄ:
Viime vuosina visuaalisten lämpökarttojen (eng. heatmap) käyttö on yleistynyt myös käyttäjäkokemussuunnittelussa. Lämpökartat tiivistävät suuria määriä käyttäjistä kerättyä tietoa havainnolliseen graafiseen muotoon. Edistyneimmillä lämpökarttatyövälineillä on kyky yhdistää tietoa käyttäjien keskittymisestä myös tunnereaktioihin, mikä voi olla arvokasta käyttäjäkokemuksen arvioinnin kannalta. Monista mahdollisuuksistaan huolimatta, lämpökarttojen tulkintaan liittyy riskejä, esimerkiksi puutteellisen analyysin tai tavoitteiden rajauksen osalta.

Aiempi tutkimus on keskittynyt pääasiassa visuaalisten lämpökarttojen tuottamiseen käytettyyn teknologiaan. Erityisesti silmänliikeseurantaan liittyvää teknologiaa käsittelevät tutkimukset ovat korostuneet. Toisin kuin aiemmissa tutkimuksissa, tämän opinnäytetyön tutkimusaiheena ovat käyttäjäkokemussuunnittelijoiden asenteet lämpökarttateknologiaa ja sen käyttöä kohtaan sekä käytön taustalla vaikuttavat tekijät. Aihetta lähestytään kolmen tutkimuskysymyksen kautta. Laadullinen tutkimusaineisto kerättiin haastattelemalla kymmentä käyttäjäkokemussuunnittelun ammattilaista. Aineisto analysoitiin käyttämällä temaattista analyysia.

Tulokset osoittivat, että suunnittelijat ovat tietoisia lämpökarttateknologiasta, mutta sen käyttö käyttäjäkokemussuunnittelussa on rajallista. Haastateltujen suunnittelijoiden asenteet muodostivat kirjon kielteisen varovaisesta positiiviseen optimismiin teknologiaa kohtaan. Teknisemmän taustan omaavat suunnittelijat luottavat alan vakiintuneisiin menetelmiin. Visuaalisen tai humanistisen taustan omaavat suunnittelijat näkevät arvoa lämpökarttojen visuaalisessa muodossa ja kokeellisessa luonteessa. Suunnittelijat pitävät lämpökarttoja tehokkaimpina tilanteissa, joissa niistä saatua tietoa käytetään täydentävästi muiden työvälineiden ja metodien kanssa. Rajalliset resurssit muodostavat merkittävän rajoitteen teknologian käytölle. Käyttäjäkokemusalan ja sen suunnitteluprosessien vakiintuminen on vähentänyt kokeilujen tarvetta myös käyttäjäkokemuksen arvioinnissa. Vakiintumiseen ovat vaikuttaneet osaltaan saavutettavuuteen ja tietosuojaan liittyvät lainsäädännön uudistukset.

Koska temaattista analyysia tehtiin haastattelujen aikana, koodien esiintymisvaihtelun voitiin havaita kyllääntyvän. Tämä viittaa tulosten luotettavuuteen. Tulosten merkitys voi kuitenkin vaihdella esimerkiksi suunnitteluprojektin laajuuden tai organisaatiorakenteen perusteella. Koska visuaalisiin lämpökarttoihin liittyvä teknologia ja lämpökarttojen visuaaliset ilmentymät ovat moninaisia, jatkotutkimuksissa tulisi selvittää eri lämpökarttateknologioiden ja -menetelmien sekä näiden yhdistelmien tehokkuutta. Lisäksi olisi arvokasta selvittää vaikuttaako koulutustausta asenteisiin teknologiaa ja sen käyttöönottoa kohtaan.

AVAINSANAT: Ihmisen ja tietokoneen vuorovaikutus, käyttäjäkeskeinen suunnittelu, käytettävyys, käyttäjäkokemus, käyttöliittymät, silmänliiketutkimus

Contents

Figures

Tables

Abbreviations

AI	Artificial intelligence
DT	Design thinking
ECG	Electrocardiography
EDA	Electrodermal activity
EEG	Electroencephalography
EMG	Electromyography
ECD	Experience-centred design
GDPR	General Data Protection Regulation
GSR	Galvanic skin response
GUI	Graphical user interface
HCD	Human-centred design
HCI	Human-computer interaction
UAT	User acceptance testing
UCD	User centred design
UI	User interface
UX	User experience
UXD	User experience design

1 Introduction

The user adoption process as well as user satisfaction are often influenced significantly by good usability and the overall user experience (UX) (Burger et al., 2018, p. 2; Georges et al., 2016, p. 4850; Guo et al., 2022, p. 797). In the past decade, visual UX heatmaps, that illustrate user behaviour in a two-dimensional graphical representation, have become widely used in the domain of user experience design (UXD) (Bojko, 2009, p. 30; Novák et al., 2023, pp. 1–17). In recent academic research, the discourse surrounding the use of visual heatmaps in UXD frequently diverts attention from their application to the underlying technology involved in their generation. Specifically, in interest related to eye tracking, there has been a significant increase in scholarly articles in recent years. (Novák et al., 2023; Schall, 2014; Yang & Qin, 2021). While these articles often examine the application and potential advantages or disadvantages of this technology, they typically do not address the attitudes of UX designers toward their utilization or the factors influencing their adoption in UX design (Novák et al., 2023). Thus, this thesis aims to explore the attitudes of UX designers regarding the use of visual heatmaps as well as the adoption factors and effective methods associated in their use.

In UXD, conventional assessment techniques, like questionnaires and interviews, depend mostly on self-reported information to evaluate users' affective and cognitive states (Georges et al., 2016, p. 4850). With these methods, a variety of response effects, such as social desirability, can regularly affect users (King & Bruner, 2000, pp. 79–103) and inventive and creative new approaches have been sought after in product development (Arhippainen & Pakanen, 2013, p. 80). Given that user experience is regarded by most UX professionals to be an evolving, context dependent, and subjective concept (Lallemand et al., 2015, p. 44; Law et al., 2009, p. 719), physiological measurement tools provide an opportunity to collect more objective data that complements subjective UX evaluations, thus offering valuable insight into user behaviour (Mussgnug et al., 2014, pp. 1–2).

Perspectives of UX designers regarding UX methodology have been previously explored by Law et al. (2009, 2014) and Lallemand (2015). Law et al. focused on how UX designers define their own field of practice and what are their attitudes towards UX measurements. The majority of UX designers considered the UX field to be dynamic, yet strongly linked to the human-computer interaction (HCI) domain and user centred design (UCD) practices (2009, p. 722). Lallemand et al. replicated and extended the survey conducted by Law et al. in 2008. The results of this study largely confirmed previous findings.

In regards with this thesis, a significant finding by Lallemand et al. was that the respondents preferred evaluating Momentary UX, experienced during usage, over Episodic UX, which is assessed after usage. There was consensus among respondents that UX assessment should occur "while interacting with an artifact." (2015, p. 44). Momentary UX is the time span where physiological tools, such as eye tracking software, are most likely to be utilized. Physiological measurement tools can provide continuous, instantaneous data during UX evaluation, while conventional evaluation methods may offer data only at particular moments in time (Georges et al., 2017, pp. 1–4; Zeng et al., 2009, pp. 39–58). The resulting visual heatmaps have the ability to summarize and convey large quantities of data quickly to the designer. Heatmaps can easily visualize various user interactions, ranging from eye tracking and attention fixation and duration to touch interaction and cursor movement (Bojko, 2009, pp. 30–32; Novák et al., 2023, pp. 1–17). UX heatmaps can even have the ability to display the location of users' gaze throughout particular emotional and cognitive states (Georges et al., 2016, p. 4850; Yang & Qin, 2021).

Despite the advantages of physiological measurement tools and visual heatmaps, according to Bojko (2009), visual heatmaps can “often be used incorrectly and for the wrong reasons”. Bojko asserts that issues may surface due to lack of appropriate data analysis or focus, and that "let's-track-and-see-what-happens" thinking is prevalent, even though this method has very limited usability (Bojko, 2009, pp. 37–39). While recognizing the utility of visual heatmaps in UXD, Bojko emphasizes the need to consider

that the appealing visuals and user-friendly appearance of visual heatmaps have the potential to overwhelm designers, thereby impeding their effective utilization in design processes. Furthermore, the technology used to generate visual heatmaps has been relatively expensive until very recently, limiting its predominant use to academic research (Georges et al., 2016, pp. 4850–4860).

Recent studies have suggested that when used correctly, it is possible to advance UX design even when using inexpensive and readily attainable visual heatmap tools (Burger et al., 2018, pp. 1–3, 16; Georges et al., 2016, p. 4850). As with any novel technology, it is important to establish effective practices to ensure the quality of user interactions and the resulting quality of products and services (Souza et al., 2022, p. 646). According to Hussain et al. (2018, pp. 1–31), the best way to obtain useful results in UXD is by attaining a triangulation of physiological, self-reported, and observational measurement techniques during UX assessment. In this way the data collected from one method can confirm findings from another or point towards the need for additional evaluation. In essence, it has been suggested that optimal outcomes in UX evaluation are achieved when a combination of various implicit, explicit, and observational methods are employed.

1.1 Research objective and methodology

The objective of this thesis is to explore the attitudes of UX designers regarding the use of visual heatmaps as well as the adoption factors and effective methods associated in their use. This research objective will be analysed by answering the following three research questions:

- RQ 1: What attitudes do UX designers exhibit regarding the use of visual heatmaps in UXD?
- RQ 2: What are the primary factors influencing the adoption or rejection of visual heatmaps in UXD?

- RQ 3: What are the effective methods that UX designers utilize when using visual heatmaps in UXD?

Research data is collected through interviews conducted with UX designers. By employing thematic analysis, a widely used qualitative method, the research explores the recurring themes and patterns within the interview data, contributing to the understanding of the role that visual heatmaps have in current UX design processes.

1.2 Structure of the thesis

This thesis is structured into six chapters. Following the introduction, chapters two and three provide the theoretical framework of this thesis: Chapter two examines the concepts of UX and UXD, while chapter three focuses on the physiological tools used in UXD and the visual heatmaps generated by the utilization of this technology. Chapter four offers a detailed overview of the research methodology and process employed in this research. Chapter five discusses the research findings and conclusions. Finally, chapter six provides a discussion of the thesis, along with an analysis of the validity and reliability of the research and proposes future research avenues related to visual heatmaps.

2 User experience design

Due to the multidisciplinary nature of UX that encompasses a variety of viewpoints ranging from psychological to commercial, UX can be viewed as a phenomenon, field of study and as a practice (Roto et al., 2011, p. 3). As this thesis focuses mainly on the application of visual heatmaps within the realm of UX design, the main focus is on UX as a part of a design practice, often referred to as user experience design (UXD) (Roto et al., 2011, pp. 22–23). This chapter of the thesis aims to define the fundamental concepts within the field, describe the relevant previous research related to the topic, and present UXD as an integral element among the field of contemporary UCD.

2.1 Defining user experience

As a result of the rapid shift from traditional industries to an IT-driven economy, in the field of Human-computer interaction (HCI), devices along with their features multiplied in form and complexity (Castells, 2023, pp. 940–941). The digital transformation, that occurred during this period, led to an increasing number of people relying on digital devices to perform various tasks and activities in their daily lives (Ho & Chung, 2020, pp. 13–15; Khan et al., 2023, p. 275), and technology "spread from the workplace to our homes and everyday lives and culture" (Bødker, 2006, p. 1). Around the Millennium, user experience became a popular topic of the third wave of HCI as a component of the User Centred Design (UCD) approach (Arhippainen & Pakanen, 2013, pp. 80–86; Hassenzahl & Tractinsky, 2006, pp. 91–97; Roto et al., 2021, pp. 1–26).

Aligning with the principles of UCD, UX gained a footing as a counterpart of the dominant and task-related usability paradigm, while early UX researchers aimed to identify more holistic key features that contribute towards people having a 'good' user experience, (Hassenzahl & Tractinsky, 2006, p. 91). UCD is an iterative design approach and philosophy, that prioritizes users' requirements throughout the design process. In order to understand and fulfil these needs, designers engage with users through a variety of UCD

research and design methodologies (Abras et al., 2004; Interaction Design Foundation, 2016). UCD is closely related to the concepts of Design Thinking (DT) and Human Centred Design (HCD), as they share a common objective of prioritizing user needs and experiences in the development of goods and services. While UCD and HCD are viewed as mindsets, DT is defined as an approach that combines users with business and technology. In HCD mindset all people are seen as possible customers of a product, while in UCD a certain target set of users is the focus of the design process. At the core of each of these concepts are the user, problem solving an iteration (Göttgens & Oertelt-Prigione, 2021; Kohli, 2022). The structure and relationship of the concepts of UCD, HCD, and DT is depicted in Figure 1.

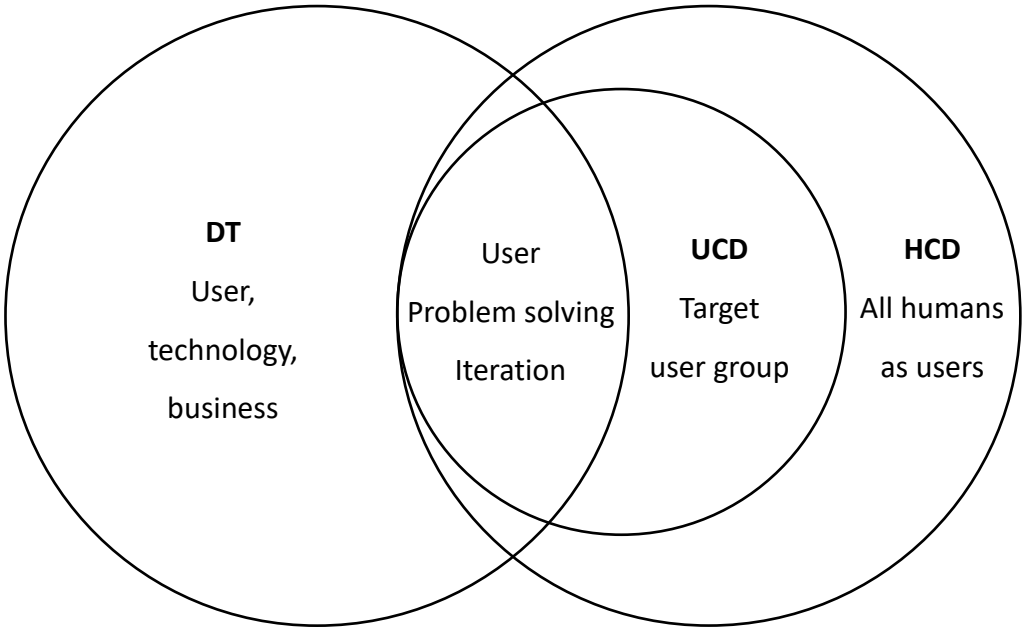

Figure 1: DT, UCD and HCD (Kohli, 2022).

Donald Norman is often cited as being the first person to use the phrase "user experience" in the beginning of 1990s when he was employed by Apple (Lialina, 2016; Norman et al., 1995, p. 155). Norman wanted to emphasize the value of usability and UCD, and thereby created the classic definition for UX as encompassing “all aspects of the user’s interaction with the product: how it is perceived, learned, and used.” (Norman, 1999 as

cited in Xu, 2012, p. 172). The second wave of HCI had replaced traditional methods with more proactive approach, e.g. participatory design workshops, emphasising groups using multiple applications in work settings, establishing communities of practice. It highlighted frameworks like situated action and distributed cognition. The third wave extended the scope of HCI to include a variety of new elements revolving around human live, incorporating more emotional, artistic, and cultural aspects into the design process. In terms of methodology, it adopted "more exploratory take-it-or-leave-it approach", moving away from user-centricity in order to look for inspiration from use (Bødker, 2006, pp. 1–3).

Especially in the beginning of the Millennium, there was a notable surge of interest in both academic and business domains surrounding the concept of UX. The degree of interest was so significant that there were assertions UX could simply be a buzzword (Arhippainen & Pakanen, 2013, p. 80). In response, concerted efforts have been made to advance UX research, teaching, and practice through the delineation of UX (Roto et al., 2011, p. 4), leading to the exploration and discourse of various definitions and research frameworks (Lallemand et al., 2015, p. 35; Law et al., 2009, pp. 719–728). The significance of human experiences has continued to escalate, as we have entered a "post-materialistic world, where people are investing in experiences rather than in material possessions." (Roto et al., 2021, p. 1). Furthermore, the perpetual evolution and expansive nature of the digital landscape have profoundly influenced the field of user experience, accentuating its relevance (Novák et al., 2023, p. 1).

Although UX is now a commonly used and accepted concept in the field of HCI, it is noteworthy that there is still no complete consensus regarding its definition (Buono et al., 2020, pp. 6901–6914; Lallemand et al., 2015, p. 35). Some have disputed the benefits of UX over more well-established notions like usability, ergonomics, and user acceptance testing (UAT) (Barcenilla & Bastien, 2009, pp. 311–331). UX designers themselves have also concurred that the concept of UX is as multidimensional and challenging to define, yet concurring with the notion that the field of UX is part of the HCI domain and should

adhere to the principles of UCD (Lallemand et al., 2015; Law et al., 2009). The following chapter aims to present different facets UX.

2.2 The facets of UX

One of the most widely utilized frameworks in UX practice is the UX Honeycomb, devised by Peter Morville (Mansson et al., 2020, p. 2; Morville, 2004). This model was further adapted by Katerina Karagianni (2018), to present the practical aspects more clearly (Figure 2). In recent years, the utilization of the adapted model by Karagianni has become common, particularly in writings produced by industry professionals within the field. The honeycomb model enumerates seven elements that UX designers should take into consideration. Morville placed these elements inside a honeycomb, with six hexagons surrounding a central hexagon (Morville & Sullenger, 2010, pp. 33–38; Morville, 2004). After the adjustments by Karagianni, the facets of the UX Honeycomb model are findable, accessible, usable, desirable, credible, useful, and valuable; users are interacting with the product by thinking, feeling, and using (Mansson et al., 2020, pp. 1–17).

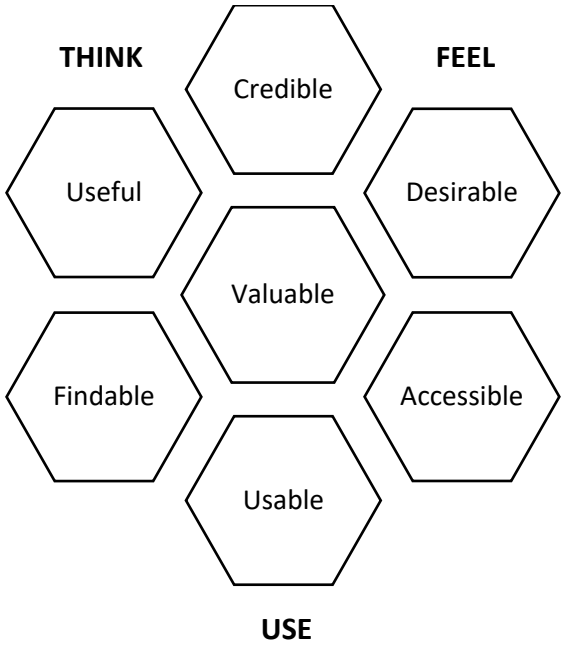

Figure 2: UX honeycomb (adapted by Karagianni, 2018).

While the Honeycomb model offers a valuable tool for the practical tasks of UX designers, its utility may be limited due to the multidimensional and dynamic nature of the concept of UX.

Another well-known model is the Facets of UX by Hassenzahl and Tractinsky (2006). In early 2000's, Hassenzahl and Tractinsky paid attention to the momentum of the conversation around UX and sought to chronicle the evolution of research related to UX. They claimed user experience to be a "strange phenomenon" (2006, p. 91), as it was rapidly being adopted as a key feature in the field of HCI, yet it was elusive in its definition. Hassenzahl claimed UX to represent a significantly expanded and separate viewpoint concerning the quality of interactive products (Hassenzahl, 2008, pp. 11–15). This also makes UX "a key competitive factor for product development." (Davila et al., 2023, p. 3). Others argued for an integrative model, that would take into account the different roles of usability, ergonomics, accessibility and UX (Sauer et al., 2020).

Hassenzahl and Tractinsky stated that "Perhaps the most intriguing question is how the overall quality or the 'goodness' of an interactive product is formed." (Hassenzahl & Tractinsky, 2006, p. 93). To answer this question, Hassenzahl and Tractinsky concluded that UX encompasses three distinct facets that contribute to it, although none of them singularly captures the complete nature of UX. These facets were visually represented in a Venn diagram with three circles (Figure 3).

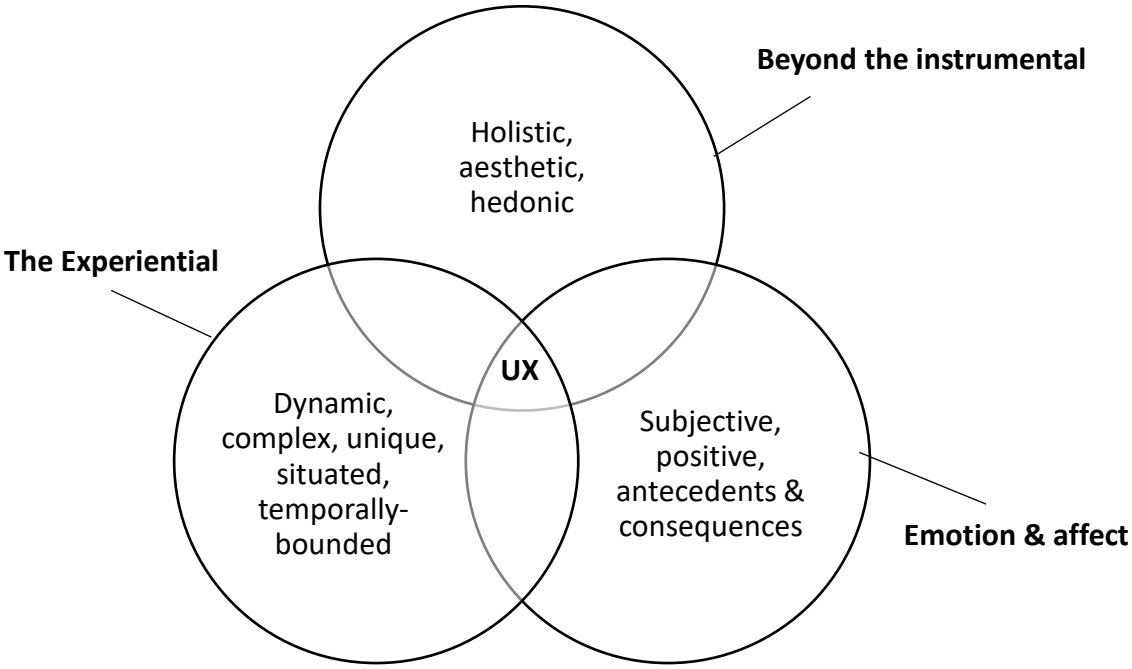

Figure 3: Facets of UX (adapted from Hassenzahl & Tractinsky, 2006, p. 95).

Firstly, there is significance in holistic, aesthetic, and hedonic elements, that are not necessarily instrumental for task completion by users. However, these *beyond the instrumental* factors such as beauty, surprise, and intimacy hold intrinsic importance in how users perceive quality, considerably enhancing usability and fostering a more inspiring and favourable user experience (Hassenzahl & Tractinsky, 2006, pp. 92–93).

Secondly, human decision-making is heavily depended upon *affect and emotions*. While the primary objective of HCI traditionally aimed at avoiding frustration and dissatisfaction, UX expands this objective further to not only prevent negative experiences but also emphasize fostering positive emotional outcomes such as enjoyment and fun from user interaction (Hassenzahl et al., 2010, pp. 353–362; Hassenzahl & Tractinsky, 2006, p. 93).

Thirdly, according to Hassenzahl and Tractinsky, "*the experiential* perspective . . . emphasizes two aspects of technology use: its situatedness and its temporality." (2006, p. 94). Experiences are distinctive, formed through a blend of complex and dynamic factors, including users' temporally bound personal mood and goals, alongside the product's

state during usage. All these factors are interconnected, mutually influencing the final UX (Hassenzahl & Tractinsky, 2006, pp. 94–95). The distinct attributes, time perspective, and the nature that differentiates UX will be discussed in the following chapter of this thesis.

2.3 Distinctiveness and time spans of UX

The concept and definition of UX underwent further development in 2010, when thirty UX researchers and practitioners convened at Dagstuhl to explore various approaches, modelling techniques, and standardization efforts related to UX. The purpose of the seminar was to produce a User Experience White Paper, forming a better consensus on the fundamental ideas of user experience. The paper states that UX can be comprehended as a phenomenon, an area of study, and as a practice. It sought to delineate that while usability and user interface (UI) design are both fundamental elements to UX, they represent distinct disciplines. UX distinguishes itself by not solely revolving around technology but rather focusing on more human-centric aspects (Law et al., 2009, p. 719; Roto et al., 2011, pp. 1–26; Lallemand et al., 2015, p. 36).

The white paper also acknowledged the fact that UX is strongly linked to a time perspective. Users may have pre-existing experiences that influence subsequent user experiences indirectly. Likewise, user experience can continue to evolve indirectly after the user experience. It is advisable for a UX designer to consider the time spans of UX during the design phase in order to identify key areas that may need more of the designers attention. The white paper categorized four different time spans of UX (Figure 4): Anticipated, Momentary, Episodic and Cumulative UX (Roto et al., 2011, pp. 5–9). Each time span delineates the nature of the associated user experience and the internal processes occurring during these distinct time spans.

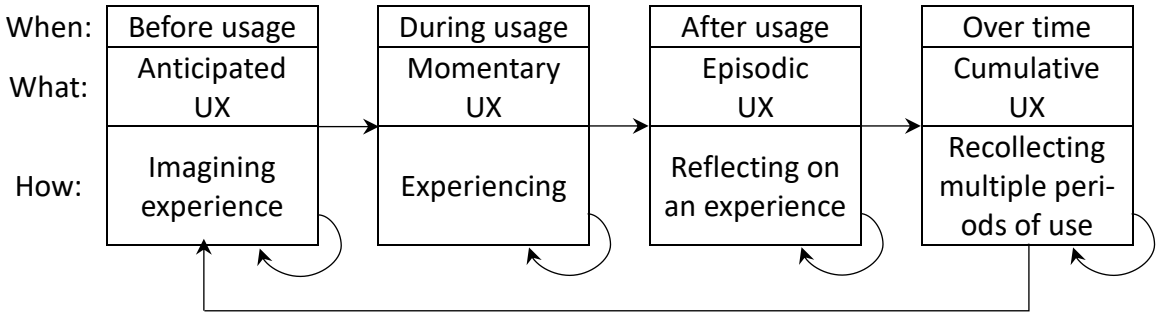

Figure 4: Time spans of UX.

Concentrating on momentary UX during the usage can offer insight into an individual's emotional reactions concerning the specifics of the user interface (Roto et al., 2011, p. 6). Momentary UX is the time span where physiological tools, such as eye tracking software, are most likely to be utilized. At this stage, it is valuable to note that extending the interaction to encompass longer durations can reveal significant information about the overall user experience. For instance, a strong negative reaction during the early stages of use might lose significance if the user experience continues over an extended period, and the user later achieves better success. Considering this aspect, UX design and evaluation during the momentary experiences presents distinct challenges (Roto et al., 2011, pp. 1–12).

2.4 UX design as a practice

As previously described in this thesis, UX is a dynamic and subjective concept, leading to the absence of a singular correct approach in UX design and process. UXD as a practice and profession is therefore also a dynamic and subjective concept. However, there are also many aspects of UX on which there is widespread consensus among UXD professionals. E. g., a functional user experience that is focused on the principles of UCD processes is largely seen as a key factor in successful user adoption (Burger et al., 2017, pp. 1–17; Lallemand et al., 2015).

As humans have become more critically reliant on technology and devices, the emphasis on user experience design has led to notable progress in usability, accessibility, and inclusivity (Patrick & Hollenbeck, 2021, pp. 360–381; Wanka et al., 2023, pp. 177–180). UX designers are confronted with the challenge of crafting user experiences that are not only functional but also inclusive and attractive, all while being motivational and conducive (Hegemann et al., 2023, pp. 1–5).

Perspectives of UX designers within their own field have been explored in at least two comprehensive international surveys. These perspectives hold particular intrigue for this thesis, given that the research subjects are professionals working in the field. The first survey was conducted by Law et al. in 2009, followed by a replicated study by Lallemand et al. in 2015. In these studies, individuals working in the field as consultants, managers, and practitioners as well as researchers and students were asked questions. Their opinions were sought on statements related e.g. to the definition and nature of UX. In this thesis, I focus on the research findings of Lallemand as they are more recent and the sample size of their research was larger compared to the earlier study by Law et al. from 2009. However, I also examine how the results have evolved since the Law et al. study conducted in 2009. The 2009 study is of interest also because its largest proportion of respondents (48) operated in Finland (Law et al., 2009, p. 721).

In their responses, industry professionals corroborated many previous studies within the field. The respondents agreed that temporal, contextual, and user-related variables are all important factors that influence UX, hence UX has a dynamic and subjective nature. However, differences in perspectives were also identified. Various background criteria, such as language, education, role in UX, as well as years of experience in UX, influenced the respondents' decisions on how to define UX. More experienced professionals were less likely to feel a need for a precise definition of UX in comparison to those with less experience in the field (Lallemand et al., 2015, pp. 38–47).

One of the key findings related to this thesis was that “Momentary UX (while interacting with an artifact) was favoured against Episodic UX (evaluated after usage).” (Lallemand et al., 2015, p. 46). As stated in the previous chapter discussing UX time spans, this is the time frame wherein physiological tools are most likely to be utilized. On the other hand, it is important to note that a more comprehensive customer or user “journey” thinking has gained more prominence in recent years (Cockbill et al., 2022, pp. 1915–1926; Roto et al., 2021, pp. 1–26). Although longitudinal study of user experience is laborious, Kujala et al. (2011, pp. 473–483) have introduced the UX curve method, which enables the examination of user experience concerning products already available on the consumer market. The data collected through this method can be utilized in the design of a new version or an entirely new product.

2.5 UX methods and evaluation

As emotions arise from conscious cognitive interpretations of perceptual-sensory responses, UX can be seen as a cognitive process that can be modelled and should be measured (Law et al., 2014, pp. 526–541). The field of HCI, from which UX has emerged, encompasses various methods of collecting information about human interaction. Some of these methods originate more from engineering sciences, while others stem e.g. from the humanities. UXD methods, tools, and measurements can vary significantly and are context-dependent, influenced by factors such as project objectives, requirements, resources, and preferences. The inherent nature of UX also entails the continuous evolution of methods and tools within the field, which can pose a challenge to designers and other practitioners in the field (Lallemand et al., 2015, pp. 35–48; Matthews et al., 2012, pp. 1219–1228; Q. Yang et al., 2018, pp. 585–596).

According to Hussain et al. (2018, p. 1) “UX is measured using different constructs related to usability (perspicuity, efficiency, etc.), user perception (stimulation, dependability, novelty, etc.), and human emotional reaction using various methods.” As UX is considered a challenging and dynamic concept that involves measuring human experiences

such as happiness and surprise, it is evident that consequently, the measurability of UX and the methods employed in UX practices are also subjective and context dependent (Law et al., 2014, pp. 526–541). UX related interactions are typically a mixture of "well-observable user actions and cognitive processes, which are considerably more difficult to detect." (Mussgnug et al., 2014, p. 1).

The research findings from the research by Lallemand et al. (2015) did not reveal significant differences regarding whether UX should be approached through qualitative or quantitative means (2015, p. 43). The findings of Law et al. (2014) implied that qualitative input allows for the creation of novel design concepts, while quantitative measures can be effective in persuading decision makers to accept adjustments to problematic designs (Law et al., 2014, pp. 526–541). According to UX practitioners, usability and UCD are unquestionably key cornerstones of user experience. Most respondents of the survey by Lallemand et al. agreed with the statement that usability is a "necessary precondition for good UX". While Lallemand et al. do not directly challenge this viewpoint upheld by industry professionals, they suggest that a positive user experience could manifest despite challenges in usability. Their implication stems from the recognition that elements linked to UX, such as aesthetics or hedonic qualities, might significantly influence the perceived usability (Lallemand et al., 2015, p. 43).

In 1998, Jakob Nielsen and Don Norman founded The Nielsen Norman Group (NN/g), which has emerged as a leading consulting firm in the field of user interface and user experience design. In addition to providing consulting services, the company also offers training programs and brings together professionals in the field (Nielsen Norman Group, n.d.). In 2022, experts Kelley Gordon and Christian Rohrer from NN/g developed a model to assist designers in determining the appropriate UX research method for different situations. This model consist of a three-dimensional framework where 20 often used UX research methods are placed based on three defining factors: attitudinal vs. behavioural, qualitative vs. quantitative and the context of product use (Gordon & Rohrer, 2022).

Based on this framework, usability testing and physiological measurement tools and the resulting heatmaps are seen to align more with the behavioural aspect, illustrating what people do, rather than the attitudinal aspect, which pertains to what people say. Concerning qualitative and quantitative methods, these methods lean more towards qualitative approaches, addressing questions related to "why and how to fix." (Gordon & Rohrer, 2022).

In UX related literature, there is often reference to what is known as UX maturity (Buis et al., 2023; Lallemand et al., 2015). In addition to the previously addressed framework, the Nielsen Norman Group has introduced “the 6 Levels of UX maturity” model, that assesses UX maturity though six levels. In this model, UX maturity encompasses various elements, including the organization's understanding of UX principles, integration of UX procedures into product development workflows, allocation of resources for UX research and design, alignment of UX objectives with overarching business goals, and the organization's ability to monitor and enhance UX outcomes over time. An organization with a high level of UX maturity demonstrates sophisticated UX processes and capabilities, leading to better-designed products and services, improved customer satisfaction, and ultimately, profitable operations (Pernice et al., 2021).

The pinnacle of UX maturity is achieved at level six, where the organization operates in a user-driven manner, characterized by a dedication to UX at all six levels, resulting in exceptional user centred design outcomes (Pernice et al., 2021). To attain this level, there is a need for a profound understanding of users. Hussain et al. emphasize the perspective that by solely relying on any explicit and observational methods, UX designers are not able to understand the emotional introspection of the user and therefore might not fully “uncover the true user emotional experience." (Hussain et al., 2018, p. 2). Since UX methods, particularly physiological measurement tools and visual heatmaps, are at the core of the research in this thesis, they will be examined in the next chapter.

3 Physiological measurement tools and visual heatmaps

The previous chapter of this thesis delved into the multifaceted and multidimensional nature inherent in the concept of UX and UX design. It is evident, that employing a triangulation of UX methodologies, incorporating explicit, observational, and implicit methods, is more likely to yield successful outcomes. Therefore, in addition to traditional UX approaches, such as self-report questionnaires and user behaviour evaluation, the utilization of physiological measurement tools, along with the consequential data they generate, offers crucial supplementary information (Davila et al., 2023, pp. 3–17).

Over recent years and decades, both the quantity and significance of devices, along with the range of daily tasks accomplished through their use, have significantly increased in both number and diversity (Castells, 2023, pp. 940–941). Additionally, in the field of UX design, one of the most significant changes in recent years has been the rise of mobile devices and applications, with user numbers on mobile surpassing those of traditional desktop devices (Guo et al., 2022, pp. 795–808).

As a consequence to this digital transformation, the GUIs of devices have evolved to become increasingly diverse and frequently more complex. In order to gather this information, UX designers have at their disposal a variety of tools for web analytics, but one of the key aspects to understand is how users interact with the designed graphical user interface (GUI). Good interface design aims to ensure the high quality of the user experience (Souza et al., 2022, p. 646). Visual heatmaps, which are graphical representations depicting user movement and interaction on the interface, are designed specifically for this analytics purpose (Aviz et al., 2019; Bojko, 2009; Souza et al., 2022).

Visual complexity of a user interface can have a significant impact on usability (Guo et al., 2022, p. 795) and there is a significant consensus among UX practitioners that good usability is a crucial component when creating a positive user experience (Buono et al., 2020, pp. 6901–6914; Lallemand et al., 2015, pp. 35–48). These changes present

challenges for user experience designers, who must attempt to assess user experience for increasingly diverse audience and device spectrum.

In this chapter, I will present physiological tools used to gather information from the interactions of users, as well as the end results, the visual heatmaps. Due to the scope of the thesis, I will focus on presenting those physiological measurement tools that have the ability to create two-dimensional visual heatmaps, namely eye tracking and touch related interaction tools. Physiological measurement tools are presented in chapter 3.1. while visual heatmaps are the focus of chapter 3.2.

3.1 Physiological measurement tools

A wide range of different physiological measurement tools, devices, and software are available for creating UX heatmaps, that help UX designers to have a clear comprehension of possible issues and key areas of the user interface (Aviz et al., 2019; Souza et al., 2022). These tools can range from affordable smartphone applications to more expensive biometric sensors, that can measure a mixture of physiological and cognitive responses (Hussain et al., 2018, pp. 1–31; Novák et al., 2023, pp. 1–17; Valliappan et al., 2020, pp. 1–12). These still emerging technologies are increasingly becoming integral part of novel product design and manufacturing in industry 4.0 paradigm (Borgianni et al., 2018, pp. 192–196; Peruzzini et al., 2017, pp. 806–813).

The most commonly used physiological tools, and the information generated from their use, are presented Table 1 (Georges et al., 2020, pp. 1–9; Hussain et al., 2018, pp. 1–31; Novák et al., 2023, pp. 1–17; Peruzzini et al., 2017, pp. 806–813). Biometric sensors serve as valuable tools to detect cognitive and emotional states, including user motivation, emotional arousal, stress levels, and visual attention. Conventionally, these instruments have found primary use in medical research, focusing on monitoring physiological metrics like heart rate (HR), electrocardiogram (ECG), electroencephalogram (EEG), and electrodermal activity (EDA). Predominantly these measurements have aimed at

investigating diseases or potential anomalies in human health. In recent years, the utilization of physiological tools in design has expanded significantly due to specialization in design as well as the widespread downsizing and cost reduction of many of these technologies (Peruzzini et al., 2017, pp. 806–813).

Table 1: Commonly used physiological tools.

Physiological tool	Device	Detected parameter	Description
Eye tracking	Eye tracker	Visual attention	Monitors eye movements and gaze fixation
Electroencephalography (EEG)	EEG Machine	User engagement, emotional state	Records brainwave activity
Electrocardiogram (ECG)	ECG Machine	Stress levels, emotional arousal	Measures heart activity
Galvanic Skin Response (GSR)	GSR Sensors	Stress level, emotional arousal	Measures skin conductance during emotional response
Electromyography (EMG)	EMG Machine	Muscle tension, facial expressions	Tracks muscle activity and response (e.g. hands or face)
Respiration Rate Monitoring	Respirometer or spirometer	Relaxation, stress response	Measures breathing rate and volume

One of the most difficult tasks in UX evaluation is to understand how the user genuinely feels when using an application, service, or system. What emotional and cognitive processes does a user undergo when interacting with a designed service, such as a GUI. Even though it is often possible and quite easy to monitor external body signals for emotion recognition, it is important to note that interpreting these signals requires expertise (Yang & Qin, 2021, p. 162198).

Additionally, the diversity of available tools yet again poses a challenge to UX designers: What hardware and software are the best for each specific usage scenario and experiment. Perhaps, this challenge is also one of the key reasons why Bojko states that the “let’s-track-and-see-what-happens” has been a popular approach, even though it has very limited true value in UX evaluation (Bojko, 2009, p. 37). If resources are unlimited, there is an opportunity in design to experiment and take risks, enabling the discovery of novel and unexpected findings.

The aforementioned technology enables UX designers to observe a variety of user behaviours, but the metrics most ideal to be used in UXD and presented by visual heatmaps are touch interaction, mouse movements and clicks in addition to eye tracking, and gaze attention, fixation and duration (Bojko, 2009, p. 30; Davila et al., 2023, pp. 3–17; Novák et al., 2023, pp. 1–17).

Hussain et al. propose that best results in UX evaluation are achieved, when a triangulation of observational, self-reported, and physiological measurement methods are employed. The data collected through one method in this manner can validate results obtained from another method, or it may indicate the need for further research. Additionally, inside these methodologies different blends can be used. E.g. eye tracking can be used in combination with EEG signals (Hussain et al., 2018, pp. 1–31).

3.1.1 Eye tracking

Traditional and rather simple eye tracking tools swiftly inform designers about where users look or focus during the user experience (Georges, Courtemanche, Sénécal, Léger, Nacke, & Pourchon, 2017, pp. 4850–4860). However, this may not always offer significant benefits to the designer, as it does not answer the question “why is the user focusing here” (Bojko, 2009, pp. 30–39; Georges et al., 2016, pp. 4850–4860). Georges et al. have pointed out, “the main obstacle to the use of physiological and behavioural signals remains their reduced informative value when they are not specifically associated with user behaviour or interaction states.” (2016, p. 4851). They concur, that for both academic research as well as design purposes, the most intriguing outcome could be achieved by combining various physiological measurement tools.

The purpose of eye tracking technology, as the name suggests, is to determine how user's gaze behaves during the user experience. Through eye tracking, it is possible to identify, for instance, the specific areas where the user's gaze focuses for the longest period, how the user reads text or navigates through a user interface. With more precise eye

tracking technology, it is feasible to track aspects e.g. changes in pupil size during usage (Novák et al., 2023, pp. 1–17). Eye tracking technology can also be integrated with other physiological measurements that were listed earlier in Table 1. Consequently, this integration allows for more detailed insights into UX, such as information about the impact of specific visual contexts on stress levels or arousal (Hussain et al., 2018, pp. 1–31).

While eye tracking technology has been in use for some time, recent technological advancements have introduced more accessible, lower-entry-barrier technology to the field (Peruzzini et al., 2017, pp. 806–813). Studies have indicated that even with more affordable technology, it has been possible to gather results that aid in identifying potential issues in UX design (Burger et al., 2018, pp. 1–17)

According to Novak et al. (2023, pp. 1–17), who conducted an extensive review of eye tracking research, "The use of eye tracking technology is a well-studied and functional approach to the evaluation of user experience." (p. 13). Their review also indicated a significant increase in the volume of research related to eye tracking over the past decade (p. 6). Approximately half of the studies selected by Novak et al. utilized eye tracking as a primary component within the UX evaluation workflow. A quarter integrated eye tracking within a more comprehensive evaluation approach, often in conjunction with various heuristics and interaction data. Most studies focused on assessing digital product UX, with external eye tracking devices commonly used. A smaller portion explored eye tracking in physical product design, mainly in automotive and medical industries.

According to the review by Novak et al. (2023), the most commonly used eye tracking devices were the so-called standalone eye tracking sensors or cameras, which could be freely positioned depending on the needs of the test situation. Tobii company devices were the most utilized, which Novak et al. attributed to their user-friendly nature. While these devices may still be costly, Novak et al. noted, as previously mentioned in this work, that more affordable technology is becoming increasingly accessible. Although the more economical technology still lags behind in several aspects, it is continuously evolving.

These newer and more affordable technologies can already be employed in simple ways, for instance, using a smartphone, by using its built-in camera functionality. Some of the technology also utilize open-source software (Novák et al., 2023, pp. 6–9).

3.1.2 Touchscreen interaction and cursor tracking

In addition to eye tracking, heatmaps generated by tracking touchscreen interactions or cursor movements can offer UX designers analytics and insight about user behaviour. As previously mentioned in this thesis, the number of mobile users has surpassed that of traditional desktop users (Guo et al., 2022, pp. 795–808). As smartphones and tablets heavily rely on touch interactions, utilizing visual heatmaps generated through touchscreen interaction can be beneficial when evaluating the user experience of these devices.

The user experience on a mobile devices notably diverges from that on a traditional desktop devices due to distinct and limiting factors such as screen size (Yang & Qin, 2021, pp. 162197–162213). Considerations related to user features, including left-handedness, hand size, and finger length in relation to the mobile screen dimensions, can significantly influence the overall user experience (Yang & Qin, 2021, p. 162209). In addition to these physical factors, UX designers must also possess the capacity to discern behavioural, emotional, and cultural user contexts, which include significant considerations like the fact that user gaze precedes touch. Both gaze and touch are also closely linked to human cognitive processes, including memory (Weill-Tessier & Gellersen, 2018). In order for UX design work to be of high quality, it is imperative that UX designers contemplate these variables in the design of user experiences (Guo et al., 2022, pp. 797–799; Weill-Tessier et al., 2016).

Often, one advantage of the data collected through cursor tracking, touchscreens and smartphones is that, unlike the more typical eye tracking methods, this data can be collected through many non-intrusive and unobtrusive methods (Yang & Qin, 2021, p.

162198). Due to their greater availability and affordability, mobile devices are utilized by a broader user base, that can result in more diverse data. Additionally, the update frequency of mobile devices is typically higher than that of more traditional display devices, resulting in more up-to-date applications (Krafka et al., 2016, p. 2176).

While the information collected from touchscreen interaction and cursor tracking sources can sometimes be used directly, ideally it should be used to complement and enrich insights gained from eye tracking or other UX methods (Ahrens, 2020, p. 434; Cegan & Filip, 2017; Park et al., 2011). According to Souza et al. (2022, p. 648) “Mouse and keyboard monitoring can provide a more complete view of the user experience under high cognitive load such as decision making and for carrying out tasks.”

3.2 Visual heatmaps

To enhance user experience and make necessary changes to improve the usability of the graphical user interface (GUI), there are various tools available. Visual heatmaps, which display user actions in a two-dimensional graphical manner, have gained popularity in recent years. Visual heatmaps can take a variety of form. For instance, utilizing eye tracking allows the creation of fixation count and gaze duration heatmaps. Visual heatmaps depict areas of interest (AOI) using hot-to-cold colour patterns, visually displaying the regions that garnered the most user engagement (Davila et al., 2023; Jurkonytė, 2021; S. Khan, 2024).

Heatmaps are extensively utilized due to their ability to efficiently condense copious amounts of data into a visually comprehensible format. Heatmaps have proved to be very effective owing to humans' innate inclination towards visual perception and our rapid understanding of colour significance rooted in cultural familiarity. For example, the gradation of colours from red denoting heat to cooler shades of blue can be recognizable without the need for explicit instructions (Engebretsen et al., 2020; Schloss et al., 2018, pp. 1–17). UX designer can benefit from visual heatmaps in several ways. They do not

only identify potential issues with the design but can also clarify various stages and objectives of the design process to different stakeholders. They in turn may lack the time for deep engagement with the design (Schall & Romano Bergstrom, 2014, pp. 67–70).

Many heatmap tools streamline data manipulation: they serve as repositories for diverse forms of data collected from various sources, allowing for multifaceted processing and synchronization. This empowers designers to swiftly discern, for instance, the specific demographics or samples represented on the map (Georges et al., 2016, p. 4850). The main types of visual heatmaps used in UXD are described in Table 2 (sourced from Bojko, 2009; Davila et al., 2023; Jurkonytė, 2021; S. Khan, 2024; Muhammad, 2017).

Table 2: Main types of visual heatmaps used in UX design.

Type of heatmap	**Description**
Click heatmaps	Derives data from user clicks on a GUI. Number of clicks indicate higher user engagement. One of the most commonly used heatmap tools.
Scroll maps	Depict the scrolling behaviour of website visitors, indicating how far user engage and scroll down though the website or other interface. Scroll map can indicate where users might lose interest.
Hover heatmaps	Indicate how users have moved in the GUI, usually by tracking touch on touchscreen or mouse and cursor movement.
Eye tracking heatmaps	Illustrates where the gaze of the user has been directed and how it has moved within the interface.

The different categories of heatmaps can further include distinct subcategories. For example, in eye tracking, visual heatmaps can be derived through absolute gaze duration or relative gaze duration heatmaps. The term movement heatmap can be used to describe several heatmaps derived from actions such as interface scrolling or cursor movement and clicks. Further subcategories exist within these subcategories as well (Caposino, 2023; S. Khan, 2023; Moran, 2017), and visual heatmaps can be categorized in various ways depending, e. g., on the perspective of design or the desired outcome of the design process (Jurkonytė, 2021; S. Khan, 2024; Muhammad, 2017; Sukumar, 2023). In recent years, there has been an increase in visual heatmaps produced by artificial intelligence (AI) (Jurkonytė, 2021).

4 Research method and process

This chapter of the thesis presents the methodology and process of the research, including the methods used for data collection and analysis. The purpose of this thesis was to understand the utilization of visual heatmaps by UX designers, examine their attitudes towards the heatmaps and related technical tools, and to assess the proficiency with which UX designers interpret data derived from visual heatmaps.

To gather the perspectives of the designers, qualitative data was gathered through ten, semi-structured interviews. This number of interviewees was deemed sufficient for ensuring the validity of the results (Guest et al., 2006; Nowell et al., 2017). Questions and topics were prepared in advance, but there was also room for improvised questions arising from the interviewee's response (Myers & Newman, 2007, pp. 2–26). Thematic analysis was used to analyse the interview transcripts.

4.1 Qualitative interviews

According to Myers & Newman, “the qualitative interview is the most common and one of the most important data gathering tools in qualitative research” (2007, p. 3). They assert that qualitative interviews allow us to explore the underlying aspects of various phenomena and research problems. Indeed, qualitative methodology is particularly employed in situations where the subject of study is complex and intricate (Tong et al., 2007, p. 349). Given that the topic of this thesis deals with a complex phenomenon, this method is well-suited for the subject matter.

When utilizing qualitative methodology, it is crucial to be mindful of specific common pitfalls often associated with this approach (Kallio et al., 2016). The primary challenges frequently arise from the social interaction that is the essence of the qualitative interviews, hence there is significant room for human errors. Common pitfalls include lack of time, lack of trust as well as the artificial nature of the interview, given that the

interviewer and interviewee are most often complete strangers to one another (Myers & Newman, 2007; Tong et al., 2007).

According to Myers and Newman, merely being aware of the potential issues is advisable (Myers & Newman, 2007, pp. 3–5). For ensuring quality and avoiding errors, it is also recommended to utilize established frameworks and methodologies in conjunction with the method (Tong et al., 2007). To address possible challenges, Myers and Newman have established seven guidelines and a dramaturgical model for conducting qualitative interview in the field of IS related research (Myers & Newman, 2007, p. 11). These guidelines and the dramaturgical model serves as the framework for the interviews conducted in this thesis.

To maintain openness and flexibility regarding the discussion and topic, interview themes were structured beforehand, but the specific questions varied in each interview depending on the direction the interviewee took the conversation. Interview themes are depicted in Table 3 and examples of interview questions are presented in appendix 1.

Table 3: Interview themes.

Theme	**Description**
UXD as a profession	Perspective on what UX and UXD entail.
UX tools and methods	UX tools and methods in use.
UX heatmaps	Experience and perspectives on heatmaps.
Future of UX	Perspective on the future of the industry.

In the dramaturgical model, the entirety of the qualitative interview is seen as a theatrical performance, complete with actors, a script, and props. The interviewer's objective is to cultivate a relaxed and empathetic atmosphere, in which the interviewee feels at ease to openly disclose information. The interviewer should aim to highlight the interviewee's personality and thoughts, keeping their own personality and thoughts to a lesser prominence during the interview. The interviewer functions somewhat like a director, striving to showcase the interviewee's brilliance in their performance. To accomplish this, the interviewer should strive to clearly articulate the interview's purpose,

while avoiding overly steering toward a specific personal agenda. To foster openness in the interview, the interviewee should not feel any fear of embarrassment or the possibility of being taken advantage of (Myers & Newman, 2007, pp. 12–14).

To ensure that the interviewees understand the purpose of the interviews, the objectives of the thesis were communicated already in the interview invitations. These objectives were reiterated at the beginning of each interview. The participants were recruited via mailing lists, social media, and word of mouth. To identify additional interviewees, insights were sought from individuals already interviewed, employing the snowballing method (Myers & Newman, 2007, p. 14). The “stage”, in which the interviews were conducted remotely, was Microsoft Teams. Conducting interviews remotely presents its own challenges in creating a comfortable atmosphere; however, it may also offer advantages, as the interviewees may feel most comfortable in their own familiar and informal environment. Additionally, it was possible to find interviewees regardless of their physical location (Iacono et al., 2016, pp. 1–15; Myers & Newman, 2007, pp. 1–26).

Both the interviewer and the Interviewees are seen as the actors as well as the audience in the dramaturgical model. According to Myers and Newman, the interviewer should demonstrate interest in the interviewee and their thoughts, striving to show as much empathy as possible. To accomplish this, special attention was given to active listening during the interviews for this thesis. The interviewer also aimed to identify aspects of the interviewee that were left unspoken: their attitude toward the themes emerging in the interview, various gestures, and facial expressions. For this reason, it was crucial that during the remotely conducted interview, in addition to the microphone, the camera was also activated throughout the interview. This was instructed to the participants in advance. The interviewer dressed appropriately for the occasion and took the time to thoroughly understand the interviewee's background, role, and organizational context before conducting the interviews (Myers & Newman, 2007, p. 13–15).

Each participant underwent a single interview session, which lasted a maximum of approximately 60 minutes. The semi-structured interview method offered the essential flexibility for the interview, while also enabling the effective coverage of key topics within a well-defined timeframe for each interviewee (Gill et al., 2008, pp. 201–216). The interviewees presented a diverse group of UX designers, who already had at least some relevant work-life experience in the field of UX design. It was not deemed necessary for the designers to have extensive experience in the use of visual heatmaps, but this was seen as a benefit for the depth of the interview. The diversity of the interviewees was a goal that was achieved successfully. The interviewees represented well different genders, age groups, and levels of experience. This diversity optimized the triangulation of subjects (Myers & Newman, 2007, p. 17).

4.2 Thematic analysis

According to Braun and Clarke, thematic analysis is the first technique in qualitative analysis that researchers should familiarize as it teaches several basic skills. It is also a highly flexible method, which presents both an advantage and a challenge for the researcher. Precaution should be exercised to prevent the method from being completely unstructured (Braun & Clarke, 2006, pp. 77–101). One way that was used to avoid total disorder was through the use of the interview themes. This ensured that each interview covered the same issues, while also allowing for more improvised and in-depth questions. The six phases of thematic analysis presented by Braun and Clarke (2006) were used to identify the main themes and create connections between them. These phases are presented in Table 4.

Table 4: Phases of thematic analysis (Braun & Clarke, 2006, pp. 77–101).

Phase	Description
1. Familiarizing yourself with your data.	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes.	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.

Phase	Description
3. Searching for themes.	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes.	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes.	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report.	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Upon the completion of the interviews, each interview was transcribed using the automatic transcription tool in Microsoft Teams. These transcriptions were made to facilitate coding and thematic analysis of the material. The interview transcripts were organized using the qualitative data analysis software NVivo 14. It was possible to review and rearrange the codes and interview material multiple times through NVivo, during the approximately one-month-long interview period.

In the first stage of the analysis, the interview material was transcribed into Word-files, anonymized, and read at glance in order to create preliminary conclusions. This stage was conducted immediately after each interview had been concluded. After the first three interviews, the material was imported to NVivo, where preliminary codes were created, following Braun and Clarke's instructions for the second phase of the analysis. Subsequently, material from each interview was imported into NVivo and coded immediately after the interview. In the initial stages of the analysis, there were nearly a hundred codes in NVivo.

From these codes, it was possible to proceed to the third phase, which involved identifying preliminary themes. At this stage, codes were organized into multiple levels. Thematic analysis was further facilitated using Excel in addition to NVivo, and proceeded to phases four and five, which were carried out cyclically throughout the interviews. The aim was to adhere to the idea presented by Braun and Clarke, that thematic analysis is

a “more recursive process, where movement is back and forth as needed, throughout the phases” (Braun & Clarke, 2006, p. 86).

Writing is a pivotal component of the thematic analysis. Hence, it was an ongoing activity as the research progressed. It was not a process that occurred only after the completion of all research work, as in statistical analyses, but rather coding commenced already once the initial interviews were completed. This allowed for an organic emergence of ideas and potential themes as the work unfolded. The final themes were named during stage six, conducted during the writing of the final report. In the final report, there were ultimately three overarching themes.

Through the analysis, three main themes emerged, the first pertaining to the attitudes of UX designers, the second to adoption factors, and the third to effective methods. These themes further divided into eleven subthemes. Regarding attitudes, the themes also divided further into six different subthemes. Final themes are presented in Table 5.

Table 5: Themes and their concluding chapters in the thesis.

Main theme	**Subtheme**	**Further subtheme**	**Chapter**
Attitudes of UX designers towards utilization of visual heatmaps	Raincloud attitude	Scepticism in utilization	5.2.1.1
		Anxiety over resources	5.2.1.2
		Fear of drawing false conclusions	5.2.1.3
	Sunshine attitude	Appreciation of visual representation	5.2.2.1
		Enthusiasm with new methods and technology	5.2.2.2
		Curiosity towards surprising results	5.2.2.3
Influential factors in heatmap utilization	Strength of existing design principles, tools, and platforms		5.3.1
	Limited resources		5.3.2
	Privacy concerns		5.3.3
	Objectivity of heatmaps		5.3.4
Effective methods	Use as part of a triangulation		5.4.1
	Verifying and validating existing results		5.4.2
	Seeking solutions for complex design cases		5.4.3
	Gaining stakeholder approval		5.4.4
	Enhancing customer journey design		5.4.5

Within the spectrum of designer attitudes, scepticism, anxiety, and fear were observed, forming the "Raincloud attitude" theme. Contrarily, an appreciative attitude, enthusiasm, and interest towards visual heatmaps and their utilization constituted the "Sunshine attitude" theme. Concerning adoption factors, the subthemes included trust in existing methods and tools, resource constraints, privacy concerns, and the objectivity of heatmaps. As for effective methods, the themes encompassed integration of heatmaps as part of a triangulation of various tools and methods, verification and validation, uncovering solutions in unorthodox and complex design cases, instrumentality in seeking stakeholder approval, and incorporation into customer journey design. The results of the thematic analysis will be presented in more detail in the following chapter.

5 Results

This chapter of the thesis presents the results of the qualitative interviews and thematic analysis. Chapter 5.1. describes the interviewees, their experience, education, and background at a general level. The following chapters are then divided according to the research questions of this thesis. Chapter 5.2 focuses on the attitudes of UX designers towards heatmap tools. Chapter 5.3 addresses the factors that influence the utilization of heatmap tools in UX. Finally, chapter 5.4 discusses methods and practices related to heatmap tools. The research questions of the thesis are answered by reflecting on the results emerging from the interviews within the theoretical framework of the study, which was introduced in the preceding chapters two and three of this thesis. The results are presented through the utilization of anonymized direct quotations (P1–P10).

Ten individuals participated in the interviews. Interviews were conducted during January and February 2024 using Microsoft Teams. During the interviews, both the interviewee and the interviewer kept their cameras on at all times, although in one interview, the video connection was interrupted due to technical issues. Technical difficulties like connectivity problems and audio or video quality issues were experienced in some of the interviews, but for the most part, these issues were avoided and they only lasted for a short period of time. With the exception of one interview, all interviews were conducted in Finnish, although many interviewees used English terms extensively alongside Finnish when discussing technology and methods in the UX industry. However, the anonymized quotations in this work were largely translated from Finnish to English.

5.1 Participants background

The interviewed individuals primarily possessed extensive and varied experience in a range of UX design-related tasks. There was variation in the relevance of their work experience, field of education, current industry, and length of their career. The participants

of the study, along with their anonymized code and background information, are detailed in Table 6.

Table 6: Interview participants and their background.

Code	UX experience	Main field of study	Industry	Use of heatmaps
P1	Under 10 years	Technology	Software	Limited experience
P2	Under 10 years	Humanities	Consulting	Inactive use
P3	Under 10 years	Humanities	Consulting	Active use
P4	Under 10 years	Business	Media	Limited experience
P5	10 to 20 years	Technology	Internet	Inactive use
P6	10 to 20 years	Humanities	Internet	Active use
P7	10 to 20 years	Technology	Consulting	Limited experience
P8	Over 20 years	Technology	Software	Active use
P9	Over 20 years	Humanities	Consulting	Inactive use
P10	Over 20 years	Humanities	Consulting	Inactive use

Each of the ten interviewees had at least some insight or experience with visual heatmaps. Three interviewees were actively using heatmaps in their current work. Four had utilized heatmaps in previous positions but were currently inactive in their use. Three interviewees had limited experience with heatmaps, meaning they understood what heatmaps are either through their education or past work experience, but they did not possess any practical experience of their use in UX.

5.1.1 Education and work experience

Given the relatively recent emergence of the term user experience, the educational backgrounds of the more experienced participants did not typically encompass formal training specifically related to UX design. Instead, many respondents pursued further education in UX later in their careers, while others acquired relevant knowledge and skills through work experience. This is evident in example (1).

> (1) At the turn of the millennium, there were no systematic or advanced design courses available in my university. -- Instead, it has been more of a learning process through work experience, trial and error. (P8)

For many participants, particularly those with a background in humanities, entry into the field occurred through initial work positions where their interest in technology or digital tools and methods became more prominent than before. This is evident in example (2).

> (2) At first, I was involved in more traditional design-related work within product development. Then, I ended up working specifically in digital channels. The opportunity arose, as others perceived the work as a necessary evil at the time. I noticed that these were actually projects where I could do much more design work, meaning I could genuinely design processes and think about content. (P3)

Those interviewees, who had entered the UX industry more recently, possessed more specialized training tailored to UX related tasks and methodology, e.g. usability testing and eye tracking. Nevertheless, the majority of the interviewees had been drawn to the industry due to their personal interests and, to some extent, fortuitous circumstances. This again reflects the dynamic nature of the industry, where stabilization and establishment has only begun to manifest more recently (Hassenzahl et al., 2010; Roto et al., 2011; Varsaluoma, 2018).

5.1.2 Perception of the UX industry and its recent development

The dynamic nature and more recent stabilization of the industry, discussed in the previous chapter, was echoed by most interviewees, particularly those with more experience. By experiencing a variety of roles and positions in the industry, they had firsthand experience of the industry's long-term development. One of the interviewees described how the change has occurred slowly and as a bottom-up process. This is evident in the example (3).

> (3) User-centred design has developed tremendously over the past twenty years -- It has been a process of bottom-up collaboration, so that even internally, there is understanding that attention must be paid to users. (P9)

This progress was seen as a positive phenomenon by the respondents. Despite this improvement, almost all respondents believed that there is still need for development regarding industry recognition and UX maturity. Even the more experienced UX designers

had experiences where their expertise in design had been questioned in an unprofessional way by stakeholders. Often this opposition stemmed from the individual personal preferences of the stakeholders. The attitude towards UX and UCD in general varied greatly depending on the broader corporate culture. One of the respondents stated that the UX maturity level in Finnish companies falls within the range of 2 to 3. This is evident in example (4).

> (4) Considering the Nielsen Norman Group's UX maturity model, it's unlikely that Finnish organizations are above levels 2 or 3, indicating that there is still much work to be done in this regard. (P5)

Many interviewees noted that UX and UCD have emerged as topics that are raised even by clients during projects, and they are increasingly recognized for their positive impact on sales. This is evident in example (5).

> (5) It is something I have been striving to emphasize strongly within our company, so user-centricity is a key value proposition that we discuss with our clients in new sales or account development. (P6)

Nearly all respondents recognized the phenomenon addressed by Cockbill et al. (2022, pp. 1915–1926), regarding the ongoing development in the tech industry towards holistic service journey thinking, which brings UXD closer to service design (SD). Some respondents had experienced a shift in their job descriptions, transitioning from their previous role as UX designer to service designer. While some viewed this development with mild scepticism, majority believed that it is of no importance, as long as user experience is taken into account as a fundamental design principle and cultivated in high quality.

5.2 Attitudes of UX designers towards utilization of visual heatmaps

The first research question of this thesis examined the attitudes exhibited by UX designers regarding the use of visual heatmaps in UXD. Thematic analysis revealed a spectrum of views and attitudes among the interviewed designers, ranging from more negative attitudes and scepticism to more positive attitudes and optimism regarding the

utilization of heatmaps. The classic idiom "Is the glass half empty or half full?" could reflect these perspectives. In the thematic analysis of this study, different aspects and extremes of attitudes have been described using the terms "Raincloud attitude" and "Sunshine attitude." These terms aptly depict attitudes, as they include reflection and expectation with regards to potential conditions and concerns.

Through the analysis, it was observed that only one interviewee positioned themselves entirely on the negative end of the spectrum, while one designer leaned entirely towards the positive attitude side. The remaining interviewees represented a mixture of different factors and themes on different parts of the spectrum. The following chapters 5.2.1 and 5.2.2 describe the results and analysis related to these attitudes.

5.2.1 Raincloud attitude

During the thematic analysis, more cautious, sceptical, and negative attitudes were categorized under the theme of Raincloud attitude. Nine out of ten interviewed designers exhibited at least some level of this negative and more cautious attitude towards heatmap tools and their utilization. Designers with a more technical education seemed to lean slightly more towards scepticism regarding the utilization and value of heatmap tools. They preferred the use of existing tools and felt confident in the use of well-established UX methods. In regard to this attitude, three subthemes emerged during the thematic analysis, which are described in the following three subchapters.

5.2.1.1 Scepticism in utilization

The predominant concern raised by the interviewees centred around the uncertainty regarding the appropriate timing, methodology, and phase within the design process on when to effectively utilize different heatmap tools. As example (6) demonstrates,

designers attitude could initially be quite optimistic towards heatmap technology, but later turned more sceptical when they analysed the utilization in greater detail.

> (6) When I first read about these tools, I initially thought they could be a really cool thing. But already as I read more, I was sceptical about them. Like, why and to what extend to use them? And because UX designers find it sometimes hard to understand even what UX is, it's important to have focus on what truly matters. (P1)

On several occasions, interviewees suggested that their knowledge about heatmap tools might be inadequate or outdated. Even if this was not explicitly stated by the interviewee, there appeared to be a prevailing inclination towards the notion that satisfactory outcomes could be achieved without the utilization of any heatmap tools. Therefore, there was reluctancy to invest any time into exploring the potential use of heatmap tools.

The interviewees cited numerous commonly used alternative data gathering and design methods, e.g. user surveys and interviews, user shadowing, and simulation-based design. Many believed that, at best, heatmaps could offer only marginal additional insight of users in comparison to these methods. At worst, they feared that the use of heatmaps could lead to erroneous conclusions or result in inefficient use of time and resources. These concerns are evident in examples (7) and (8).

> (7) If the wrong tool is used, incorrect conclusions are drawn. If one lacks experience or hasn't seen how the selected tools work, it often feels like user research is conducted just for the sake of it. I strongly believe that the hypotheses we want to investigate should be kept firmly in mind, and the methodology should be chosen based on how cost-effectively and accurately we can obtain the right answers to those questions. (P8)

> (8) In large part what was observed from the Hotjar mouse movement and click data had already been known from server statistics. There wasn’t any significant surprises emerging from there. (P5)

There was variation in the tools used to generate heatmaps. Most experience was associated with visual heatmaps generated from the data of cursor movement or touch interaction, while experiences with heatmaps derived from eye tracking were less common. Experiences with eye tracking tools were typically gained during formal education, although five participants had also applied eye tracking in their work projects.

The interviewees who had more experience with heatmaps also expressed criticism regarding their utility. In terms of tools used for gathering heatmaps and other user behaviour and insight analytics, Google Analytics and Hotjar were most frequently mentioned. Currently, two of the interviewees were incorporating heatmaps generated from eye tracking into their work projects. The diversity in technology and methods was also a leading cause of anxiety over resources, a theme analysed in the next chapter.

5.2.1.2 Anxiety over resources

UX designers must possess knowledge in a variety of tools and methods and strive to comprehend the requirements of the customer thoroughly. Understanding the needs of the customer can often be one of the most challenging parts of a design project, especially in the initial stages of the assignment. According to the interviewed designers, the clients and other stakeholders may not always explicitly know what they want. The client e.g. may only have a vague idea of the desired outcome and a list of problems to be addressed, which the UX designer and design team set out to solve. Often, the challenge arises when the resources and implementations required to address the problems surprise the client and do not align with their expectations.

Due to the complexity of the problems to be solved, throughout the interviews, participants discussed a range of technical tools that they must be able to use. While many hesitated to name specific technology, they underscored that the dynamic nature of a UX designer's toolkit means that technical tools can evolve and change rapidly over time. This is evident in example (9).

> (9) The tools depend entirely on what the project is and at what stage it is in. – For example, currently I use Figma for drawing, but these tools change every year. (P10)

The extensive variety of technology, tools, and methods combined with their dynamic nature as well as difficulties with stakeholder communication can cause pressure,

especially for less experienced UX designers. This pressure of making mistakes, losing efficiency and possibly wasting resources was highlighted in some of the interviews. If designer employs a method or technology that does not significantly benefit the project, there is a risk of deviating from the intended direction, wasting resources, or obtaining incorrect or irrelevant results. This situation is evident in example (10).

> (10) We have sometimes had workshops underway, and already during them we realize that we are not getting any useful answers. I have thought that I cannot use any of these answers, there is no point in them. (P1)

In addition to the complexity of the work and technology in use, the uncertainty surrounding the appropriate utilization of heatmap technology, discussed in chapter 5.2.1.1, also raised the fear that limited design resources might be wasted. It is noteworthy, that the efficiency mindset was not only driven by performance pressures derived from stakeholders but was also frequently adopted by designers themselves, especially those with a more technical background. As is evident from example (11), they felt that dedicating time and resources to experimentation is not worthwhile.

> (11) Cost-benefit analysis must be considered. – what insights can be gained from this? Regarding eye tracking, the cost of implementing such a system, acquiring data, and determining the necessary repetitions for reliable data are all factors to be considered. How can I justify the costs to a client, when I am myself sceptical about its worthiness. (P7)

The concern over resources was voiced by both designers actively utilizing heatmaps and those with inactive use. It is important to note that the concern over resources was not solely related to the use of tools, methods, and technology, but often arose in interviews while participants contemplated the general trend towards increased efficiency in work life.

5.2.1.3 Fear of drawing false conclusions

Half of the interviewees mentioned in their responses that designers might derive false positives and inaccurate conclusions from heatmaps. Consequently, they at least

partially echoed Bojko's (2009, p. 31) perspective that the attractive and intuitive visual presentation of heatmaps can hinder designers from critically evaluating the information they convey.

This line of thinking can be understood as a fear, in the sense that respondents were not always able to directly verbalize or justify why such a situation could arise. While the interviewees expressed concern, they lacked direct experiences where instances of false positives had manifested. This fear and the associated uncertainty around it is illustrated by example (12).

> (12) I see that the use of these tools might lead to false positives or otherwise inaccurate results. Yeah, well, I actually don't know much about this, so I can't say for sure, but I would guess so. (P1)

Given the numerous mentions on the issue of False positives, it is clear that the notion should be regarded as a real problem rather than only an attitude. Most of those who raised the issue had several years of experience in the field and were highly educated. Their assessment was based on an informed perspective, even if they did not have direct experience with the situation.

Several interviewees also mentioned that overly positive thinking can arise from the fact that the technology in use, especially in laboratory-level user testing, is often so novel that it captivates both the test participants and the testers. One interviewee recounted a situation where the visual allure of heatmaps became very apparent. The company's management and client showed such high levels of enthusiasm for the technology and its outcomes that, according to the interviewee, this enthusiasm might have impeded the stakeholders' judgment regarding the accurate analysis of the results. Many other interviewed designers echoed this account by sharing their experiences regarding how enthusiastically especially biometric sensors and eye tracking technology was initially embraced. This is evident in example (13).

> (13) In my company the thinking was like ‘we love eye tracking -- because it tells us everything about user behaviour’. I left from that experience thinking like

> ‘everything's amazing’. But afterwards I learned more by myself and thought maybe I shouldn't trust all the bits of this technology. (P2)

One reason for somewhat more sceptical attitudes could also be negative experiences with heatmap technology. One of the more experienced interviewees noted that heatmap technology has evolved significantly in recent years, and as a result, not all UX designers may necessarily be aware of the new opportunities it offers. Interestingly, the same visual appeal that was criticized as a negative aspect in heatmaps was also seen as perhaps their greatest asset. The following chapters will present these positive attitudes and emotions regarding the utilization of heatmaps.

5.2.2 Sunshine attitude

The positive attitudes and emotions towards the use of heatmap technology was named as Sunshine attitude in this thesis. Nine out of ten interviewed designers exhibited at least some level of this positive attitude towards heatmap tools and their utilization. Those with background in humanities showed slightly more optimistic views towards the use of heatmaps.

The attitudes and emotions that leaned more positively towards heatmaps mentioned the potential of vivid visuals and the exploratory, unexpected nature of the results derived from the utilization of heatmaps. They also highlighted aspects concerning visual aesthetics, user-friendliness and intuitiveness as well as the objective nature and novelty of heatmap technology. Additionally, the technology was perceived as fostering inspiration and the idea of experimentation in a constructive manner. Its capacity to stimulate and engage design teams, user testing participants, and other stakeholders was also acknowledged.

5.2.2.1 Appreciation of visual representation

Many of the respondents concurred with Bojko's (2009, pp. 30–39) perspective, that the potency of heatmaps stems from their ability to convey extensive datasets swiftly and effortlessly in visual format. Heatmaps utilize intuitive colouring, ranging from warm reds to cool blues, and at least in western culture people have learned to associate these colours with temperature from a young age.

Several tools and technologies employed in generating heatmaps are readily adaptable with relatively small barriers to entry. This is particularly true concerning technologies associated with cursor movement and click as well as touch interaction heatmaps, which are frequently integrated and available in leading data analytics and customer insight tools. Heatmaps convey a highly tangible and visually accessible message, with outcomes often obviating the need for extensive analysis and justification. This makes them easily applicable in certain situations where there is a need to discuss and justify UX decisions with stakeholders who are not themselves industry professionals. These perspectives are evident in example (14).

> (14) From my perspective, heatmaps are quite straightforward tools to offer to clients because the message they convey is so concrete and visual. Plus, they can be created using relatively lightweight tools and processes. (P6)

As comprehending and interpreting heatmaps can be accomplished effortlessly and with minimal cognitive exertion, there is no necessity to acquire new skills specifically for understanding their visual representation (Bojko, 2009, p. 30). This feature, along with the potential for rapid internalization of information, was underscored by the interviewees, as is evident in example (15).

> (15) In my experience, almost the same insights can be derived from other forms of data analytics. But with heatmaps, it's perhaps about hundred times faster to internalize data. They serve as an effective visualization tool. (P8)

Several respondents, who emphasized the visually derived benefits of heatmaps, had received education related to visual art, or they had interests and hobbies related to

visual pursuits. When questioned about the nature of UX design, they more frequently employed terms such as invention and creation.

One of the most experienced interviewees, who had also served as a team leader, perceived it as a significant advantage when design teams are comprised of both more technical and more visually minded designers. The differences in educational and work experience backgrounds can manifest in projects as distinct mindsets and ideas of methods, as is evident in example (16).

> (16) A more technical team member thinks more about the technical aspect, that it works, that user is able to move from page one to page two. People with more visual background think more about the human as a whole and consider why is the user there in the first place. (P10)

Other interviewees who raised the theme of diversity were in agreement that it is a key factor in successful UX projects. This theme is further discussed in chapter 5.4.1.

5.2.2.2 Enthusiasm with new methods and technology

Most of the interviewees displayed at least some level of curiosity and interest towards heatmap technology. This enthusiasm was frequently apparent prior to the interviews, evidenced by pre-interview messages, where interviewees expressed their fascination, curiosity and excitement about the topic of UX related visual heatmaps. Often at the beginning of the interviews, the interviewees remarked that the topic was intriguing, and this was also a key reason why they wanted to participate in the interview.

Enthusiasm with heatmaps was particularly evident among those interviewees who had previous experience with heatmaps from e.g. their studies in university, but who had not utilized the technology in recent years. Thus, they could perhaps recognize the opportunities offered by the technology and were interested in learning about its recent advancements and new possibilities. This enthusiasm for possible experimentations with heatmap technology is evident in example ((17) It would be fascinating to see if

there are any areas where we could improve. What could I do differently to ensure that we haven't become entrenched in thinking that something is just fine as it is?17).

> (17) It would be fascinating to see if there are any areas where we could improve. What could I do differently to ensure that we haven't become entrenched in thinking that something is just fine as it is? (P9)

The possible use of various biometric sensors and usability testing laboratories was perceived as particularly exciting. This excitement may stem from the fact that such technology represents the future and presents exciting new opportunities for its users. This is particularly crucial in creative work, where staying abreast of emerging technologies and leveraging them to enhance the design process is essential.

Several designers interested in heatmaps highlighted the technology's potential as an inspiring and motivating factor for not only UX designers themselves but other stakeholders as well. Concerning stakeholder communication, the utilization of heatmaps will be elaborated upon in chapter 5.4.4.

5.2.2.3 Curiosity towards surprising results

Two of the interviewees, who held a more positive attitude, demonstrated a curious mindset towards physiological tools, biometric sensors, and their outcomes, the visual heatmaps. This attitude was strongly associated with the idea that the results might reveal unexpected insights that the designer alone or the entire design team had not been able to anticipate.

For instance, tracking emotional load in a test situation solely by observing participants without the help of any technology can be challenging for UX designers. One of the interviewees had first-hand experience with such a situation. As the example (18) demonstrates, eye tracking technology made it possible to obtain information on the user's cognitive load.

(18) From the eye tracking you could get the blink rate which is a proxy for concentration and cognitive load. -- Having different sort of data pieces like that was very useful to see what needed a lot of concentration. – This helps you to understand the things you're putting in front of people. (P2)

Another interviewee recounted a scenario in user testing, where eye tracking yielded unexpected outcome that shifted the focus of designers from a previously examined aspect to this surprising result. The interviewee asserted that this illustrated the capability of eye tracking and heatmap technology to unveil unforeseen results that had not been predicted by other means. This instance is illustrated by example (19).

(19) In one eye tracking study related to investigating how to position headings in a form, the major finding was unexpectedly that users focused most on the submit button. A significant portion of users observed the button at the beginning of filling out a 6-7 field form to ensure they could submit it. To me, it was an amazing finding and demonstrated that the answers do not always directly relate to what you were originally trying to study but to something else. (P8)

The utilization of heatmap technology in the context of form design was a matter that arose in several interviews. Forms are discussed in more detail in chapter 5.4.3 of this thesis.

5.3 Influential factors in heatmap utilization

The second research question of this thesis concerned identifying the factors influencing the adoption or non-adoption of heatmap technology in UX design. Several different factors emerged in the qualitative interviews, but the thematic analysis revealed that four factors were notably reiterated in the responses. Three of these factors were deterrents to adoption, while one was in favour of adoption. These factors are presented in the following chapters of this thesis, where first, the three inhibiting factors are discussed, followed by the supporting factor, i.e. the objectivity of heatmaps.

5.3.1 Strength of existing design principles, tools, and platforms

For most respondents, the primary factor in not using heatmaps was the confidence in achieving good results in UX design with the methods and tools already in use. Consequently, there is no perceived need to adopt new tools unless specifically requested, for instance, by the client. According to this study, client requests for heatmaps are rare, as only one interviewee had experience with a situation where a client had explicitly requested heatmap analysis.

Based on the thematic analysis, it appears designers as well as the clients' own design principles have become more robust in recent years. This could be a result of the stabilization of UX and UCD fields, as well as the improved understanding of UX processes by the clients. Consequently, the clients comprehend the activities that can be conducted at various stages of the design project, such as user testing, and they also have a greater insight into execution. These phenomenon minimize or even eliminate the need for experimentation in user testing, as illustrated in example (20).

> (20) It is kind of like once you haveve learned the design principles and know how to create a good user interface, you don't need to test it again because you already know what will happen, how the user behaves. (P9)

However, one designer also described a situation where the client had a very high design maturity, yet they had been surprised by the usefulness of heatmaps when they had been utilized in the design project. This experience was quite recent, dating back to 2022. The situation is illustrated by example (21).

> (21) I have worked with quite large clients and listed companies. -- They have had a high design maturity and design team, as well as data on user experience -- and licenses for various tools, and a pretty high understanding of what -- can be used to improve the user experience. So, they know what to demand. Still, the power of heatmaps -- I think it came as a bit of a surprise to the client at that point, like, hey, this is actually so useful. (P3)

The findings from the interviews suggest that heatmaps have not gained widespread adoption within the design principles of most clients. Concurrently with the strengthening of the design principles and the increased awareness among clients, platform

technology has evolved and become mainstream. A significant portion of available solutions are now based on existing platforms, that are tailored to fit the needs of clients. These developments are illustrated by example (22).

> (22) Talking about platforms -- they provide ready-made templates, good categorization structures, navigation for a wide range of data and files, and so on. It has become so basic -- all this grouping and UI structure, so they are really established. Design principles have evolved so much -- They have come with a bang. I would say that in the last five years alone, many of our clients have created their own design system. -- So that kind of random design has certainly decreased a lot in recent years. (P9)

In the case of platforms, the responsibility for original UX design and user testing falls mainly on the platform provider, and during the customization phase, there may no longer be a need to utilize more experimental technology in UX design. It is worth noting that confidence in existing tools and design principles is linked to the uncertainty on when and how heatmaps should be used, which was analysed in chapter 5.2.1. These two factors intertwined in the responses of the interviewees.

5.3.2 Limited resources

Several interviewees identified limited resources as a significant obstacle to the adoption of heatmap technology or other more experimentative methods and technologies. Resources were identified to encompass both time and financial limitations. Interviewees often cited resource constraints to be the primary factor hindering the utilization of heatmap technology. This is illustrated by the example (23).

> (23) It is very much a resource issue. -- In addition to money, a lot of time has to be spent when you need to involve a third party, the provider of the heatmap service. (P3)

Often, UX designers also lack autonomy in resource allocation decisions, as financial determinations may originate from other stakeholders, or the framework related to finances and resources may not be very flexible. The workload associated with justifying the adoption of a new tool may be too burdensome amidst other work responsibilities.

In these situations, team leaders bear significant responsibility for being well-versed in the appropriate use and experimentation of technology, ensuring that the design teams make informed decisions regarding when and how to utilize it effectively. Limited resources and their allocation towards matters that were more irrelevant to designers' core responsibilities, e.g. bureaucracy, were factors causing frustration among designers. This is illustrated by the example (24).

> (24) We have a large organization -- Increasingly there are various corporate bureaucracies, ongoing changes, and other things that may not interest me the most. And perhaps I have had some frustration at times with things like the slow pace of technological updates. (P4)

Nevertheless, the notion of limited resources as a deterrent to utilizing heatmap technology was also contested, particularly by those actively engaged in its use. They found the technology to be relatively affordable and straightforward to implement. Furthermore, some interviewees highlighted that heatmap technology might already be integrated into existing analytics tools, but amid the pressures of work this can be overlooked and underutilized opportunity.

5.3.3 Privacy concerns

The concern for user privacy emerged frequently in the interviews, and in many cases, it had been a barrier to the adoption of technology or had caused designers to contemplate its use. Interviewed designers raised concerns regarding the responsible use and ethical considerations surrounding user testing situations, essentiality of the collected data, along with users' understanding of how their information is gathered on e.g. websites and mobile applications.

An experienced designer and active user of heatmap technology remarked that the technology remains safe and beneficial as long as it is used to gather only essential information for UX design purposes and ethical considerations are taken into account. This consideration is illustrated by example (25).

(25) Heatmap technology is safe as long as the data collected from individuals is not misused. For example, in a test, a participant may identify strongly as a heterosexual but their movements indicate otherwise. Such information, when it does not align with the objectives of the study, is irrelevant and must be disregarded and not stored anywhere. (P8)

Some of the interviewees mentioned that their organization's policies regarding user privacy have become so stringent that the use of heatmap technology is practically impossible. This was attributed to be a direct consequence of the European Union's general data protection regulation (GDPR) and the subsequent national legislative amendments. This legislation significantly defined the methods for collecting and storing user data, while also enhancing regulatory oversight on the subject. This is illustrated by example (26).

(26) GDPR comes into play regarding the collection of user data, making it feel like you're not allowed to track users. That's why it seems to me that it's being done less and less all the time. (P3)

It is noteworthy, that some of the interviewees felt that the changes made to EU-level legislation in recent years have contributed to the improved recognition of the industry. Accessibility legislation as well as GDPR have played a part in creating an environment where discussions about UX and UCD design have been more prevalent, and understanding of the importance of user-centricity has increased.

5.3.4 Objectivity of heatmaps

The most significant positive factor highlighted in the interviews, was the objectivity of the results heatmap technology can provide. Many interviewed designers mentioned situations where it has been necessary to defend their own professional perspective against, e.g. the client's gut feeling. Example (27) illustrates a situation where the client's perspective is strongly based on their own gut feeling rather than on professional design principles, and personal preferences are often an element in visual design.

> (27) I like all the tools that can produce data very visually and indisputably. -- It eliminates that silly debate like 'my wife doesn't like that.' I've been in hundreds of client meetings, and sometimes this is really the client's opinion. I once had a meeting where the client came back after we had given them the first drafts, saying, 'I made these on my own and my wife liked these.' Those situations can be quite unsettling. (P9)

Usability and visual design constitute essential components of UX design. A few of the more experienced UX designers brought up their view that in recent years, in some situations, visuality in design may have started to overshadowed usability. However, they also noted that it is the responsibility of a professional to find a solution that achieves both good visual design and meets accessibility requirements, for example. In these situations, heatmaps and their objectivity were seen as a useful opportunity.

The interviews revealed that designers can leverage the objectivity of heatmaps to address uncertainties regarding their visual concepts and validate their designs. Consequently, heatmaps serve as a valuable tool to corroborate specific aspects of visual design. Example (28) highlights a scenario where designer articulated the need for heatmap objectivity to support their visual design process.

> (28) There can be a kind of harmony and visual appeal that looks really good to the designer's eye. However, it may not necessarily achieve the hierarchy or call-to-action that we desire. Sometimes, there are conflicting situations where we feel that this looks really cool, but if we implement it, customers end up clicking in the wrong places. So, the visual appeal has completely disrupted the hierarchy in a way. (P3)

Situations with stakeholders where there is a need for objective data can be very stressful and frustrating for designers. In the interviews, designers with less experience raised this issue and contemplated on the potential of heatmaps as a source of objective perspective. The utilization of heatmaps in stakeholder communication is further elaborated as part of the next chapter 5.4.

5.4 Effective methods in heatmap utilization

The third research question of this thesis explored the effective methods employed by UX designers when utilizing visual heatmaps in UXD. Throughout the interviews, participants elaborated on numerous effective methods drawing from their practical work experience or other expertise. The five methods found through the thematic analysis are illustrated in the following five chapters.

5.4.1 Use as part of a triangulation of methods

All interviewees unanimously expressed the view that depending exclusively on a visual heatmap as a tool is seldom advisable. Instead, they emphasized the importance of supplementing its use with other methods to attain optimal results. This thinking is illustrated by example (29).

> (29) I want to emphasize that heatmaps should be seen as part of a toolkit, and in my opinion, regardless of the case, there should be several tools available. The only real constraints are time and money. (P5)

Designers, especially those in leadership positions overseeing design teams, held the belief that a greater diversity of backgrounds, education, and experiences among team members led to the best outcomes. This diversity enables design plans to be examined from a wide range of perspectives. This diversity was particularly valued in UX software projects, where ongoing internal team discussion and the resulting development are at the forefront. This perspective is demonstrated by example (30).

> (30) The more diverse the design team, the better the product will turn out. Few are capable of truly doing and considering everything. As software becomes more complex, it requires even more diversity and different specialists. Specifically in software design, where discussion and feedback are crucial. When you have various design backgrounds, it sort of helps you to clear the air. (P10)

Many interviewees emphasized that having diversity in UX teams is generally not a significant challenge as the backgrounds of UX professionals tend to be quite diverse. Moreover, the interviewed seasoned team leaders exhibited adeptness in presenting their viewpoints from various angles. They were able to articulate both the merits and

possible drawbacks of different design backgrounds, and also analyse how these backgrounds usually complement each other.

5.4.2 Verifying and validating existing results

Many interviewees noted that the most sensible use of heatmaps occurs when they are employed to enhance existing designs rather than as the starting point for design. Over half of the interviewees highlighted the potential use of heatmaps as part of verification and validation processes. They perceived that the visual and objective nature of heatmaps is well suited to be integrated as part of these processes that aim to ensure the quality of the design.

Although verification and validation were often mentioned in the interviews as potential benefits of heatmaps, it should be noted, that they frequently served to confirm pre-existing expectations. Example (31) illustrates this situation.

> (31) The analysis we conducted was largely centred around the initial 3-second period during which individuals focused on this area, followed by a shift in focus during the subsequent 3 to 5 seconds. Did this data benefit customers? To put it kindly, not significantly. The findings often merely confirmed expectations rather than offering novel insights. (P8)

Although the results may be predictable, as discussed earlier in this thesis, there are occasions when they can also be surprising and lead the plan in a new direction. Confirmation can also boost the designer's self-confidence, even if the outcome was expected. Two interviewees also mentioned that combining heatmaps with A/B-testing could prove to be useful.

5.4.3 Seeking solutions for complex design cases

The interviewees highlighted in various ways that heatmaps could be utilized in design cases that deviate in some way from traditional design cases, where there is lack of

strong pre-existing knowledge and design principles or need for more quantitative user data. These cases or illustrated in examples (32) and (33).

> (32) I believe that there are certainly some areas, such as the gaming industry, where this type of more quantitative analysis, such as studying different game phases and conducting longer-term research, can be both useful and feasible for companies that have sufficient resources to invest in it. (P7)

> (33) I am thinking of services that are quite complex. Or those with a lot of information in a small space. So if you have a landing page with, like, three levels of navigation or an online store where you have, like, 100 categories side by side, it is helpful there to understand where the user is wandering. (P5)

In addition to game design, interviewees brought up form design frequently. Different forms are content that users frequently encounter online. The content of forms can be quite complex and the use of forms might need multiple steps before completion, especially if the form is used to collect extensive amount or different types of information. Some interviewees mentioned that designing a successful online form can be quite a challenging task, and in their design, objective raw data received from heatmaps could be utilized in a beneficial way.

Several interviewees also noted that in the design of form pages, there is a need for precise information on user movement, and sometimes these design choices can be controversial and debatable. Example (34) illustrates this thinking.

> (34) If you have a form with fields -- there are eternal questions regarding the design associated with the fields, such as whether titles above, below or beside the fields are better -- in such detailed and somewhat controversial aspects where the usability of one option over the other is debatable, I think heatmap research can be quite useful because then it provides raw data. (P9)

One of the interviewees had utilized heatmap data generated through eye tracking in the design of forms. They noted that, in their experience, heatmaps were particularly useful in the design of forms where data was collected in ways that deviated from traditional form fields or when the form was especially complex. Example (35) illustrates this.

(35) I would argue that the most interesting findings from eye tracking studies can be found in form displays when verifying layout, especially when the form contains elements not typically seen in forms. (P8)

Thus, it may be concluded from the interviews that in more unorthodox, complex and challenging user cases in UX design, heatmaps can provide direction, confirmation, and support for designers decision-making.

5.4.4 Gaining stakeholder approval

Repeatedly, during the interviews, one challenging aspect of the work surfaced: the difficulty of justifying one's own design decisions to stakeholders, such as clients or the management. Some interviewees regarded this aspect as particularly negative, like example (36) illustrates.

(36) What is most frustrating is actually when the people involved do not truly understand UX design -- when decision-makers rely on gut feelings about certain issues. This has been encountered in several different instances, and I am not just talking about my current company. These cases occur elsewhere, where there is simply management that believes they are always completely correct. (P1)

Many interviewees emphasized that justifying their own decision choices is part of the designer's job and should not be allowed to discourage, but rather should be approached from a perspective of self-improvement. Several interviewees felt that the visual and easily understandable representation of heatmaps, as well as their objectivity, could provide a foundation for their utilization in stakeholder communication. Even if stakeholders have strong opinions about design decisions, data, especially visual data, can provide relatively indisputable support for design decisions. Example (37) illustrates this situation.

(37) When we showed eye tracking results, the management absolutely loved it because it just was a little bit of confirmation. What I found in my career, whenever I was working with sort of senior stakeholders -- what really gets them is showing them like a data point or something that seems unobjective to really

> like all day man and so with this project they were like, wow, like, look at this amazing heat. (P2)

Example (37) also illustrates how stakeholders, when enthusiastic, may potentially draw incorrect conclusions from heatmap data, similar to designers as discussed previously in chapter 5.2.1.3 of this thesis. In these situations, designers have a significant responsibility regarding the data they present to support their design decisions.

5.4.5 Enhancing customer journey design

As outlined in this thesis, UX professionals need to select the tools and methods to be used based on the requirements of the situation and the design case at hand. In many cases, interviewees who had little experience with heatmaps or had used them minimally cited that in their case heatmaps were irrelevant, because they did not meet their particular needs.

Based on the interviews, it appears that heatmaps were particularly useful in situation where it is important to gather information on how users progress along the desired customer journey, especially in consumer business. Example (38) illustrates this.

> (38) If you have a clear purchase funnel where there are not as many different actions, but rather all users in one way or another aim for the same outcome, then I feel that in such an environment, the use of analytics to be easier. (P4)

In these situations, heatmaps enable a detailed examination of consumer behaviour in the purchase funnel and facilitate comparison with the desired behaviour. It is also relatively easy to utilize analytics to see whether the customer was able to perform the desired conversions and call-to-actions.

5.5 Summary of findings

Almost all interviewees emphasized that due to the dynamic nature of UX, the tools used in the field change rapidly, and designers are required to possess and maintain a wide range of technical and specialized skills and knowledge. Designers must be capable of understanding and selecting the suitable tools and methods based on the requirements of each distinct design case and stage of the project. Practically all interviewees concurred that relying solely on physiological heatmap technology, in most UX design cases, would not offer sufficient information for UX designers to make informed design decisions. Instead, heatmap technology is most effective when used in combination with other tools and methods, thereby achieving triangulation of different methodologies. As discussed in the theoretical framework of this thesis, triangulation is a crucial factor in ensuring the quality of UX design work.

The understanding of the significance of triangulation among the interviewed designers appears to be high. The concern Bojko raises (2009, p. 37) regarding the prevalence of "let's-track-and-see-what-happens" mentality in the field does not seem to hold true, at least based on the data collected in this thesis. On the contrary, interviewees frequently raised concerns about the adequacy of resources and the need for efficiency in their design projects. This was a significant factor for many designers when considering the potential use of heatmaps. Efficiency has emerged as a result of the evolution in UX design work, where different processes have become more systematic in recent years, with fewer experiments conducted compared to previous years. Additionally, clients' own design principles and systems have evolved and solidified. Many interviewees concurred that these developments, increased awareness of user-centricity and more systematic approach to design, have been accelerated by legislative changes, such as those related to accessibility and data privacy.

Based on the analysis, it appears that attitudes towards heatmaps are somewhat influenced by the educational background of UX designers, with designers from a more technical background being slightly more sceptical towards heatmap technology compared

to designers with visual or humanistic backgrounds. However, it is not a significant divergence in schools of thought but rather these two attitudes represent the opposite ends of a spectrum. At the more sceptical end, termed in this thesis as the "raincloud attitude", there was a greater emphasis on concerns about the effective, accurate, and resource-efficient utilization and interpretation of heatmap tools by UX designers. Conversely, the more optimistic "sunshine attitude" identified opportunities in the visual nature of heatmap technology to inspire, communicate, and produce unexpected outcomes that may not be achievable through other methods. Most of the interviewed designers did not align strongly with either end of this attitude spectrum. It is also noteworthy that no discernible differences in attitudes were found in the responses based on the length of the interviewees' career. Interviewees with less experience showed more uncertainty regarding some workplace skills, e.g. communication. However, due to the rapid advancement of the UX industry, many of these designers had received more specialized and targeted education in UX design in comparison with the more experienced designers.

As previously mentioned, most interviewed designers recognized the potential for heatmaps to effectively complement results obtained through other UX methods. Heatmaps were seen to enable UX designers to verify and validate their design decisions and have more confidence in their work. While heatmap data was widely perceived to be objective, UX designers acknowledged that heatmap analysis demands a high level of expertise from designers in order to prevent erroneous and false positive conclusions. Somewhat contradicting this conclusion, however, the visual, intuitive and comprehensible attributes of heatmaps were also deemed well-suited to serve as facilitators in challenging stakeholder communication situations. Hence, it can be argued that especially for designers in decision-making positions and those responsible for stakeholder communication, it is important to understand the capabilities and limitations of heatmap technology. This understanding allows them to consider when to adopt the technology and when the investment may be unnecessary or even detrimental.

6 Discussion

This concluding chapter of the thesis interprets the key findings and their implications, as well as the limitations of the research. The first chapter offers interpretation of the research objective and compares the findings to previous research through the examination of each research question. The second chapter discusses the implications and contribution of the research. The third chapter evaluates the validity and reliability of the research. Finally, the last chapter provides recommendations for further research avenues.

6.1 Interpretation and implication of results

The aim of this thesis was to explore the attitudes of UX designers regarding the use of visual heatmaps as well as the adoption factors and effective methods associated in their use. The objective was divided into the following three research questions:

- RQ 1: What attitudes do UX designers exhibit regarding the use of visual heatmaps in UXD?
- RQ 2: What are the primary factors influencing the adoption or rejection of visual heatmaps in UXD?
- RQ 3: What are the effective methods that UX designers utilize when using visual heatmaps in UXD?

The research findings of this thesis were able to highlight new and compelling perspectives that have not been observed in previous research. The following three chapters contextualize the findings within previous research and interpret and discuss the results by examining each individual research question.

6.1.1 Designer attitude

The first research question examined UX designers' attitudes toward the utilization of visual heatmaps in UX design. While recent scholarly articles often examine the potential advantages or disadvantages of the technology that results in visual heatmaps, e. g. eye tracking, these articles do not typically address the attitudes of UX designers toward their utilization (Novák et al., 2023). Given that attitudes play a crucial role in the adoption of technology, it was both intriguing and imperative to examine this question.

Interviewees acknowledged the presence of visual heatmaps in UXD, but the attitudes and perceptions towards their utilization varied in many respects. Although the use of visual heatmaps has become more common in recent years (Bojko, 2009, p. 30; Novák et al., 2023), at present, based on the findings of this study, their utilization did not appear to be particularly significant in UX design. Of particular interest was the correlation between respondents' educational background and their attitude toward visual heatmap utilization in UXD. Individuals with a technical background tended to have more confidence in established methods, while those with humanities or arts backgrounds more open towards experimentation.

Those with a more technical educational background showed more often signs of more sceptical and cautious attitude. They expressed strong confidence in their own expertise and in the existing established UXD methods and tools. Conversely, respondents with a background in humanities or arts demonstrated greater interest in experimenting with visual heatmaps. They were more likely to believe that the results obtained from heatmaps could lead to conclusions that would not be obtained through current methods. Overall, their attitudes reflected a greater interest in experimentation with technology related with visual heatmaps.

In light of the findings of this research, Bojko's (2009) concern that designers' attitudes towards heatmaps could be too heavily exploratory did not appear to hold true. While there was some evidence of this attitude, the research data suggested much more

commonly an attitude leaning towards a sense of caution and an awareness that UX designers should generally be efficient and resource-conscious in their work. Despite this caution, the majority of respondents exhibited some openness in their attitudes towards new possibilities and methodologies, with many expressing that there is a continuous need for inventive and creative new methods in UXD (Arhippainen & Pakanen, 2013).

6.1.2 Adoption factors

The second research question investigated the primary factors influencing the adoption or rejection of visual heatmaps in UX design. Although technology was seen as a strong component in the UX industry, the interviewees often wanted to emphasize UCD and the human-centric nature of their work. This perspective, where technology was regarded by the interviewees as valuable, yet not prioritized above user-centeredness or considered inherently valuable, is closely aligned with recent scholarly articles and the views expressed by the majority of UX professionals (Arhippainen & Pakanen, 2013; Bojko, 2009; Lallemand et al., 2015; Law et al., 2014).

Collectively, the interviewees often articulated the notion that the growing acknowledgment and maturation of the UX field have led to a decrease in experimentation. Visual heatmaps and their related technology were often regarded by the interviewees as emblematic of such experimentation, and there was often a lack of recognition of their necessity by the interviewed designers. Some of the interviewees acknowledged potential issues associated with conventional methods, such as response effects that regularly influence users' self-reported information (Georges et al., 2016, p. 4850; King & Bruner, 2000, pp. 79–103). In light of this, some interviewees perceived the potential objectivity of visual heatmaps as a significant advantage in their utilization.

Often, a significant determinant influencing the adoption of visual heatmaps and their associated technology was the constraint of limited resources. The interviewees demonstrated diverse experiences with a variety of visual heatmaps, with a considerable

portion of active utilization focusing on tracking cursor movements or interactions on touchscreens. In the case of these technologies, the adoption threshold was perceived to be lower in terms of costs as well. Although eye tracking technology was frequently discussed during the interviews, and in many cases there was evident interest in its utilization, it was commonly viewed as potentially still being prohibitively expensive. Evidently, the more recent academic research, which has explored the potential benefits of affordable eye tracking technology, has not yet been disseminated to at least the participants of this study (Novák et al., 2023; Schall & Romano Bergstrom, 2014; L. Yang & Qin, 2021; Q. Yang et al., 2018).

6.1.3 Effective methods

The third research question explored the effective methods that UX designers employ when utilizing visual heatmaps in UX design. Throughout the interviews, the dynamic nature of the field was clearly evident. the interviewees recognized the impacts of user satisfaction and good usability on enhancing the overall user experience (Burger et al., 2018, p. 2; Georges et al., 2016, p. 4850; Guo et al., 2022, p. 797). The perpetual evolution of technology necessitates that UX designers need to continuously adapt and acquire proficiency in novel tools and methodologies.

In the context of assessing UX maturity, it was noteworthy that nearly all interviewees underscored within their responses the insufficiency of relying solely on visual heatmaps to achieve comprehensive results in UX design. Hence, designers demonstrated an awareness of the necessity for triangulation involving diverse methods and tools, reflecting an emerging trend in UX evaluation (Hussain et al., 2018). In the study made by Lallemand et al., respondents, who were professionals in the UX field, concurred with the notion that both user-related factors and contextual factors are crucial variables in shaping UX (2015, p. 46). The participants in this study also represented this perspective.

6.2 Summary of contributions

In the preceding chapter, the contribution of this study has been discussed with respect to each research question. The purpose of the research was to contribute to the understanding of the role that visual heatmaps have in current UX design processes. As a scientific contribution of this research, new knowledge was gathered to specifically address the first two research questions of this thesis. Through these questions, the aim was to elucidate the attitudes of UX designers as well as the factors related to the adoption of visual heatmap technology.

As previously mentioned in the study, while previous academic research has often explored the implementation and potential benefits or drawbacks of technology concerning the creation of visual heatmaps, they generally do not investigate the attitudes of UX designers toward specifically the utilization of this technology or the factors influencing their adoption in UX design (Bojko, 2009; Lallemand et al., 2015; Law et al., 2014; Novák et al., 2023). Since this aspect had not been previously examined, this study focused on this perspective.

The results of this study have been able to explain UX designers' experiential assessments of effective methods for utilizing visual heatmaps in UX design. While these methods are academically intriguing as well, their contribution may be considered particularly significant for the practical work of UX designers. Many of the interviewees expressed the need for this research and the value of the new knowledge it provides. UX designers can benefit from and incorporate the findings of this study directly into their own work.

6.3 Validity and reliability of the research

It is possible to identify certain limitations in the study, which are important to acknowledge when interpreting the results. The study sample was limited, and the variances revealed with thematic analysis were subtle. As the thematic analysis was

conducted simultaneously during the interview process, the variability of code frequency could be observed to stabilize before the end of the final interviews. As the data began to repeat itself, it is possible to successfully draw conclusions that are more generalizable than just those specific to the dataset (Saaranen-Kauppinen & Puusniekka, 2006). According to Guest, this phenomenon indicates that the study successfully achieved sufficient data saturation and consistency. This is crucial when analysing the validity of qualitative research employing interviews for data collection, as it aids in determining when conducting additional interviews is less likely to yield significant new information (Guest et al., 2006, p. 74).

Efforts to enhance the study's reliability were made by employing a sufficiently extensive and varied sample of interviewees. The final pool of interviewees encompassed a diverse range of educational and experiential backgrounds within the UX field, as well as personal attributes such as age and gender. The interview participants boasted diverse educational backgrounds, with many having interdisciplinary studies, complicating the differentiation between technical and humanistic backgrounds used in the analysis.

Lastly, the diversity of heatmap technology implies that participants may have held diverse perspectives on the specific characteristics of the discussed heatmap technology. Consequently, the background of the study and heatmap technology were reviewed and clarified in the interview invitation, at the outset of the interviews, and as needed during the interviews. These measures were also intended to cultivate motivation among the interviewees.

6.4 Future research

Further research in this area could explore in more detail which methods and technical tools work best in conjunction with heatmaps. Since heatmap technology itself is diverse, it would be beneficial to investigate the differences between heatmaps generated by specific technologies such as eye tracking or touch interaction.

The attitude gap between the more technical and more humanistic fields highlighted in the research could be an intriguing subject for further assessment. For instance, it could be examined whether designers from a visual background tend to create and innovate more frequently, thus benefiting from maintaining a more open and experimental mindset. On the other hand, more technical expertise might be needed during project development stages when refining existing designs. In such cases, the creative phase is often behind, and precision and efficiency are prioritized over experimentation. Additional research avenues stemming from the recent reinforcement of design principles and the growing prevalence of platform services, as indicated by the interviewees in this study, could also be explored.

Some of the interviewees expressed interest in visual heatmaps generated with the assistance of machine learning (ML) and artificial intelligence (AI). These domains and their relevance concerning visual heatmaps and their associated technologies offers interesting opportunities for further research.

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Appendices

Appendix 1. Examples of interview questions

Theme: UXD as a profession

- Q: How would you describe the work of a user experience designer?
- Q: How do you perceive the different roles of UX and UI designers or Service Designers?
- Q: What is your view and experience of potential differences and links between usability and user interface design, customer experience design and service design?
- Q: What are the best aspects of your work? On the other hand, what do you find frustrating in your work?
- Q: Who are the end users and customers in your work?
- Q: How is UCD / UX perceived in your organization, and how familiar is the organization with UX?
- Q: How do you assess the UX maturity of your organization? What about the maturity level of the UX field in Finland?

Theme: UX tools and methods

- Q: What UX methods, tools and technology do you use?
- Q: What UX methods, tools and technology do you perceive to be most important, and why?
- Q: How do you research user needs?
- Q: How do you assess the development of UX industry tools and methods during the span of your career?

Theme: UX heatmaps

- Q: Do you have experience using any type of UX Heatmaps in your work, or elsewhere?
- Q: What technology have you used, when, and what observations have you made of this particular technology?
- Q: In what situations have you used heatmap technology?
- Q: How do you perceive the differences between different types of heatmap technology?
- Q: How have users experienced situations where physiological technology was used?
- Q: What if any experience did you attain around this technology during your education?
- Q: Do clients or other stakeholders have knowledge of UX heatmaps?
- Q: What are the reasons you would utilize / not utilize this technology?
- Q: In what situations or stages of design do you feel that visual heatmaps can be most effective?

Theme: Future of UXD industry

- Q: How do you perceive the future of the UX industry?
- Q: Have you any experience with AI Heatmaps?
- Q: How do you view the role of AI and ML in the field?