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Enhancing Inclusivity in Human-Computer Interaction through the Implementation of Temporal Uncertainty Tools

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Abstract

This doctoral study explores how Temporal Uncertainty tools can enhance inclusion in HCI. It proposes that HCI should design tools that accommodate individuals' diverse and uncertain temporalities. It argues that dominant concepts of time can exclude people who experience time differently, drawing on theoretical and empirical work from social sciences. It focuses on the social aspects of time in relation to health experiences, and how they shape and are shaped by uncertainty.

The core argument of this thesis emerged early in the research process when studying people with Chronic Fatigue Syndrome (CFS). The findings show that health uncertainty can clash with social norms of time, leading to exclusion. This is reflected in the research question: ***In what ways do people with Chronic Fatigue Syndrome experience time with regard to health and social interaction?*** Participants with CFS reported that the pressure to conform to rigid social and professional interactions, despite their uncertain health, was problematic and compromised their well-being. This often resulted in social exclusion.

Building on the research with CFS individuals, this study expanded its scope to explore Temporal Uncertainty more broadly. A key question that guided this exploration was: ***What insights are produced from a broader audience when given the ability to communicate uncertainty?*** To answer this question, a speculative probe named HAZE was created based on design guidelines from the CFS study. HAZE was deployed with a wider audience to encourage participatory speculation and allow people to communicate and remain in uncertainty. The findings revealed a significant demand for tools that facilitate the expression of uncertainty. Participants indicated that uncertainty is not commonly accepted in society, and tools like HAZE could help normalise the experience, improve health outcomes, and foster empathy.

This thesis critiques the lack of attention given to the exclusion experienced by individuals who do not have access to tools that support the expression of uncertainty in HCI research. Addressing this issue presents a significant challenge, as HCI currently lacks methods for investigating people's experiences

of Temporal Uncertainty. To address this gap, this study posed several research questions: ***What is needed within a Toolkit to support people and designers in exploring times that create uncertainty?*** This question led to the development of a toolkit and method. ***What notions and scenarios of uncertainty do people and designers want to design for?*** This question advanced our understanding of the temporal experiences that create uncertainty. ***What tools and solutions do people and designers come up with when using the toolkit?*** The co-designed interventions that followed revealed the types of tools that participants desired to support them in expressing Temporal Uncertainty.

The study yielded novel insights into designing for Temporal Uncertainty. While participants experienced similar types of uncertainty, their subjective contexts often differed. This meant that, although thematically similar, each participant required a unique design intervention. This insight suggests that, in order to advance our understanding and design of uncertainty, HCI researchers should avoid generalising dichotomies of uncertainty, such as embracing or reducing it. The research contributions highlight the complexity of designing for uncertainty when taking into account the temporal subjectivity of individuals. However, by representing individual needs and experiences of uncertainty, inclusion can be expanded through the development of more tools, features, and design outputs that support people when they experience Temporal Uncertainty.

To answer the research questions and obtain the findings, this thesis accomplished the following: **1)** Conducted semi-structured interviews to uncover how social uses of time could exclude people with CFS; **2)** Used speculative probes to explore how others might benefit from communicating Temporal Uncertainty; **3)** Developed a methodological toolkit, including a workshop and an uncertainty language, to facilitate reflection and speculation on times of uncertainty; **4)** Co-designed interventions that were tailored to the subjective experiences of participants' uncertainty; and **5)** Provided designers with the option to use the toolkit to speculate about potential users' moments of uncertainty

This thesis underscores the significance of Temporal Uncertainty tools in promoting inclusion and advancing the design of uncertainty in HCI. It is the author's hope that the knowledge, findings, materials, methods, and tools presented in this work will inspire HCI designers to explore Temporal Uncertainty as a means of expanding inclusive design.

Lay Summary

This thesis is about how to design tools that can help people in times of uncertainty. It says that people have different ways of experiencing time, and some people face more uncertainty than others because of their health or social situations. It also says that most tools do not support people to express their uncertainty, and this can make them feel excluded or worsen their health.

The thesis is based on research with people who have a health condition called Chronic Fatigue Syndrome (CFS). This condition makes people fatigued among other symptoms, and affects their ability to conform to strict plans and do many everyday activities. The research found that people with CFS often struggle with the temporal expectations and norms of society. The research also found that people with CFS need more flexibility in planning events and a better understanding of the condition by others.

The thesis then explores how other people might benefit from tools that can communicate uncertainty. It describes a prototype tool called HAZE, which lets people show how uncertain they are about their plans or availability. The research found that many people could benefit from HAZE, and participants thought it could improve their well-being and relationships. Participants also said that HAZE could help them accept and cope with uncertainty.

The thesis then discusses how to create more tools like HAZE. The thesis proposes a method and a toolkit that can help people and designers think about the times when they feel uncertain and the solutions they want. The thesis shows some examples of the tools and features that were co-designed using this method. The thesis also highlights some insights and challenges for designing for uncertainty.

The thesis concludes by saying that Temporal Uncertainty tools can promote inclusion and advance the design of uncertainty in HCI. It hopes that the findings and materials in this document will inspire designers to explore Temporal Uncertainty as a way of expanding inclusive design.

Dedication

I dedicate this thesis to all the people who have ever experienced living with Chronic Fatigue Syndrome. To the families of people with Chronic Fatigue Syndrome. To the carers of people with Chronic Fatigue Syndrome. To the people pushing our knowledge and understanding of Chronic Fatigue Syndrome. Furthermore, I dedicate this to my family and my doctors who since the age of 12 have allowed me to understand my own experience living with Chronic Fatigue Syndrome. To my partner Kayleigh who continues to support me in my bad health days and good health days with compassion, understanding and love. Without them, I would never have had the chance to be where I am today.

Declaration

I hereby declare that this thesis was composed by me and that the work contained herein is my own, except where explicitly stated otherwise in the text. This work has not been submitted for any other degree or professional qualification except as specified. Some of this work has been published at CHI, found under the following title: Exploring Uncertainty in Digital Scheduling, and The Wider Implications of Unrepresented Temporalities in HCI.

Acknowledgments

I would like to start by expressing my heartfelt gratitude to Dr. Benjamin Bach, my lead supervisor, for his unwavering dedication, support, and encouragement throughout my journey of exploring my thesis topic. His openness and willingness to meet with me regularly to discuss the progress and direction of my PhD were truly remarkable and gave me the confidence to achieve all that I did during my time as a PhD student. Thank you, Benjamin, for everything

I would like to express my sincere gratitude to Dr. Larissa Pschetz for believing in me and giving me the opportunity to pursue a Ph.D. on a topic that is so dear to my heart. Her teachings provided me with a fresh perspective on conducting user research and introduced me to the fascinating world of design research.

I am also deeply grateful to Dr. Michelle Bastian, my third supervisor, who ignited my passion for temporal studies during my Masters by introducing me to the intriguing concepts of time and society. Her teachings revolutionized my thinking about the world and the hidden rhythms of everyday life that impact people in many ways. Through her guidance, I was able to learn not only about the subject matter but also about myself and my own temporal experiences. During my Ph.D., Michelle offered me kind words, emotional support, and encouragement, showing me that despite my dyslexia, my underlying concepts and thinking were good enough to be written down.

Collectively, I would like to thank all three of my supervisors for their dedication, patience, and teamwork, especially during the challenging times of Covid-19. Thank you for making this a truly memorable experience.

My heartfelt gratitude goes to my partner, Kayleigh. Pursuing a Ph.D. can be emotionally challenging not only for the student but also for those around them. Kayleigh's understanding and support during my late nights, long hours, and emotional ups and downs were truly remarkable. She was always there for me, providing a listening ear and a sounding board for my thoughts and ideas, even when our discussions led to debates about whether bees can tell human clock time at 3 in the morning. Living with Chronic Fatigue Syndrome means having to make choices about where and when to spend my energy, and often that

meant focusing on my PhD at the expense of other aspects of my life. Kayleigh's understanding made that choice easier and frictionless. She encouraged and believed in me, even when I doubted myself, and it was her encouragement that led me to pursue my Masters in the first place. Kayleigh knows me better than anyone, often better than I know myself, and her selflessness and support throughout my academic journey have meant more to me than words can express. I hope this is a good attempt at conveying my gratitude.

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A special note of thanks to Dr. Jo Ronan, who supervised me during my undergraduate studies and allowed my curiosity to flourish despite the many hurdles that came my way. Without Jo, I would never have been introduced to the world of research. She opened up this world to me and showed me how to apply critical thinking and methods to the things I cared about. Thank you for never losing faith in me and providing a structure for me to reach this point in my life. You are an inspiration and a true example of a dialogic pedagogy practitioner who empowers students through best practices. Thank you.

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Contents

Chapter 1

Introduction

1.1 Background and motivation

Chronic Fatigue Syndrome: A Social and Temporal Perspective

The global prevalence of Chronic Fatigue Syndrome (CFS) is estimated to be between 17-24 million individuals (Lim & Son 2020). People with CFS encounter significant functional impairments that cause vast physiological impact (Afari & Buchwald 2003). This means that the disease alters the functioning and operation of the body. Classified as a heterogeneous condition (Afari & Buchwald 2003), it is characterised by a multitude of symptoms. Among the recognised symptoms is persistent fatigue that continues despite rest, along with muscle and joint discomfort, sleep difficulties, cognitive impairment, and irregular heartbeats. The prediction and management of health for individuals affected by CFS pose significant challenges (Davies et al. 2019). The challenge of predicting and managing this condition is primarily linked to post-exertional malaise, where symptoms escalate after engaging in specific activities, although they may be delayed by several days or even weeks. This creates difficulty in predicting the occurrence and severity of what is commonly referred to as relapsing.

Unlike the detectable nature of certain health conditions, CFS is predominantly invisible. This can give rise to difficulties in gaining credibility and result in a greater likelihood of encountering stigmatisation (McManimen et al. 2018). This leads individuals suffering from CFS to face numerous challenges in social interactions, further exacerbating the already arduous health effects of the condition. The combination of social and health challenges presents a formidable obstacle to routine activities, such as managing household affairs or participating in social recreation (Schweitzer et al. 1995). A lack of social understanding of the condition can be harmful to individuals with CFS, rendering them unable to access the social aspects of life. The restricted future prospects faced by children with

CFS (Sankey et al. 2006) highlight the shortcomings of the education system in accommodating their needs, making schooling a prominent illustration. This problem carries over into adulthood, where adults may find themselves unemployed due to the tension between their health and the demands of their jobs (Collin et al. 2011). The inability to continue working in the same capacity as before their illness forces many individuals to resign from their positions (Jason et al. 2008). Therefore, it can be deduced that individuals with CFS face intricate difficulties, encompassing both health-related and social aspects, rendering CFS a 'multidimensional' condition (Vercoulen et al. 1994).

The social challenges that individuals with CFS encounter show a larger issue, that comes to understand disability is in fact shaped and produced through societal constructs. To reflect the socially constructed understanding of disability, the World Health Organisation has updated its definition of disability. Stating, it is the societal barriers, rather than an individual's health condition, that contribute to the disabling experience (World Health Organization 2021). The emergence of this new understanding of disability has prompted scholars to investigate the social mechanisms underlying disabling experiences. One mechanism in question pertains to time, specifically the incorporation of temporal concepts or tools like clocks, which, when utilised, can contribute to the perpetuation of ableism. (Kafer 2013*b*). The inquiry into time as a catalyst for social ableism is propelled by the theory of Crip time. This originates from broader time studies that have been conducted within the social sciences. Crip time suggests that the use of clocks and calendars, widely accepted as essential timekeeping tools in different societies, can have negative consequences for individuals who find it challenging to coordinate their physical and mental states with rigid time frameworks, particularly those grounded in numerical calculations. Time-telling devices are not inherently designed to be exclusionary. However, it is the manner in which these tools are employed within social systems (Hjärpe 2022) that can cause encounters of exclusion. As a case in point, implementing a clock can facilitate the management of a 37-hour work week. However, the health required to maintain these hours may not be achievable for certain individuals. This makes the income associated with these hours unattainable, potentially resulting in personal repercussions such as poverty, worsened health issues, or other exclusionary experiences.

However, Crip time researchers critique more than just time-telling tools; they also challenge concepts such as linear time. The concept of linear time entails events happening in a sequential order of past, present, and future. However, linear time has become associated with social expectations that dictate a specific sequence of actions: attending school, going to university, getting married, having

children, working for a set period, retiring, and then dying. This sequence is referred to as 'chrononormative' in temporal and Crip studies (Freeman 2010*a*). It represents a standard set of expected actions that can marginalise those who cannot meet these temporal norms at the expected times or at all. Crip time theory provides a lens through which to view the temporal barriers that generate human social inequalities (Baril 2016). Social inequalities are expansive and are both the cause and effect of many social processes, including perceptions and uses of time. Such processes become normalised and are upheld by institutions (Giddens 1984), with people learning these temporal norms as social moralities from an early age (Compton-Lilly 2016). This leads to emerging ideologies of non-normative practices or experiences of time. Not everyone can orient themselves to normative notions of time, and being able to do so is considered a privilege (Freeman 2010*a*). This challenge is particularly evident in children with CFS, who struggle to align health to the temporal pressures of schooling, which can lead to significant consequences. For example, a recent study by the M.E. Association (2023), a charity supporting those with Myalgic Encephalomyelitis (another term for CFS), found that one in five children with CFS was investigated by social services. With some being removed from their families and placed in hospitals or foster care. This highlights the need for research on inclusion to understand how social conceptions, expectations, and practices of time can exclude people. Such exploration could reveal opportunities for enhancing social inclusion for people with CFS through representing alternative time practices or by interrogating current temporal practices.

Exploring Temporal Diversity in Chronic Fatigue Syndrome: The Potential in a Crip Time and HCI Perspective

Invisible chronic illness (ICI) presents unique challenges in diagnosis and social acceptance. Human-computer interaction research has explored how technology can support people with ICI in their daily lives and combat stigma (Berger et al. 2005, Isika et al. 2020). However, despite Chronic Fatigue Syndrome (CFS) being an invisible health condition, there has been minimal HCI research on how technology can support people with CFS, except for Davies et al. (2019), who explored how people with CFS use technology to manage their symptoms. A gap persists in understanding the challenges faced by people with CFS in a social context, and the potential role of HCI tools in addressing or exacerbating these social challenges. One potential approach to addressing this gap is to explore alternative temporalities and their potential impact on social inclusion for people with CFS.

Turning to temporal research, which has been extensively explored in social science domains and has influenced HCI researchers and designers, may be beneficial. Notably, Pschetz (2014) pioneered a practical and theoretical framework for designers known as Temporal Design (Pschetz 2014). This framework suggests that design perpetuates certain ideas about time and encourages designers to challenge these dominant temporal notions by exploring alternative expressions (Pschetz 2014, 2015, Pschetz et al. 2016, Pschetz & Bastian 2018). The approach has transitioned into HCI research, arguing that HCI can shape people's temporalities, for better or worse (Rapp et al. 2021). It echoes the need for HCI to broaden its understanding of time and its designs (Rapp et al. 2021), which could lead to positively impacting forms of temporal exclusion (Pschetz 2014) and increasing temporal empathy (Pschetz & Bastian 2018).

This thesis aims to explore the diversity of temporal experiences among individuals living with certain health conditions, specifically CFS. By drawing on Crip time theory and Temporal Design, this research seeks to contribute to an area that has yet to be examined from an HCI, temporal, and social perspective. The goal is to acquire a deeper understanding of how time can lead to marginalisation and to better comprehend the role of HCI in addressing exclusion. This research aligns with Crip time and HCI, both of which support diverse temporal experiences. However, there is limited research on integrating these two concepts. By understanding the experiences of people with CFS, HCI could advance its temporal understanding and potentially improve their well-being. People with CFS could help HCI become more inclusive by providing insights that could benefit others who feel excluded for similar reasons.

Uncertainty in HCI: Challenges and Opportunities

Uncertainty, like time, is a complex and elusive phenomenon that is a natural part of our world. It is a feeling that everyone experiences and can be shared across nations, economies, and societies. Despite extensive research, uncertainty remains elusive (Merz & Thieken 2005). For people with CFS, uncertainty is highly encompassing, ranging from uncertainty in medical approaches and treatments (Marks et al. 2016) to personal challenges such as getting a diagnosis (Parslow et al. 2017, PP. 7). This has led to recommendations for reducing uncertainty from a medical perspective. Research across many domains mostly focuses on mitigating uncertainty but viewing it solely as negative can limit understanding of it. Design research has begun to show that uncertainty can also be a source of creativity and exploration (Akama et al. 2015).

Uncertainty has led researchers in HCI to focus on the designer's subjective

experience of uncertainty during the design process (Christensen & Ball 2017). This is particularly evident in design thinking or design research, where the knowledge level of a designer is a key factor of uncertainty. As a result, researchers have often treated uncertainty as something that can be reduced through the active process of knowledge gaining (Cash & Kreye 2017, 2018, Paletz et al. 2017). This has led to uncertainty in HCI, especially from the design perspective, being viewed as negative. However, reducing uncertainty is not always possible, and health is one area where uncertainty can be most profound. That's why recent calls by HCI researchers to embrace uncertainty are welcomed. These calls tend to focus on seeing uncertainty as a positive resource in design methodologies like participatory design (Luck 2018, Tironi 2018), rather than dealing with people's experiences of uncertainty.

However, the debate between embracing or reducing uncertainty has created a simplistic divide in thinking about what uncertainty is and how it might impact everyday people, especially those with certain health conditions, as this thesis will explore. This dichotomised approach to uncertainty has been challenged by researchers who are working to bring HCI into a taxonomy of uncertainty understanding depicted as the "Modes" of uncertainty in HCI (Soden et al. 2022*a*). Despite these attempts, it has not produced practical tools or frameworks to address people's diverse and subjective experiences of uncertainty. Research presented within this thesis involving individuals with CFS highlights the necessity for tools that extend beyond embracing or reducing uncertainty, focusing on other aspects, such as Temporal Uncertainty. Without such tools, frameworks, or methods, the potential of diverse notions of Uncertainty as phenomena that could engender notions of inclusion has yet to be fully realised in the design and HCI domain.

1.2 Research Question and Objectives

The following is a breakdown of the research questions 'RQ' and Objectives 'O' that are explored within this thesis.

RQ 1 - In what ways do people with Chronic Fatigue Syndrome experience time with regards to health and social interaction?

O.—1.1. Identify if people with CFS encounter any frictions between health, notions of time and social participation.

RQ 2 - What insights are produced from a broader audience when given the ability to communicate Temporal Uncertainty?

O. —2.1. Explore if any other people are marginalised due to the similar notion of time.

O. —2.2. Understand the implications for HCI research and its specific needs to expand inclusion.

RQ 3 - What is needed within a design toolkit to support people and designers in exploring Temporal Uncertainty?

O. 3.1. — Identify the components needed that make up an effective toolkit.

RQ 3.1 - What notions and scenarios of Temporal Uncertainty do people and designers want to design for?

O. 3.1.1. — Engage participants to use the toolkit, identifying if the toolkit helps reveal specific notions of uncertainty.

RQ 3.2 — What tools and solutions do people and designers come up with when using the toolkit to address Temporal Uncertainty?

O. 3.2.2. — Aim to have participants co-design interventions using the toolkit.

1.3 Thesis statement

This thesis investigates the temporal experiences of people with Chronic Fatigue Syndrome (CFS) and explores how Human-Computer Interaction (HCI) can design tools to support uncertain temporalities. By involving people with CFS, the study generated general Temporal Uncertainty guidelines, created speculative prototypes for nuanced communication of uncertainty, and formulated a methodology and toolkit for exploring Temporal Uncertainty in HCI. The thesis offers new perspectives on Temporal Uncertainty and provides guidelines for designing around it based on the insights produced throughout the study. It concludes by encouraging HCI designers to expand on Temporal Uncertainty and explore alternative notions of time that may be marginalising, to expand inclusion, reduce exclusion, and enhance equality in society.

1.4 Contributions

In Chapter 3 of this thesis, the author reports on a scoping study on the experiences of people with Chronic Fatigue Syndrome (CFS) in relation

to time, health, and social interactions. The study's qualitative results reveal the uncertainty and challenges faced by people with CFS in social interactions due to the unpredictability of their health. Based on these findings, the author proposes a set of uncertainty design guidelines (U1-U8) for HCI designers to follow to create uncertainty tools and features, especially designs created to orchestrate social planning. These guidelines aim to provide more flexibility and accommodate the needs of people with CFS, and potentially those without CFS, to ultimately reduce the pressures put on having to feel or be certain, that in accordance with the findings can exacerbate health.

In Chapter 4, the author applies their uncertainty guidelines (U1-U8) to address Research Question 2: ***What insights can be gained from a broader audience when given the ability to communicate Temporal Uncertainty?***. Expanding inclusion requires considering alternative insights into Temporal Uncertainty, especially from the perspective of people beyond those with CFS who might also face temporal challenges in social interactions. To explore this, the author created three speculative probes - Haze Days, Haze Events, and Haze Widgets - that allow for speculation about the ability to communicate uncertainty around various aspects of a social event, rather than orienting people towards certainty. These probes have flexible features that aim to aid with experiences of uncertainty that may arise in social events. The author used these probes to engage with people, to better understand their experiences of Temporal Uncertainty.

The results produced new knowledge about the implications of uncertainty in social interactions. Participants stated that they felt morally judged if they were uncertain, leading them to avoid communicating their uncertainty. However, the probes were seen as a positive intervention. Haze probes were considered by participants as a potential way to normalise the experience and times when uncertainty is felt. These results have implications for HCI designers, who may need to consider how technologies that orient people towards certainty might perpetuate the non-normativity of being uncertain. Tools and technologies that promote notions of uncertainty could normalise people's times of uncertainty, thus promoting tools that expand inclusion. However, such tools are sparse, leading the author to make a call for a drive in more Temporal Uncertainty tools, as an important component in expanding inclusion.

These findings however highlight a gap in the field of HCI design that impeded their previous call for more Temporal Uncertainty tools. Specifically, there were no existing methods or designs, such as Haze, for exploring people's Temporal Uncertainty. To address this gap, the author developed a method and toolkit that supports designers in exploring people's specific times of uncertainty,

answering Research Question 3.1: ***What notions and scenarios of Temporal Uncertainty do people and designers want to design for?*** Chapter 6. The author provides insights into the requirements for a Temporal Uncertainty toolkit, that encompasses a way to speak about uncertainty through cards, tokens and methods, along with details on the testing and adaptations made to aid participants in producing co-design interventions. The effectiveness of the toolkit is assessed by whether design interventions are formed by participants through its use. The author takes an analytical approach to understand the types of solutions people consider around their Temporal Uncertainty, leading to the answering of Research Question 3.2: ***What tools and solutions do people and designers come up with when using the toolkit to address Temporal Uncertainty?***. The findings demonstrated that designing for people's times of uncertainty is complex, but ultimately worthwhile.

To address this complexity, the author demonstrates the need for Temporal Uncertainty tools and the importance of allowing participants to shape these tools, features, or outputs. This approach allowed for uniqueness and subjectivity to emerge, expanding how the author understood the types of tools people require in moments of Temporal Uncertainty. Findings suggest that even when participants shared similar themes around their times of uncertainty, their individual needs and requirements were different. This demonstrated that designers cannot consider uncertainty in generalised terms of reducing or embracing it when dealing with subjective times of uncertainty. The author contributes new knowledge that shows how people's uncertainty branches into varying types of uncertainty, each with new implications, based on the context and dimensions of their uncertainty scenario and life at that point in time. This means that when designing for people's times of uncertainty, designers must consider uncertainty not as a holistic concept, but rather as parts, with each part requiring a different type of intervention to support that specific uncertainty.

Overall, two methods for using the toolkit were developed. The first method allows participants to reflect on a time of uncertainty, while the second is a speculative version for designers to explore a participant's potential time of uncertainty. In the designer's version, the author aimed to demonstrate that designers can use the toolkit to generate speculative Temporal Uncertainty insights. However, designers mostly tended to speculate on the general nature of uncertainty rather than Temporal Uncertainty. The author discusses that this is due to the speculative nature of the approach, along with the unfamiliarity of Temporal Uncertainty within the design community. The author goes on to conclude that alterations to that specific approach of the toolkit may be necessary. However, it was clear that findings suggest the toolkit aids designers in changing

their perspectives on uncertainty and broadening how they consider it and its potential for design.

Overall, the author has contributed a series of research studies that demonstrate how Crip theory can uncover new insights into how notions of time marginalise certain experiences. This work led to the identification of Temporal Uncertainty and the development of prototypes that facilitated the continued exploration of Temporal Uncertainty tools. Ultimately, this research culminated in a toolkit designed to encourage other researchers and designers to foster further discussions and insights around Temporal Uncertainty.

1.5 Structure

- Chapter 2 reviews the current literature on the interdisciplinary topics that inform this research, such as Chronic Fatigue Syndrome, social time, Crip time, time design in HCI, and uncertainty in HCI research. This chapter establishes the theoretical background and the premise of the importance of revealing diverse experiences of time to support and expand social and HCI inclusion.

- Chapter 3 presents the first study, which explores the experiences of people with CFS in relation to time, health, and social interactions. This study addresses RQ1: ***In what ways do people with Chronic Fatigue Syndrome experience time with regard to health and social interaction?*** The objective of this study is to identify if people with CFS encounter any friction between health, notions of time and social participation (O1.1).

- Chapter 4 presents the second study, which introduces three speculative probes under the name of Haze. Haze is a concept of tools that supports the communication and management of uncertainty around social events. These tools are based on digital calendars and social event planning. The Haze probes are tested with a wider audience to understand any implications they encounter when in Temporal Uncertainty. This study addresses RQ2: ***What insights are produced from a broader audience when given the ability to communicate Temporal Uncertainty?*** The objective of this study is to create speculative probes to engage wider audiences around any temporal discourse emerging from study 1, which was later found to be Temporal Uncertainty (O2.1).

- Chapter 5 presents the third study, which develops and evaluates a Temporal Uncertainty toolkit. This toolkit is designed to support both people in

reflecting on their experiences of uncertainty and designers in exploring times of uncertainty to co-design interventions. This study addresses RQ3: ***What is needed within a Toolkit to support people and designers in exploring times of uncertainty?***. Also, RQ3.2: ***What tools and solutions do people and designers come up with when using the toolkit to address Temporal Uncertainty?***. The objectives of this study are to identify the components needed that make up an effective toolkit (O3.1), to engage participants to use the toolkit and identify if it helps reveal specific notions of uncertainty (O3.1.1), and to have participants co-design interventions using the toolkit (O3.2.2).

- Chapter 6 builds on the third study by introducing a speculative version of the toolkit, specifically designed for use by designers. This alternative method aims to support designers in exploring novel ways of thinking about uncertainty and speculating on potential users' Temporal Uncertainty, even without direct user engagement. The goal is to help designers prepare their minds, tools, designs, or probes for addressing Temporal Uncertainty before they engage with users face-to-face. This chapter also addresses RQ 3 and RQ 3.2. The chapter concludes by presenting findings on the effectiveness of the speculative version of the toolkit, particularly in terms of its ability to change designers' perceptions and understanding of uncertainty.

- Chapter 7 discusses the main findings and contributions of this research. It synthesises the results from all three studies and answers the research questions in the context of the overarching research goals. It also discusses the implications and limitations of this research, as well as directions for future work.

- Chapter 8 concludes this thesis by summarising the key points, providing future work and reflecting on the research journey.

1.6 Publications, talks and recognition

I collaborated with my supervisors, Larissa Pschetz and Michelle Bastian, to co-author a chapter in the book Speaking for the Social: A Catalogue of Methods. Our chapter, titled "Revealing Social Infrastructures of Time" (pp. 255-294), focused on how social infrastructures are shaped by a standardised understanding of time, primarily through the use of clock time.

My specific contribution centred on a workshop called "Threads of Time." In this workshop, participants explored how time is negotiated in relation to various

factors, such as habits, preferences, and power dynamics. This experience led me to delve deeper into the impact of social infrastructures of time on individuals, especially those who face social barriers due to health-related experiences. As a result, I began working on the topic of Crip time.

I became intrigued by Crip time, which led me to approach my supervisor, Michelle Bastian, to inquire about presenting and discussing Crip time at an event called “The Material Life of Time.” This event was the second iteration of the conference on temporal belongings. Michelle provided me with the opportunity to address the broader temporal community about how social infrastructures and materials associated with health can impact perceptions of time, along with the challenges of adhering to strict time standards. The importance of health and time within society was underscored by this platform and the feedback received from the audience. As a result, I researched individuals affected by CFS, leading me to explore the concept of Temporal Uncertainty.

Halfway through my research, some of my findings on Temporal Uncertainty were published in a paper written for CHI, titled “Exploring Uncertainty in Digital Scheduling, and The Wider Implications of Unrepresented Temporalities in HCI.” This joint paper, written by myself and my two supervisors, Larissa Pschetz and Benjamin Bach, was a pivotal point in my research and plays a significant role in this thesis, particularly in Chapter 4. My supervisors assisted me with my research approach as well as the construction of the paper to ensure it was CHI-ready.

Chapter 2

Related Work

This thesis begins by exploring the experiences of individuals living with Chronic Fatigue Syndrome (CFS) in relation to time and social interaction, and the implications for Human-Computer Interaction (HCI) research. Despite its medical and social significance, CFS has received relatively little attention in Design and HCI research. The following section provides an overview of CFS as a dimensional condition and highlights the need for more HCI research that explores how to support people with CFS in managing their health and social needs.

2.1 Chronic Fatigue Syndrome: A Dimensional Condition

Chronic Fatigue Syndrome (CFS), also known as Myalgic Encephalomyelitis (M.E), is a condition that affects 17 million people worldwide and is characterised by persistent or recurrent fatigue (Reid et al. 2004, pp. 327). Symptoms include cognitive decline, stomach issues, muscle and joint pain, immune reactions, inflammation, and swollen glands (Layzer 1994). People with CFS often use terms such as “relapsing” or “crashing” to describe a sudden onset of symptoms leading to health decline. This is medically referred to as post-exertional malaise, which is an extreme fatigue that typically occurs 24 hours after physical or mental activity. It is common for people with CFS to experience being bedridden for prolonged or periodic amounts of time.

Despite its debilitating symptoms, it has been stated that CFS goes beyond symptoms and requires a dimensionalised approach. Vercoulen et al. (1994) created dimensions of CFS that include subgroups to address the wider implications experienced by people with CFS—cognitively, physically, and importantly, socially. Research has shown that understanding the social experience of living

with CFS is important. A heightened suicidal ideation or depression occurs among people with CFS, in part due to social stigmatisation brought on by a lack of understanding around the condition (McManimen et al. 2018). Young people with CFS especially face depression as life limitations become evident and the abilities to do activities pre-illness are no longer applicable (Taylor et al. 2017). Medical intervention should not only focus on the condition but also on the personal experiences of people with CFS, such as feeling like a burden correlating to suicidal ideation (Pederson 2018).

As depicted, invisible illnesses like CFS can bring many social difficulties that exacerbate or produce alternative physical or cognitive challenges. This extends into livelihood when living with CFS. Given these social difficulties, living in ill health has led people with CFS to discontinue their employment (Collin et al. 2011). Furthermore, social life and personal responsibilities are equally impacted (Schweitzer et al. 1995). Young people with the condition are prominently impacted socially. It is common for young people with CFS to experience disbelief from peers as well as adults (Fisher & Crawley 2013), an experience that extends to adults with the condition (Jelbert et al. 2010). Yet, young people with CFS face a few unique social challenges. For instance, the difficulty of attending school directly correlates with decreased educational opportunities for young people with CFS (Sankey et al. 2006). Decreased opportunities are not the only consequence young people with CFS face. The M.E. Association (2023) reports on children being removed from their parents and placed into foster care. Getting a timely diagnosis and being believed can protect people with CFS from some social consequences.

However, achieving a timely diagnosis and receiving appropriate medical support is often not easy for people with CFS. They face many medical barriers that hinder their access to care and support. One of these barriers is the lack of knowledge or personal biases of medical professionals, which can delay the diagnostic process (Webb et al. 2011). As a result, this uncertainty about their own health can leave people with CFS feeling a lack of control over their condition (Haines et al. 2019). While understanding their condition is crucial for adopting effective management strategies, such strategies must be tailored individually. Previous approaches, such as graded exercise therapy (GET), have demonstrated potential risks and may even worsen the health of individuals with CFS (Vink & Vink-Niese 2020). Moreover, interventions such as cognitive behavioural therapy have been used to delegitimise the biological symptoms of CFS, suggesting that they can be cured through mind over matter. This approach has been shown to be ineffective (Twisk & Maes 2009). Given the complexity of the social and medical aspects of CFS, there is a need for more comprehensive

and effective approaches to support people with this condition.

As previously mentioned, many social factors impact the lives of people with CFS, many of which are harmful to health, individual integration, or social acceptance. Recently, in light of these social factors that also impact other types of invisible conditions, HCI has been increasingly attentive to invisible conditions and how technologies can support their medical and social dimensions (Das et al. 2021), (Sannon et al. 2019), (Jessen et al. 2018), (Isika et al. 2020).

Davies et al. (2019) provides one of the few HCI studies on CFS, exploring digital devices for health management in CFS patients. Their patient-centric approach offers design recommendations for symptom management, highlighting the specific nature of the condition. However, their work also underscores the current minimal impact of HCI research on designing for CFS, particularly in addressing its social aspects.

In summary, this section has shown that CFS is a serious condition affecting millions worldwide, yet its social and medical dimensions remain under-researched in HCI. There is a need for HCI research to follow Vercoulen et al. (1994)'s dimensional approach. While progress has been made in the medical aspect, as seen with Davies et al. (2019), the social dimension has yet to be explored.

2.2 The Social Uses of Time: A Critical Perspective

This section will examine an important dimension of many people's everyday lives, which is time. Time is a diverse and ubiquitous phenomenon that is associated with various concepts and forms: clock time, calendar time, lunar cycles, solstices, colonial time, political time, and ancient time, to name but a few. The following sections will highlight some of these notions of time, but particularly how societies, more generally, can use time to orchestrate seemingly normative everyday practices and events.

Time discussed in this section, therefore, is within the context of society and will use the term social uses of time, rather than already present, but contested, concepts like social time. Social time was coined by Sorokin & Merton (1937), who aimed to turn it into a methodology for looking at social phenomena of time, introducing that social time structures derived from temporal tools such as calendars, are not solely based on quantifiable measurements of time derived from astronomical observations. Instead, social time incorporates a qualitative perspective, where communities, cultures, and social requirements create their own periodicity time phenomena, such as market days and lucky days (Sorokin & Merton 1937). The reference to social time refers to the following counter-arguments Subrt (2015), who criticises Sorokin & Merton (1937)'s notion of social

time. He argues that the concept of social time assumes that time is a human creation, but is deemed problematic in Subrt's eyes because the objective flow of time (past, present and future) is not a human creation. In other words, social usages of time are influenced by other times and Social time is not in isolation as its own form of time.

The following section does not look to sustain the theoretical concept of Sorokin & Merton (1937) Social time, nor Subrt (2015) counter to it; rather, to draw from one specific area of Subrt's argument on how social practices inform specific social realities. Emphasised by the following:

> "As people produce and reproduce social formations, institutions and social systems by their actions, they construct the individual parts of the social reality of their time." (Subrt 2015, 340)

He argues that these social structures of time would vanish if they were not supported by action. This implies that social structures of time depend on specific human actions to keep them alive. However, the disappearance of social structures governed through time might be nearly impossible due to the existence of time-reckoning artefacts such as clocks and calendars, which are used to measure and regulate time (Birth 2012, Glennie & Thrift 1996). Since the 1700s, clock time has been used to synchronize labour forces for industrial efficiency Thompson (1967), driven by the use of clocks to govern bureaucratic, institutional, and social systems (Hjärpe 2022) and subject to manipulation by those in power (Birth 2022). This lens grounds the next section, "Forming Temporal Norms," which examines how time practices are maintained and controlled to create specific social practices and how people's actions within them sustain certain temporal discourses. It also shows how these specific temporal practices can be problematic for some individuals when their 'social reality of time' does not match social expectations.

This is because within such social systems of time, people experience 'other times' Shipp & Jansen (2021), or subjective experiences of time. One reference for this type of time, is Flaherty (2003) 'time work', which is the ability to slow down or speed up a temporal experience. Though the ability of humans to align their subjective experiences of time with a standardised concept of time has been recognised as an accomplishment (Zerubavel 1982, pp 3), the main discourse for the following section emerges from the social frictions that arise from the inability to fully align the subjective with standardised temporal practises.

Time in all manners is a pivotal aspect of social interaction, structures, practices and knowledge embedded in artefacts and in the body (Adam 2013*b*). Making time a key part of social theory (Adam 2013*a*). And looking at social

uses of time, which can mean many notions of time used by societies, becomes important in understanding how such usages might have implications for certain people. The following sections discuss this in-depth, drawing on notions of Normative Time and Ablest Time. Further arguing the implications, as others have done, that certain notions of time, like clock time, create desirable times that everyone is expected to conform to (van Fenema & Räisänen 2005).

2.2.1 Forming Temporal Norms

One way to conceptualise time is as a quantifiable and measurable phenomenon that is used to coordinate social activities and expectations. Clocks and calendars are some of the most prevalent tools for organising people socially. Clocks use quantifiable units to help orchestrate the actions of people (Postill 2002, PP 251). Clock time is used to inform people of where, when, and with whom they must spend an allocated amount of time (Ilägcrstrand 1970). This is said to facilitate in combating anti-disorder through self-governance (Hjärpe 2022). In other words, clock time generates a sense of personal responsibility to be proactive and "fill up" allocated units of time (Lewis & Weigert 1981, PP 439). Calendars use a different approach to coordinate the collective actions of society. Namely, by drawing a number of people to engage in cultural or socially significant activities (Sorokin & Merton 1937, PP 626). Sorokin & Merton (1937) argued that calendar time was a different way of coordinating social activities, one that was independent of clock time and informed by the cultural significance of dates. Clocks and Calendars play an important role within societies. Even though many human subjective experiences are practised and calculated in a variety of ways, clocks and Gregorian calendars remain the standardisation of time. (Zerubavel 1982)

Time can be understood as emergent from social constructs that arise from the actions and expectations of individuals and collectives. According to (Moran 2015), "a time" is "a practice conducted by associated beings in a more or less regular manner" (Moran 2015, PP 289). However, while events and tasks can be repeated, the time in which they occur remains constant (Adam 2013*b*, PP 39). The regularity of practices, though never exactly repeatable, (Adam 2013*b*, PP 40) begins to constitute a sense of time through the actions of humans underpinned by social expectations. These expectations are based on the belief that people can adhere to daily routines and schedules (Van Tienoven 2019). As a result, a social temporal morality is established, where individuals depend on each other to follow certain temporal norms and practices. This leads to the formation and maintenance of social structures through shared rhythms

and routines (Giddens 1984). Even when people have temporal agency, their practices of time inevitably reproduce society's temporal norms and practices (Flaherty 2011*a*). This highlights the complex interplay between the diversity of what constitutes time. It is not only that of clocks but of rhythms, events, subjectivity and objectivity, and it all informs and is informed by social actions, beliefs, ideas, and expectations.

Institutions significantly create and maintain these social perceptions of time. Zerubavel (1976) argues that while people may seem to have control over their personal time, it is ultimately the institutions that decide when individuals are allowed to be "periodically suspended" at given times (Zerubavel 1979, PP 45). These structures have consequences for those who deviate from them. Failing to adhere to the normative expectations of society can result in social isolation (Aberra 2012, PP 22), with individuals being labelled as "dropouts," "enemies of progress," "loonies," or "trendy lefties," at the very least (Geißler 2002, PP 131).

Schools are a notable example of how institutional time operates and normalises set practices. Using a variety of temporal practices, particularly clock and calendar times, to deliver and denote when and how knowledge is exchanged (Birth 2012, PP 159). In these environments, time becomes an indicator of personal ability, with young people's learning abilities being assessed against temporal structures that denote success or failure (Compton-Lilly 2016, PP 584). Social infrastructures, such as schools, begin to manifest a sense of temporal normative expectation. Failing to meet these expectations can result in methods being deployed to synchronise an individual back to the desired temporal pace of learning (Compton-Lilly 2013). Adam (2013*b*) informs that the times of the school are not only embedded in notions of clock time but timings of sequence, such as when to learn certain topics and are defined as "norms for timing" embedded in the "unidirectionality of processes" in which there is a right time for everything (Adam 2013*b*, PP 66). To maintain these institutional temporal expectations, participants, as put by Adam (2013*b*), must suspend their personal temporalities and join collectively and synchronise. The time of the classroom is thus that of clock time and calenders but also, informed by "norms, habits and tradition" (Adam 2013*b*, PP 67).

In maintaining the institutional temporal norms and expectations of syncing as a collective, individuals can experience significant personal impacts. According to van Fenema & Räisänen (2005), personal impacts occur when the temporal demands of institutional organisations are misaligned with what individuals can offer (van Fenema & Räisänen 2005, PP 356). This is notable, in the "Long Hours Culture," senior positions often require longer work hours, disproportionately held by men due to the conflict between caring responsibilities and long work

hours, making it difficult for many women to hold similar positions (Rutherford 2001, PP 275). This leads to the question of whether individuals are able to meet the temporal demands of institutions. However, the ability to do so is not solely determined by the individual, but rather can be influenced by pre-existing systemic social inequalities. In other words, an individual's inability to meet institutional temporal demands may not be due to their own actions, but rather due to societal factors beyond their control.

Building on the idea of temporal inequalities, we can better understand inclusion and exclusion in society's communal spaces by examining time's role in it shaping of communities. Bastian (2014) offers a comprehensive view of temporal inequalities, referred to as 'Critical Temporalities'. Drawing from 85 relevant studies, Bastian examines how time usage, such as the futurity of a community, is connected to concepts of exclusion, such as those faced by indigenous and activist communities (Bastian 2014, PP 148). Time can be a tool for segregating individuals and is active in the formation of a community. However, time can also offer possibilities for transforming communities, opening them up in more inclusive ways, or shifting what 'community' itself means (Bastian 2014, PP 145).

To create a more inclusive society, it is important to examine the role of social perceptions of time. Specifically, we must recognise that certain time practices can shape individuals' subjective experiences and that these experiences can reveal underlying inequalities. Sharma (2022) argues that people do not experience time in the same way and that hidden social powers distribute time in a way that produces inequality. As a result, individuals must adhere to a "Temporal Order" by "recalibrating" themselves. However, the ability to recalibrate can vary depending on the social-political context in which a person finds themselves (Sharma 2022, PP 45). These inequalities are echoes of the past, shaping the subjective experiences of individuals in the present.Mills (2014) offers valuable insights into how this happens, by exploring the ways in which white, Western colonial oppression has stolen time from non-white individuals. This has resulted in the extension of white time at the expense of non-white time (Mills 2014). Flaherty (2011*a*) calls the taking of time to make it one's own "Temporal appropriation" (Flaherty 2011*a*, PP 7).

Access to social normative and in retrospect being deemed normative is having access to the times that frame a society's ideals. One of these concepts is linear time, which implies a chronological order of events that the body and mind are expected to go through, such as child to adult, marriage to reproduction, work to retire, and birth to death. This concept is also known as chrononormativity (Freeman 2010*b*). Deviations from this order or practising it in

a non-linear fashion is deemed deviant (Ljuslinder et al. 2020). Following each step correctly unlocks new temporal possibilities, for instance, legally drinking to extended vacations after retirement (Wanka & Prescher 2022). Chrononormativity upholds a heteronormative temporal ideal, expelling many to experience the ideas within linear time as non-normative times, such as Queer-time.

Queer-time is defined by Halberstam & Halberstam (2005) as an experience of time that involves leaving chrononormativity, including bourgeois reproduction, family longevity, risk/safety, and inheritance (Halberstam & Halberstam 2005, PP 7). Queer-time emerges from people's experiences at friction with dominant expectations of life discourses. It is not the only temporal experience that differs from the norm. For example, research by Shirani & Henwood (2011) showed that couples who did not conceive children due to fertility experienced time differently from their counterparts who did. They felt a sense of non-control and not happening at the right time (Shirani & Henwood 2011, PP 53). Non-normative time, therefore, is the experience of anyone when the normatively expected times that regulate when bodies should execute set actions do not occur, for whatever reason.

However, time is not the sole perpetrator of these inequalities; it is the social ideologies, concepts, and norms infused into it. As Adam (2013*b*) puts, it, 'good' and 'bad' times for action are not solely derived from quantitative calculations of time, e.g. clock times, calendrical time or linear time. Many factors are involved in determining the 'right' time to engage in certain activities, ranging from the socio-political landscape to the qualitative makeup of people, the past, the future, culture, and seasons. "They all come together to be inextricably interwoven in judgments about what constitutes the 'right' time to engage in certain activities" (Adam 2013*b*, PP 22). Nevertheless, the formation of the 'right' time puts pressure on people or inability of people to execute the ideals embedded in how notions of 'right' time came to form. Often, these notions are derived from "Historically specific regimes of asymmetrical power" (Freeman 2010*a*, P3).

Time is a complex concept influenced by various factors, including context, culture, and personal experiences. It can be both reproducible and non-reproducible, depending on how it is governed. It is not only measurements but subjective, where personal agency can be met with frictions to participate in collective standardisations. Morals and expectations are imbued within its concepts, and consequences are felt if misaligned with the norms that underpin it. Time is implicit in the formation of inequalities, but only through the ways societies shape and embody the ideologies infused with time. As Bastian (2014) suggests, time is a variable in understanding issues within communities. Therefore, to critique normalised ideas of time, it is necessary to consider the contexts in which they

are practised. This allows for the exploration of how social uses of time can lead to marginalisation and isolation, which will be further discussed in the next section.

2.2.2 Ableist Time: How Social Structures and Norms Disable People with Diverse Temporalities

Ableism is defined as the “Unfair treatment of, or negative attitudes toward disabled people” (Oxford, 2022). Ableism, as inferred by Wolbring (2008), highlights that the ‘ism’ to the able has to be understood as “Something we value and something we do not” (Wolbring 2008, PP 252). Ableism toward disability is a form of support for the socially “desirable” body that engenders a “Species-Typical Normative” (Wolbring 2008, PP 253). The concept of species-typical is produced through a socially constructed network of ideas about self and body that formulate an idea of the whole that views disability as a lesser state (Campbell 2001). In essence, it is the exclusivity of a few to operate within social, economic, and political discourse that perpetuates systemic ideas that lead to ableist practice and biased social structures. Thus, anyone who does not fit the dominant norms of ability can face discrimination and marginalisation in various aspects of life.

However, ableism is not an isolated experience for disabled people according to (Wolbring 2008), it can be subjective to anybody and mind that experiences an inability to do something within society. This is not to be confused with the body and mind at fault, rather, and according to the updated example of disability by the World Health Organisation report, it is the social structures that disable people. “Disability results from the interaction between individuals with a health condition, such as cerebral palsy, Down syndrome, and depression, with personal and environmental factors that include negative attitudes, inaccessible transportation and public buildings, and limited social support” (World Health Organization 2021). This update aims to reshape the once-placed experiences of disability as an individual problem and instead indicates that health is a varying experience by many, and the inaccessibility of society is the curator of disability. First to draw on this concept were Sociologists, Oliver (1983) who termed this the social model of disability. This model shifts the focus from the medical model, which views disability as an individual problem that requires a cure, to a social one in which personal impairment is separate from socially created disability (Davis 2016). As such, disability should not be considered an attribute of a person, but rather a creation of society. The systemic ableism present in society has led scholars and activists to reclaim the word “Crip” (McRuer 2006).

Formulating into its own theory, Crip theory represents “overlapping struggles for social justice” (McRuer 2014, 532) and transforms a term with a derogatory history into an activist stance on the marginalised experiences of disabled people imposed upon by social and governmental discourse.

Recently, disabled and allied scholars have used the repurposed meaning of Crip to explore narratives of temporality and the social uses of time, formulating the concept of Crip time. This stance argues against the ableist uses of time by society. When social uses of time are standardised and practised as a sense of normative human organisation, it becomes problematic for many who cannot conform to specific notions of time. These practices become disabling for bodies and minds. Katzman et al. (2020) informs us that the Crip times of people are not quantifiable units; the times of bodies and minds are not subject to standardisation. Crip time is not the removal of times; it is a critique of the social, political, and economic values of time that affect the values of diverse bodies and minds. It is about exclusion and inclusion. Crip time is about understanding the extra times that comes with health and disability. As Kuppers (2014) demonstrates: the qualitative experience of time moving within one’s life, rest time in bed, the time when pain is prominent, and the street that is too long and too far for a body that might physically struggle with distance and speed, all while trying to regulate to standardised notions of time (Kuppers 2014, 29). Thinking about Crip time means going beyond giving “more time”; rather, it challenges the normalisation of temporal expectations placed on minds and bodies to operate at a set pace and within set schedules (Katzman et al. 2020, 521).

Bodies and minds are often connected to important social institutions that carry with them ideologies of where and how a body should be at a given point in time, becoming distinct when drawing back on Freeman (2010*a*)’s chrononormative concept. For people with health conditions who do not conform to normative temporalities, medical institutions reflect these chrononormative ideals through language such as regression or medical intervention. This language and action inform people of their inability to keep pace with the execution of temporal norms, as stated by Samuels & Freeman (2021*a*, 245). In other words, institutions imply that the body and mind are not where they are supposed to be, not executing the ‘right’ time. These ideas of temporality can become harmful. Kafer (2013*b*) found that intrusive medical intervention uses linear time to build a case about a person’s future to justify bodily and cognitive modifications on the person in the present. The future body, yet to become, is conceptually scrutinised against the backdrop of linearity and uncertainty to excuse the actions of the present.

However, Crip time defies linear notions of being and doing, as well as het-

eronormative or reproductive discourses, ageing discourses, educational timelines, and more. It is defined by Samuels (2017) as “Time Travel,” where speed is interchangeable between acceleration and deceleration, where immediate stops and starts occur, where the end of life is sudden, and where old age is felt young or those who are older are treated as children. For some, linear time becomes “Folded time,” where past lessons fold into present actions that dictate the procedures of the future (Brilmyer 2022). This indicates the context in which bodies and minds find themselves in notions of time.

It is not that the concept of linear time is wrong; many, like Brilmyer (2022), use it as a foundation to inform health practices based on past lessons and guide health moving into the future. Rather, it is the ideologies embedded in time that allow ableism to emerge. This is due to a lack of understanding about how people with health conditions experience time and how time is used to inform or change the disabled experience, sometimes devoid of personal agency, e.g. intrusive medical practices Kafer (2013*b*). Social and personal experiences of time, therefore, could benefit from the perspective of Price (2021), who states, while time may be a healer in some cases, it is also important to consider how it can be harmful.

Even in linear time, changes in health can create a new sense of time, where our preconceived notions of the future are no longer possible, and our past self is different from our present self. Through the lens of Crip time, this might better be considered as what Sheppard (2020) describes as Liminal space. The becoming of ill, the new times associated with changes to health, and new routines to access normative expectations all represent movement between normative and non-normative temporalities. This is something that can become the experience of many for various reasons. At any time.

A common reminder by the disabled community is the acronym TAB, which stands for Temporarily Able-Bodied (Kafer 2021, 418). For Sheppard (2020, 41), Crip time is not exclusive to disabled people and can be understood when anybody and mind fails to conform to normative expectations. Samuels & Freeman (2021*a*), the recent disruption of normative social temporal rhythms by the Covid-19 pandemic demonstrates that whole societies can become Crip time. The daily challenges faced by people with disabilities became simultaneous challenges for many throughout society. The time required to learn new technologies, the experience of unstructured rhythms, and the temporal agency governed by a virus with emergent mental health or physical health experiences meant that Crip time became the central and normative social time. This demonstrates that Crip time can become the experience of individuals or societies when people or societies can no longer engage in normative temporal discourse, or when

normative temporal discourse itself cannot dominate due to itself producing new times centred on narratives of health.

It is important to note that, according to McRuer (2018), Crip time is a verb. When Sheppard (2020) describes anyone as living in Crip time and when Covid-19 is described as being Crip time, these are notions of a sense to Crip something. This means that a normative temporal experience has shifted, and in its wake, new temporal experiences emerge, for better or worse. Crip was once used in an oppressive sense to denote the de-normalized aspects of bodies and cognition, to eradicate or demonize people (McRuer 2020). Therefore, in the present sense of the word, when it is said to Crip or Crip time, it is to reveal the de-normalised against the backdrop of dominant normative. However, it does so in a way that reveals and argues for diversity, social justice, and social empathy towards human life, which within those lives have diverse temporalities that require inclusion within societies. This is why any person, with or without a health condition, can experience disability when their temporal experience is not that of the norm, this is why any person, whole societies, communities, or groups of people can be in a notion of Crip time.

Crip time exists to argue for the rights of diversity that are constantly de-normalised by social views and social temporal practices. Baril (2016) explains this from the lens of transition, where there is not only a temporal normative but also a gender-normative that Baril calls Cisnormative. This integrates into Crip time and is considered Trans-Crip time. Baril explains that the time associated with medical interactions, social and legal blockades, and ignorance of people can be a Crip-time experience. Ideas of cisnormativity impose a forced identity on one's body and experience (Baril 2016). Baril indicates, like Sheppard (2020), that Crip time is a way to position an understanding of the social, temporal, political, infrastructural, and economic imbalances that impose barriers on ways of being. Any person facing social obstacles, health or otherwise, lives a Crip experience of time.

An important aspect of Crip time is understanding how time is used within social infrastructures to generate differential treatment. Inevitably, space becomes a part of this discourse. Nespor et al. (2009) explores how time and space are used to create differential treatment of people with disabilities. Nespor et al. (2009) reports on how children with disabilities are removed from classroom spaces, forming temporal experiences different from those of the majority of children who remain within the classroom setting. Taking this into account, Nespor et al. (2009) shows that societies actively practice the removal of bodies and minds from spaces, which produces exclusionary behaviours of people from social settings. In some cases, the removal of people from spaces is done

as an institutional practice to give a person “extra time” to catch up (Compton-Lilly 2013) or to “bridge” the gaps between disabled and non-disabled people. Something Price (2021, 272) explains as “Crip spacetime.”

Crip spacetime refers to the well-intentioned but sometimes misguided actions of institutions to create accommodation practices. These practices can either further remove disabled people from social spaces or involve a complex bureaucratic process, requiring individuals to repeatedly justify their need for accommodation. Being believed and having access to social rights is a significant part of the Crip time experience. As Sheppard (2020, 43) describes, people may wish to negate the symptoms of their bodies not only to ease physical and mental pain but also to avoid the experience of disbelief that hinders access to social needs and requirements. This can lead to social exclusion and the need for what Samuels (2017) might classify as the rehabilitation of bodies: fixing the body to regain access to society.

Therefore, accommodation, social requirements, and accessibility can take a lot of time to convince others in order to receive what the person requires. It can lead not only to further separation between people with health complications but also further separation between different types of health conditions, depending on the level of social disability and whether a condition is visible or invisible, physical or cognitive. In other words, spaces are occupied by active strategies performed by people to hide or manage the invisible aspects of their bodies and minds that remain hidden due to the lack of accommodation by institutions for the acceptance of diversity and the existence of invisible conditions (Cepeda 2021, 316). Temporal diversity becomes experienced when spaces do not effectively support the visible and invisible needs of people.

This lack of support for the diverse needs of people extends beyond physical spaces and into socio-economic discourse. Health narratives become entangled with socio-economic discourse when the socio-economics of a society position value on disregarding personal health requirements as practices that get in the way of what Kim & Schalk (2021, 340) described as “Capitalistic imperatives.” In this sense, health and the maintenance of well-being are negated in favour of production and consumption. It is a problem requiring “Radical politics of self-care” (Kim & Schalk 2021, 340). Care, in accordance with the “Pedagogy of Unwellness” coined by Khúc (2021, 370), notes that unwellness is not a static notion of being; it is a diversity of differential degrees, in which social structures can be disabling or enabling of bodies and minds, who otherwise require practices of care to adequately akin to the diversity of unwellness. Ideas of care and temporality are themselves institutionalised, where care is quantifiable, initiated by units of time, which regulate caregivers and remove the subjective temporal

agency of the care receiver (Lanoix 2013). That is, there is a time to bathe, eat, sleep, and take medication based mostly on the 24-hour clock rather than the individual's bodily needs.

Alternative notions of care not institutionalised do not infuse with capitalistic temporal ideas, which disregard individual pace and individual time associated with care. According to Bailey (2021, 286), there is an ever-increasing capitalistic demand for production and consumption that generates the sense that bodies should accelerate and perform according to a specific expectation that produces disability. A central argument of Bailey (2021) is to consider the "Ethics of Pace," in which the role of jobs should contend with scrutiny of social necessities; furthermore, it stands for valuing the pace of body-mind over political, institutional, or economic temporal discourses. Regardless, capitalistic narratives often disregard the ethics of bodies when the same systems produce propositions of ways to be. For instance, Pyne (2021) describes how neurotypical time is the normative and most beneficial to capitalistic narratives, where "autism advocacy" symbolizes slowness and harm to the economics of society. Pyne (2021, 349) also see McGuire (2016).

Manifesting ideals of linear living can drive our body and mind to conform to quantified notions of time. We may find ourselves thinking and moving at a set pace, being told who or how to be. We may even wish away parts of ourselves in order to fit in. This is all part of what is known as Crip time. Kafer (2013*b*) explores this concept further by asking questions such as: How do disability and illness generate new temporalities? How does social ineptness engender ableism when public services do not support a person sufficiently? How are some spaces non-accessible to some but accessible to others, infusing notions of different temporal orientations? Or, how do public services like disability support demand people to be, live, maintain and be scrutinised over accepting the status of disabled. (Keates et al. 2000, PP 104). Crip time, among many things, is therefore also a time made for a person by institutions in order to access needs and requirements.

In summary, Crip time is a lens through which we can critique the ableism that many people encounter due to dominant concepts of normalcy. These concepts apply not only to physical and cognitive abilities, but also to the temporal orientations within which our body and mind operate. Crip time argues for the inclusion of anyone who cannot conform to normative temporal practices and informs them that it is not their fault, but rather a problem embedded in society. While much work has been done by Crip theorists, more research is needed from other domains to question whether and how these disciplines might be engendering specific notions of time that lead to ableist temporal practices

and actively exclude certain people or even society as a whole. It is important to understand that social ideals embedded in time can be products of exclusion, and Crip time can act as the lens through which to reveal them.

2.3 Time as a Narrative for Inclusive Designs.

The previous section discussed how social uses of time can become ableist and marginalising, leading to the discussion of Crip time. Crip time is a social science and activist stance on how such uses of time can exclude people experiencing health or physical impairments, leading to socially created disabilities through inaccessible time structures. While inclusion is an important and emerging design thinking that has influenced HCI, the field could benefit from framing its concerns for time as a concept of exclusion from a Crip time perspective.

Crip time is an expansion of the overall concept known as Crip theory, which has begun to make a presence within the field of HCI. Crip theory challenges concepts of normative and non-normative dichotomies as socially curated and ableist, and refers to the promise of a more inclusive society (McRuer 2006). Crip HCI, as referred to by (Williams et al. 2021), looks to incorporate the teachings of Crip theory into HCI research and practice in order to create a "more just, more humane HCI practice" (Williams et al. 2021). To date, Crip time is under-researched in HCI and has not yet warranted research for understanding Crip HCI researcher temporal practices within the community or for understanding how Crip time can expand the current and lasting HCI approach to inclusion. This section provides an overview of the rich history of inclusive design and the role that HCI has played in its development.

2.3.1 Designing for Inclusion

Design is a multifaceted field that plays a crucial role in promoting inclusivity, but it can also enable exclusion. Victor Papanek critiqued design for its potential to have significant societal impacts on people and places. He argued that design "excludes major sections of the population" (Papanek & Fuller 1972, PP 137). Designers are responsible for many aspects of society that involve human interaction. Selwyn Goldsmith's book, *Designing for the Disabled* (1963), brought attention to the importance of considering the anthropometric aspects of wheelchair users when designing buildings and social spaces. This has been defined as shaping a change towards visible impairment and demonstrating how design can remove socially disabling encounters (Williamson & Guffey 2020,

PP 5). Although many of Goldsmith's ideas do not align with contemporary views on accessibility (Guffey 2020, PP 447), his focus on the role of design in shaping narratives about disability continues to be valuable. By exposing social shortcomings that exacerbate affect the disabled experience and emphasising the impact of design on inclusive social practices, his work has benefited many.

According to a recent analysis of inclusive design history by (Kille-Speckter et al. 2022), the origins of the terminology inclusive design can be traced back to 1994. Inclusive design emerged as a distinct practice at a specific historical moment, building on the pre-existing momentum of design for disability and social and technological innovation and reform (Kille-Speckter et al. 2022, PP 3). The evolution of inclusive design has been influenced by prominent figures such as Victor Papanek, Selwyn Goldsmith, Henry Dreyfuss, and Robert Coleman, who coined the term that was later adapted by Ronald Mace to form the concept of universal design, mostly used in the USA. Therefore, (Kille-Speckter et al. 2022) argues that inclusive design should be considered in relation to narrative analysis, as it derives its meaning from the changing social and political understandings of disability that design plays a role. (Kille-Speckter et al. 2022) traces precursors of inclusive design back to 1794 with George Hepplewhite's Gout Chair. Overall, the history of inclusive design has been an evolving way of designing for narratives of disability that are interconnected with social, political and interdisciplinary research domains such as disability studies.

The current narrative of inclusive design is that it is not a design speciality, but rather a conscious approach that all designers should adapt to make their products as usable as possible by a diverse range of people, regardless of ability (Clarkson & Coleman 2015, PP 235). Based on the understanding that disability is socially created by the barriers people encounter, design can be a factor in creating or reducing disability. (Clarkson & Coleman 2015) suggest two ways to counteract the role of design in creating disability. First, designers should not assume a normative standard for bodies and minds, but rather acknowledge and accommodate the diversity of human abilities. Second, designers should adapt the social surroundings that form barriers to make them more accessible and inclusive. Failing to follow these suggestions means that design becomes an active contributor to creating disability (Clarkson & Coleman 2015). To avoid this, designers need to adopt an inclusive mindset that considers the diversity of human abilities and needs.

However, the responsibility for adopting an inclusive mindset should not rest solely with designers, but should be shared by many areas of society. However, there may be misconceptions about inclusive design among social sectors and institutions, such as it being costly, technically challenging, lacking in guidelines,

or compromising aesthetics (Dong 2004). Designers can support the shift towards an inclusive design mindset by not only creating inclusive products, but also by developing methods and tools that promote the values and principles of inclusive design thinking and practice within various social sectors. An example of this is the I-Design toolkit by Dong et al. (2005), which aims to shift perceptions and develop guidelines and practices for inclusive design

Nevertheless, despite the challenges some organisation face in considering inclusive thinking, many others have demonstrated an embrace for an inclusive philosophy and are leading the way in emphasising the importance of inclusivity in their operations. Jutta Treviranus founded the Inclusive Design Research Centre in 1993 [1] and works with students, companies, and communities to promote inclusive design practice using technology as a tool for social inclusion. Other institutes, such as the International Association for Universal Design (IAUD) [2] in Japan and the Design for All Institute of India [3] have followed this trend since 2003 (Clarkson & Coleman 2015, PP 244). Microsoft is an example of a business that has made inclusive design a fundamental part of its design ethos and has created an inclusive design guide that anyone can download (Microsoft 2020).

As more people interact with computers, Human-Computer Interaction (HCI) researchers have taken a leading role in promoting inclusivity in the HCI field. Since 1995, inclusivity has been a concern for some HCI researchers, prominently Abascal & Nicolle (2005), who have provided important works on inclusive HCI guidelines and educational teachings for HCI designers. They argue that inclusive design in the context of HCI involves creating products and systems with embedded flexibility to accommodate the diverse needs of users (Nicolle & Abascal 2001, PP 3). Their approach critiques the distinction between accessibility and inclusivity, as accessible design can carry negative connotations by implying that users are incapable of using a product when, in fact, it is the product's lack of diverse functionality that creates an exclusive experience.

This exclusion can lead to the creation of a "craft industry" to make the product usable (Nicolle & Abascal 2001, PP 143-144). In this sense, accessibility can be seen as an add-on to a product or service that has not adequately considered its users. The key takeaways from Nicolle & Abascal (2001) suggest moving away from a medical model that focuses on changing the individual or providing additional technology to aid them within their environment. Instead, inclusive HCI design should aim to change the environment to accommodate a diverse range

[1] https://idrc.ocadu.ca/
[2] https://www.iaud.net/global/
[3] http://designforall.in/

of individuals who share the same spaces and interact with the same products, services, and tools

A specific role that HCI plays in the inclusion of people in the products they use is the prevention of digital exclusion. This means that products with user interfaces and user experiences should be usable or adaptable even when considering alternative equipment that might be required to use them. (Abascal & Nicolle 2005). When technologies and tools are designed to be inclusive of a diversity of accessibility requirements, they can lead to enhanced social interaction and inclusion that goes beyond the technology itself. (Abascal & Nicolle 2005, PP 491). This implies that inclusive technologies can foster inclusivity across the broad social environments that people interact with and depend on. HCI and its concern for technological inclusion has stimulated discussion on social, political, and economic inclusion (Strohmayer et al. 2019), demonstrating the interconnection between technological and social narratives. While the notion of inclusivity from the perspective of HCI is understood, it is the research practices of the community that highlight the importance of inclusivity when contextualised to a specific research goal. Doing so reveals the inequalities that exist.

For example, Metaxa-Kakavouli et al. (2018) show that women can experience exclusion from webspaces due to biased masculine web design. They propose interventions using gender-neutral interfaces to increase women's inclusivity in these spaces. McHugh et al. (2021) focus on the potential exclusion of those who might not hear music from music streaming technologies. They re-imagine what "listening" is by using vibration and visualisation as an inclusive intervention for deaf and hard-of-hearing people. Gender affirmation within some trans communities can be crucial to countering deniability and potential harmful situations. Voice training, supported by technology such as pitch apps and online learning platforms, was one area that helped achieve social and gender affirmation goals (Ahmed 2018). The researcher provided novel voice technology recommendations based on their in-depth research with transgender people, with the goal of producing anti-oppression for transgender people in social encounters. Sobel (2016) explored how technology can support play and inclusivity for mixed-abilities children. Research into inclusive design within the field of HCI has shown that using specific research approaches with particular demographics can generate recommendations that expand, critique, and make technology and its designs more accountable. This can help bridge the intersection of social, personal, and technological inclusion.

However, inclusive design can be a fine balance. Designer's approaches to inclusive technology can sometimes have unintended negative consequences. Spiel et al. (2019) critically explore this issue by demonstrating how the rising

number of HCI assistive technologies for children with autism aim to conform these children to an idea of social normativity, approaching neurodivergent people as needing to be "cured." This work highlights the potential downsides of HCI and accessible technology, further informing Nicolle & Abascal (2001) work in showing how following normative discourse can force a person into neurotypical ideologies as the "right" way to be. Spiel et al. (2019) framework encourages offering children with autism forms of agency, which can help move HCI research in this area away from steering a specific 'normative' narrative.

However, inclusive design can sometimes be used as a tool by those in power to decide which narratives of inclusivity are explored, based on the benefits they receive. This is known as "Concession to inclusive rights" (Ogbonnaya-Ogburu et al. 2020). Ogbonnaya-Ogburu et al. (2020) argue that this is underpinned by a backdrop of neoliberal technologies that propagate racism and exclusion. Moreover, researchers are arguing to go beyond what has become a single-axis approach to narratives of inequality, such as focusing only on disability. Sum et al. (2022) state that we must not view social inequalities like ableism as a single-axis issue, but rather as overlapping with other forms of marginalisation. This means that individuals who experience disability could also face other forms of exclusion, such as systemic racism or gender inequalities. As such, there is a need for HCI to consider the diversity of inequalities that individuals within an overarching demographic group might face.

These emerging lessons on thinking about inclusive design are rooted not only in the practice of conducting inclusive research, but also as a discourse of institutional learning. Petrie & Edwards (2006) argue that teaching about disabled users within curriculums is important for designers to expand inclusion. HCI inclusivity often centres around the narratives of ageing and disabled people. However, when designing for the inclusion of disabled users, the solutions can often be effective for other demographics, such as children and older adults (Petrie & Edwards 2006). These solutions can also work for people who might temporarily experience disabling situations. For example, a solution for someone with visual impairments could also work for someone whose eyes are affected by bright sunlight. In short, solutions for disabling situations can help many people. In HCI design, this is known as "Disability Interaction" (DIX), which recognises disability as a source of innovation (Holloway 2019). DIX is an approach that uses HCI methodologies to understand the interaction between people with disabilities and technology, and the experiences that arise from technological use (Holloway & Barbareschi 2021). Furthermore, DIX highlights the diversity of disabled experiences, where one solution might work for one person but have a negative impact on another. This is an important consideration

when embracing the inclusive design ethos of 'Design for all'.

Inclusive HCI is not just about creating technologies for disabled people, but also about making the tools and knowledge required to produce inclusive technology accessible to all. In the global effort to teach children coding, (Morrison et al. 2020) saw the inclusion of children with visual impairments as important and developed a tactile computer language for them. Access to the tools that produce much of the digital technological space is an initiative of many (Baker et al. 2015, Sánchez & Aguayo 2005, Smith et al. 2000). Finding methods to include a diverse range of people in researching and designing technologies can support the presence of diversity within HCI spaces through the design outputs produced by diverse individuals. This, in turn, can better inform HCI research and practice surrounding inclusive HCI and an inclusive society. It is therefore about making the HCI space accessible to disabled researchers.

In recent years, Crip theory has begun to make its presence felt within the field of HCI. Crip theory refers to the promise of an inclusive society and challenges concepts of normative and non-normative dichotomies as socially curated and ableist (McRuer 2006). Crip HCI, as referred to by (Williams et al. 2021), seeks to incorporate the teaching of Crip theory into HCI research and practice with the aim of creating a "more just, more humane HCI practice" (Williams et al. 2021).

However, despite rising attention to Crip HCI, Crip time is an under-researched area in HCI. Nevertheless, a few researchers are exploring its concept in relation to technology and the temporal self. For example, the notable work of Forlano (2017) explores how the disabled cyborg body can be an epistemic site of feminist science, drawing on her own experience of using networked technologies to manage Type 1 diabetes. Crip time within Forlano (2017) work is broken into four notions of time: slowing down, speeding up, liminal time, and sharing time, that are aligned to notions of data rituals. Self-reflection on the disabled body in relation to the constraints and affordances of time, meant for the "Rethinking of existing categories" (Forlano 2017, PP 23). Most notable is the notion of shared time, where rituals and patterns, invoke close members to check in on one another, producing a sense of empathy. The work by (Forlano 2017) examples how the living experiences of times are cause for HCI exploration. Through Forlano (2017) work, an embodiment of inclusivity is produced simply through the revealing of diverse notions of time and technologies role within such temporal practices.

However, more work is needed in this space. Crip time is under-researched and in its revealing of diverse experiences of time with regard to technology has a disconnect towards the push for inclusive design within HCI. While this

is not a gap that can be filled by one researcher, it is one that through time and using Crip time as a lens of enquiry could produce countless insights into making a more equitable social landscape driven by technologies that align with the diverse requirements of people including their experiential relationships with time.

2.3.2 Designing for Time's Multiplicity in HCI

Social Science has played an important role in defining temporality within design and HCI discourse within recent years. A notable and direct cross-over of social science temporal studies with design can be found in the Temporal Design framework. Temporal design is a framework produced by Pschetz (2014) and later extended by, Pschetz et al. (2016) and Pschetz & Bastian (2018) that draws on social science research to centre an argument for time to be considered as multiplicity. In other sentiments, multiplicity is to understand time as nuanced and beyond that of clock time or calendar time.

Arguments for multiplicity are based on the idea that much of the Western world still views time as mathematical or numerical. Lewis describes this as time that "marches on in relatively homogeneous units" (Lewis & Weigert 1981, PP 433). According to Birth (2007), time is often seen as homogeneous, linear, and measured by clocks and calendars. In other words, it is measurable, repeatable, and external. Throughout most of HCI history, objective time has been considered in this way (Rapp et al. 2021). This has led to technologies that standardise these notions of time across global communities Birth (2017). However, standardising time can be problematic because it sets a precedent for what is considered 'standard.' This can lead to expectations for people to align with the standards set by technologies that represent notions of time. For example, trying to determine the standard speed at which a person should interact with technology, such as the correct human response times for computer inputs (Dabrowski & Munson 2011). The literature previously covered has shown the marginalising complications of trying to standardise people to normative social (Compton-Lilly 2013, Aberra 2012), technical (Spiel et al. 2019, Nicolle & Abascal 2001), and temporal discourse (Kafer 2013*b*, Lanoix 2013, Freeman 2010*a*).

Designers within HCI in recent years had begun to move against ideas of time that become dominant and mainstream. For instance, a common dominant notion is that society has become accelerated due to technology's ubiquitous presence (Rosa 2003), leading to a squeeze on people and their time (Southerton & Tomlinson 2005). HCI researchers have countered these critiques by demonstrating technology's capabilities of incorporating notions of

slowness (Odom, Selby, Sellen, Kirk, Banks & Regan 2012) and data reflexivity (Gulotta et al. 2013) to enhance a sense of presence when interacting with technology. Such practices, in response to acceleration, have been noted as being slow design (Strauss & Fuad-Luke 2008, Grosse-Hering et al. 2013) or slow technology (Hallnäs & Redström 2001). Which has expanded to address generational, mental health and consumption narratives (Odom, Banks, Durrant, Kirk & Pierce 2012).

Temporal design acknowledges the multiplicity of time, but it does not position itself solely as a counter to dominant notions of time, such as clock time or accelerated time. Instead, it recognises that counters to these dominant notions can limit our understanding and expansion of the meaning of time. For example, reducing time to a dichotomy of fast and slow does not expand our understanding of time beyond these two concepts (Pschetz & Bastian 2018). This can cause designers to perpetuate specific ideas of time and reduce the potential for design to explore the complexities and contexts of time. This is an extension of the common categories of objective and subjective time. Temporal design emphasises the importance of not separating objective and subjective time into either-or dichotomies. Instead, it suggests understanding time as emerging from "the complex relations between material, cultural, social, economic, and political forces" (Pschetz & Bastian 2018, PP 174). This means that time is more than just clocks or fast and slow; it is a complex phenomenon interwoven into the social fabric.

Nevertheless, HCI and designers within temporal research have found it important to isolate and emphasise subjective temporalities to reveal the diversity of time experience and to take a stance against standardised notions of objective time. For instance, Yildiz & Coşkun (2020) focused on the perception of time among design researchers. They gave each researcher a standard concept of time and found that each had a different subjective meaning and understanding of it. This led them to argue that HCI requires more input into design comprehension that supports the subjectivity of people's inferences of time. The consensus is that HCI research is beginning to move away from objective notions of time and towards multiplicity (Rapp 2022, PP 1). This is evident in HCI research spanning topics such as ageing (Karaoğlu & Subaşı 2021), death and memory (Massimi & Baecker 2010), social rituals, festivities, local rhythms, and cultural approaches (Taylor et al. 2017).

However, not all HCI domains have embraced the multiplicity of time. One area that still relies heavily on objective and standardised notions of time is digital calendaring. Such technologies have a long history of organising and regulating people according to clock and calendar-based time (Palen 1999, Mynatt & Tullio

2001, O'Hara et al. 2003). These technologies have begun to rely on novel systems and machine learning capabilities (Faulring & Myers 2006, Tullio et al. 2002). As a result, advancements in smart technology have been integrated into various aspects of people's lives, such as the home (Mennicken et al. 2016), perpetuating objective conceptions of time.

Despite early critiques on the problems of visible social organisational technologies (Palen 1999), these technologies continue to reject the subjective experience of people when optimising for coordination (Uhde et al. 2020). This creates inequalities in people's temporal experience when interacting with such systems (Janböcke et al. 2020) and results in a lack of control over a person's expression of time (Leshed & Sengers 2011). Furthermore, dominant pursuits of time and social organisation in HCI have been linked to exclusionary practices and the active hiding of alternative temporal experiences Bowler et al. (2022).

Considering how time is understood in HCI is important, especially when taking into account tools and technology that intersect with other HCI pursuits such as inclusivity. Lessons can be drawn from Temporal Design on matters such as time and inclusivity. At its core, Temporal Design argues for the exploration and revelation of people's nuanced experiences of time, which are often overshadowed by societal concepts of time that favour the orchestration of groups rather than the priorities of individuals (Pschetz & Bastian 2018, 171). The Temporal Design framework suggests that a designer might be able to reveal social exclusions occurring through inequalities produced by dominant social and cultural temporal practices (Pschetz & Bastian 2018). In other words, by understanding specific social temporal concepts, a designer can pursue notions of inclusivity.

Temporal Design situates its call to action within the following framework: 1) Identifying dominant narratives, including the forces and infrastructures that sustain them or which they help to support; 2) Challenging these narratives, for example by revealing more nuanced expressions of time; 3) Drawing attention to alternative temporalities, their dynamics, and significance; and 4) Exposing networks of temporalities, to illustrate multiplicity and variety (Pschetz & Bastian 2018). Overall this framework looks to designers to reveal, critique and design for the multiplicities of time. This call has not gone unnoticed, with designers exploring 'Deep time' to, connect human-computer interaction with geological time, which can highlight new ways of understanding time and materials. (Rahm-Skågeby & Rahm 2022, PP 25). To researchers considering, the rupture of pandemic times, on how time became re-imagined during the first stages of Covid-19 Lyon & Coleman (2023). This shows that temporal research insights produced from a design and HCI lens extend out into other social, geological and biological complexities that are revealed to have with them their own multiplicities

of time.

The pursuit of multiplicity time continues in HCI. A milestone in this recognition can be found in the works of Rapp et al. (2021), who report that work within HCI continues to shape the community's temporal understanding. They point out that time is a complex phenomenon that requires rigorous research to reveal its immersive nature. Recently, designers following the notion of Temporal Design have turned to probes to explore the social infrastructures of time Pschetz et al. (2022). In this work, Pschetz, Bastian, and Bowler argue that the infrastructures of time are not natural, but rather the result of "significant work by time meteorologists and others to produce an infrastructure that meets the needs of key users interested in precise time" (Pschetz et al. 2022, PP 256). They note that big corporations have come to produce temporal infrastructures, and when small changes to time occur, the impact on society often goes unnoticed. They argue that "our temporal imaginary, where time is seen as universal rather than infrastructural, is ripe for challenge" (Pschetz et al. 2022, PP 261). They suggest that more methods are needed to shift our thinking from time as universal to time as social and institutional. While this work does not address institutional social time that can be marginalising as Crip time does, it does however highlight the importance of designers in revealing social constructions of time. That in theory, through their practice, can reveal social inequalities. However, how this looks in practice is under-researched. While Rapp et al. (2021) argues that HCI should develop its own temporal theories instead of relying on those from other disciplines, there are still gaps in our understanding of the potential benefits of interdisciplinary crossovers for temporal studies in HCI. One potential area of research that requires further exploration is how social exclusions can be revealed through the lens of Crip time theory, and the potential impact this could have on expanding inclusion in HCI research.

2.4 Navigating Uncertainty In Human-Computer Interaction

The next section introduces the multi-encompassing meaning of uncertainty as natural, subjective, and often seen as something to be pursued and controlled. It sets up the point that in narratives of HCI design, uncertainty is often positioned in two ways, needing to be reduced or embraced, which could be problematic as it begins to dichotomise our understanding of uncertainty, leaving a more nuanced understanding of people's uncertainty experiences unexplored.

2.4.1 Uncertainty: A Multidimensional phenomenon

Uncertainty is a complex phenomenon that has been explored by many research fields. Most definitions across disciplines come to deem the inference of uncertainty, as the “absence of certainty” (Petersen 2012). Heisenberg’s ‘Uncertainty Principle’ demonstrates that control and certainty are not inherent aspects of nature, as the coordinates and movements of objects, atoms, or particles cannot be accurately predicted, making their trajectories and locations uncertain (Busch et al. 2007). Similarly, genetics also demonstrates uncertainty, in the sense that it is not always clear which parent an individual will resemble more (Li & Du 2017). In the field of health, Uncertainty in Illness Theory (UIT) and its counterpart, Reconceptualised Uncertainty in Illness Theory (RUIT), propose that certainty is not natural and that uncertainty is the natural rhythm of life. Furthermore, disruptions caused by uncertainty are perceived as opportunities for growth and change (Mishel 1990). In common, they all deem uncertainty as a natural part of the world.

Some have stated that where outcomes cannot be certain, it’s said to be a discomforting experience that can be mitigated by confidence or control. (Penrod 2001). Yet uncertainty, its negatives or positives, is contextual. For instance, Becker (2008) states of uncertainty and unknown outcomes are exactly what drive the entrepreneur aspects of actors within a capitalistic society, based on, “openness” of the future and subsequent unknowns (Becker 2008, PP 10).

Uncertainty is not graspable, even when a sense of certainty might be deemed close, it can change just as quickly into uncertainty. Müller-Kademann (2019) offers an interesting concept of this notion of uncertainty. Stating, Uncertainty does not result in a “unique” (exactly known cause and effect) outcome. In addition, when an outcome prediction is close to a known outcome, ’shock uncertainty’, noted as an unexpected occurrence, can happen. Reverting the once-known into complete uncertainty. In other words, uncertainty is a natural part of the world and cannot always be predicted or controlled.

Nevertheless, the attempt to predict or control uncertainty remains a common objective of many that closely aligns with the notion of risk. The rise of probabilistic theory in the 1960s coincided with revolutions in technology that intersected probabilistic theories and uncertainty with “Modern” risk. Risk and uncertainty had seen their divide in the 1920s, but they became central to popular theories, such as Beck (1992) and the “Risk Society” along with “Technical risk analysis” by (Starr 1969). The former explains technology as a curator of risk and the latter society’s tolerance of risk. However, Burgess et al. (2016) accounts that hardcore pessimistic’ views of “Risk Society” can be overestimated into the

worst case scenario, Which Burgess displays accounts of when risk analysing was overstated and 'true' risk did not manifest in the perceived conception by those who considered it (Burgess et al. 2016).

Nevertheless, despite these estimations, risk and uncertainty continue to be used as tools to govern. According to O'Malley (2012*a*), they are not necessarily objective facts, but rather subjective interpretations of reality that are used to govern. Governments use the unknowns and associated risks to implement specific agendas, turning uncertainty into something that needs to be controlled to prevent negative outcomes. For example, predicting health risks, informing dietary recommendations, and preventing future pathogens can motivate millions to take action (O'Malley 2012*b*). These realities are often dependent on knowledge. Some view uncertainty as partly connected to ignorance (Smithson 2012, Kahneman & Tversky 1982). Not knowing a future outcome or what another actor might know can create uncertainty about potential risks. This is prevalent in concerns for national security (Fingar 2011) or security measures to minimize information loss that gives other actors knowledge (Minoli & Kouns 2011). Knowledge is therefore interwoven into the complexity of uncertainty, making it hard to define exactly what uncertainty is, where it derives from, and its role in creating notions of risk.

Uncertainty is not only influenced by how much or how little we know about the world, but also by how we perceive and interpret it. Decision theorist, Denis Victor Lindley, formulates the concept that uncertainty is one of individual subjective experience. Stating, a group of people can agree on uncertainty, yet the experience of such is uniquely individual, meaning the uncertainty felt by one, is a different notion of uncertainty felt by another also refereed to as personalistic (Lindley 2013). An interest in such a perspective diversifies the stance of uncertainty to being ontological as well as epistemological. The level of uncertainty of, and to use Lindley's analogy "It will Rain Tomorrow" differs based on a person's geographical knowledge, they live in Scotland, but the statement becomes definitively uncertain if considered the same statement of a person's unknown geography such as living in Texas. In such a subjective take on uncertainty, knowledge is wrapped into subjective uncertainty.

Uncertainty is not only a subjective knowledge aspect, but it also plays a role in interpersonal relationships and identification within wider social groups. According to Hogg (2000*a*), uncertainty is a precursor for social actors to create a social identity, which can be reformed by involvement with diverse social groups, either novel or pre-existing, to resolve uncertainty (Hogg 2000*a*). In other words, when people feel uncertain about themselves or their identity, they strive to re-inform their identity through correlation with like-minded people,

groups, or institutions, bringing them closer to certainty about themselves once again. Marris (2003), states that such groups or institutions offer social actors certainty by instilling truth and knowledge within social structures (Marris 2003). While Lindley understands knowledge from a personal perspective of uncertainty, Marris demonstrates knowledge on a societal scale, offered as fact and truth by the objectives of societies. These truths reinforce subconscious certainty and offer protection from uncertainty. However, Marris (2003) warns that such truths of certainty are governed by biased and untraceable adventures. This is to say, once something is deemed uncertain and aimed to be reduced to a certainty, there is no going back, it becomes a social imaginary of truth.

Despite this, even when a person is seemingly a part of an institutional system, it does not necessarily mean that they are certain about their role within it. Such an experience is termed by Lind & Van den Bos (2002) as Fairness Heuristic Theory. They state people compile an understanding of fairness to determine if they are experiencing marginalisation from institutional or social groups; judging fairness is said to reduce uncertainty. In such a theory, the quantifying of people's uncertainties can allude to the fairness level of a person within a set of social or organisational operations.

Uncertainty, whether it is a natural phenomenon or a subjective experience, is defined as real, non-deterministic, and both naturally occurring and humanly experienced. Despite arguments that uncertainty is natural (Busch et al. 2007), (Li & Du 2017), there is a common trait across research, society, and individuals that uncertainty is controllable or reducible (O'Malley 2012*b*, Hogg 2000*a*, Penrod 2001). However, while the reduction of uncertainty is perceptional and seemingly possible it begins to formulate uncertainty as something only to be pursued and removed, which once started can be irreversible (Marris 2003). This could hamper the positive aspects of uncertainty as a state that stimulates creative thinking and promotes scientific (Lind & Van den Bos 2002), personal (Mishel 1990), and entrepreneurial progress (Becker 2008). However, it also begins to shape a perception of uncertainty as a dichotomy of either reducing or embracing, a concept that has transcended into the practical and theoretical agendas of design and HCI, which will be discussed in the next section.

2.4.2 Reducing or Embracing Uncertainty: Two Dominant Themes in HCI Design

Uncertainty has seen expansive research within HCI and its encompassing communities. Exampled well by the vast uncertainty research obtained by the data visualisation community (Hullman 2016, Greis et al. 2017), and robotics

(Krestin 2011). Each discipline within design and HCI views uncertainty in differentiating ways. Though, Dyer et al. (2021) explains that uncertainty is becoming domain-specific. Meaning, views on uncertainty differ and do not transcend between disciplines.

In the HCI design community, there are two dominant themes regarding uncertainty: reducing it or embracing it. The reductionist approach views uncertainty as subjective and knowledge-based, meaning that it depends on the level of understanding and ontology (Lindley 2013). Some fields in design define subjective uncertainty as central to the designer's knowledge base (Cullen et al. 1999, PP 31). This is also known as Epistemic Uncertainty Schlosser & Paredis (2007). Epistemic Uncertainty differs from natural uncertainty, which is stochastic and irreducible (Merz & Thieken 2005).

HCI designers often deal with natural uncertainty, particularly in research on global warming (Yarina 2019). However, epistemic uncertainty remains a dominant concept in design, in line with the goal of reducing uncertainty. This is particularly true in design practice and thinking, where fluctuating levels of epistemic uncertainty can impact the designer's confidence in their knowledge (Christensen & Ball 2017). According to Christensen & Ball (2017), lingering uncertainty in the design process can prompt designers to seek greater certainty, or "epistemic certainty." This can be achieved through knowledge production or behavioural changes, with the ultimate goal being to reduce uncertainty.

Perceptions of uncertainty are dynamic and can change over time (Cash & Kreye 2018). As a designer's uncertainty changes, each step of the design process is evaluated to determine how best to resolve the uncertainty (Cash & Kreye 2017, PP 26). This means that a designer's perception of uncertainty plays a role in how uncertainty is resolved in design practice. According to Paletz et al. (2017), uncertainty can create conflicts within design teams, which can only be reduced when uncertainty is reduced. This demonstrates that reducing uncertainty is a favoured goal in designers thinking and practice, achieved by placing emphasis on knowledge and behavioural perception as key factors in controlling uncertainty.

Recently, some design and HCI methods have challenged the reductionist approach to uncertainty. Participatory and co-design methods, for example, view uncertainty as a source of knowledge rather than a problem to be solved. They embrace the incompleteness and gaps in knowledge that emerge from participatory design processes (Luck 2018). When designers engage in participatory design, they may face what Tironi (2018) calls "counter-participation". This means that the participants' ontological experiences may contest the designers' preconceived notions of certainty. Tironi suggests that this friction can be productive

and lead to design interventions.

Embracing uncertainty in both practice and method is a leading movement among HCI researchers. This approach stands in direct contrast to the notion of reducing uncertainty. Reduction, which aims to control uncertainty, is considered to be ultimately unattainable. (Soden et al. 2020). Specific attention to embracing uncertainty has derived from practitioners in anthropological design. The Design + Ethnography + Futures initiative is a prominent advocate for uncertainty. One goal of this initiative is to challenge reduction and break disciplinary boundaries. By the intent of using uncertainty as a method to reform habitual design practices (Akama et al. 2015). This framing of uncertainty becomes a transformative "Technology", in-sighting a novel imaginary of possibility (Pink et al. 2020, PP 8). One result of which, positions uncertainty as a method to encourage people to be "change makers" (Pink et al. 2018).

Recently, Soden et al. (2022*b*) have proposed that uncertainty can be engaged with in different ways, rather than treated as a fixed entity. Uncertainty, in this sense, becomes a mode of inquiry that can foster interdisciplinary HCI discussions. (Soden et al. 2022*b*, PP 2). They identify four modes of engaging with uncertainty in HCI:

> "The first, and most common, mode is to treat uncertainty as something in need of taming or disciplining. The second mode is to treat uncertainty as generative, or as a resource that can assist in human practices. The third is to look at the politics that shape how we encounter uncertainties and the fourth mode attends to the lived experience of uncertainty through affective dimension" (Soden et al. 2022*b*, 3)

Though these modes of uncertainty still reference a notion of embrace and reduce, it adds two other complimentary notions of political and human-focused uncertainty. The latter is a novel conception in HCI, especially within the context of design, wherein focus on an individual experience of uncertainty to drive design intervention is rarely seen. Understanding these experiences is important as it beckons an understanding of real-world impacts on people. For example, when racist encounters produce uncertainty, there is a need for reductionist efforts to instil comfort (To et al. 2021). This shows while we can split uncertainty into different modes, understanding the nuanced human experiences of uncertainty in regard to social marginalisation generates a contextual and inclusive need for designers to understand the reasons behind why people experience uncertainty.

Building on this idea, it's clear there is a need to address the gaps in HCI research on how different contexts and domains shape individual and

collective experiences of uncertainty, and how this can be integrated with other interdisciplinary theoretical concepts to inform HCI thinking on uncertainty. While HCI is expanding its modes of uncertainty (Soden et al. 2022*b*), more work is needed to follow To et al. (2021) in exploring how uncertainty relates to social experiences of marginalisation for different individuals or demographics. This could help HCI inclusive agendas to understand whether HCI designers' goals to reduce or embrace uncertainty are factors in perpetuating social exclusion. This has yet to be uncovered. More attention to nuanced expressions of uncertainty rather than high-level encompassing concepts could also help generate novel insights and produce guidelines for designers in HCI to design specifically for people's diverse reasons behind encountering uncertainty. Not to reduce or embrace that experience, but to design tailored to their specific needs. The following chapter illustrates the power of interdisciplinary theories in uncovering the intricate experiences people have with uncertainty, as well as the causes and effects of such uncertainty. It further highlights how understanding the underlying reasons for uncertainty can lead to the development of guidelines that shape the approach to designing for uncertainty in HCI.

Chapter 3

Exploring the temporalities of Chronic Fatigue Syndrome; Revealing Temporal Uncertainty

3.1 Motivation.

Understanding diverse temporalities has become an important theoretical concern in design and HCI (Pschetz & Bastian 2018, Rapp et al. 2021, Rapp 2022). However, the ways in which people experience exclusion due to social uses of time have not received extensive attention in HCI, despite increasing work in social science demonstrating time as a discourse of exclusion (Samuels & Freeman 2021*b*, Kafer 2013*b*, Sheppard 2020). With calls for temporal research to address HCI needs (Rapp et al. 2021) and a focus on inclusion within HCI, it is evident that HCI research must address narratives of time as a potential property of exclusion. Therefore, this study aims to contribute towards filling this gap by investigating the following research question: *In what ways do people with Chronic Fatigue Syndrome (CFS) experience time with regard to health and social interaction?*

Chronic Fatigue Syndrome (CFS) is a complex and debilitating condition characterised by persistent and unexplained fatigue, cognitive impairment, pain, and other symptoms that vary in severity and duration. Due to their health condition, individuals with CFS often face challenges in managing daily activities, work, and social relationships; for example, they may be unable to work, continue their education, or interact socially. Moreover, CFS is a stigmatised and misunderstood condition, as there is no definitive cause, diagnosis, or treatment. Consequently, individuals with CFS may experience social isolation, discrimination, and a lack of support from those who do not understand the condition or respect

their needs. This study employs the concept of Crip time to explore how CFS affects individuals' temporal experiences and how this may lead to exclusion or inclusion in various contexts. The temporal design framework (Pschetz 2014) is utilised to examine whether dominant social norms and expectations of time challenge the lived experience of having Chronic Fatigue Syndrome. This study also seeks to address the underrepresented area of HCI research on CFS, which has predominantly focused on health management (Davies et al. 2019). By examining the social uses of time with respect to CFS, health, and social experience, novel insights into exclusionary concepts of time may be revealed, providing opportunities to enhance an inclusive perspective on the temporal experiences of individuals with CFS.

3.2 Methodology

Recruitment and Participants

This study was conducted during the Covid-19 pandemic at the height of the first lockdown, necessitating adaptations in methodological approaches. Initially, the plan was to conduct in-person interviews, traveling to participants to minimize their potential health complications and fatigue from the research process. This approach would have also allowed engagement with a diverse group of individuals at various stages of CFS. However, due to the restrictions, in-person visits were not feasible, which significantly limited the ability to recruit from a broader pool of individuals with the condition.

Addressing these limitations is crucial as it highlights the constraints faced in this study. The research team was constrained to a few methodological approaches, influenced by considerations of who and when participants could be interviewed. For instance, video calling could induce fatigue or be unusable due to health constraints, making it impractical for all participants with a chronic condition like CFS. Consequently, phone calls emerged as the most viable option, although this approach inherently limited the study to participants who were able to make phone calls.

Recruitment was conducted online via the r/cfs Reddit page [1], an international online forum for individuals with CFS. Only individuals from the UK were invited to ensure a local scope and to better understand experiences within similar cultural contexts. A semi-structured interview was designed, focusing on personal management of the condition, social interaction, and experiences of time. The lead researcher, diagnosed with CFS since the age of 12, brought both personal

[1] https://www.reddit.com/r/cfs/

and general knowledge of the condition, aiding the research team in formulating and structuring questions in a manner sensitive to individuals with CFS. This background allowed the semi-structured interview to concentrate on participants' individual experiences rather than general details about the condition, which would otherwise consume valuable interview time.

Participants were informed in the consent form and throughout the interview that they could take breaks or halt the interview if needed. Individual interviews averaged one hour, with the option to be divided over several days if preferred by the participant. During the interviews, participants could cancel at any time, though none requested such an interruption. Participation was entirely voluntary and uncompensated. Ethical approval for the study was obtained.

The sample consisted of individuals with CFS residing in the UK who felt that participating in the research would not exacerbate their health. Participants were required to be over 18 years old, and employment status was not a factor of recruitment. Caregivers of individuals with CFS, a common role within the population, were excluded to maintain a focus on those directly experiencing the condition. In total, seven individuals with CFS (aged 21-62; 4 females, 3 males) were interviewed.

Analysis

A thematic analysis method was employed to analyse the data. The goal of thematic analysis is to formulate a conceptual model of the findings (Naeem et al. 2023). It serves both to accurately represent reality and to explore its underlying layers (Braun & Clarke 2006). Thematic analysis involves abstracting real-world occurrences through the examination of qualitative data. A well-known step in thematic analysis is to familiarise oneself with the data. To achieve this, the lead researcher listened to the audio recordings and transcribed each one by hand to ensure a grounded understanding of the content and to reflect on the discussions during the interviews. Processing large amounts of information during interviews can be overwhelming. Therefore, the manual transcription and careful review of the recordings facilitated a deeper engagement with the data. This approach also allowed for initial notes on potential themes to be made and cross-referenced with any memos taken during the interview sessions to assess their relevance. These initial notes, however, remained tentative as the analysis process had only just commenced.

To gain a comprehensive understanding of the data, the research team, including the lead researcher and supervisors, began by coding the data. This process involved assigning codes to chunks of information, which summarised the

information associated with each code. Coding performed by multiple individuals allowed for diverse perspectives and interpretations of the data. Following this, sub-themes were identified across the codes. This involved grouping codes with similar themes or contexts. For example, codes related to struggling with health and health relapses, though distinct, shared the theme of impacts on health. These codes were then organised under relevant themes. After identifying numerous sub-themes, the next step was to search across these sub-themes for core themes. Core themes emerged from the similarities between sub-themes and their capacity to be grouped under overarching themes. For instance, "Time" and "Uncertainty" were identified as core themes, which encompassed sub-themes such as social planning, unknown health impacts, relapsing times, future health uncertainty, and rigid schedules. This process provided a structured approach to formulating a conceptual model of the experiences of individuals with CFS.

The implementation of a thematic approach was guided by a constructivist perspective. In a constructionist framework, thematic analysis focuses on theorising the sociocultural contexts and structural conditions that shape individual accounts, rather than motivations or individual psychologies (Braun & Clarke 2006). Given the relevance of time and societal factors, analysing the data from a constructivist perspective was appropriate to contextualise the temporal experiences of health within a society that heavily relies on various aspects of time.

The final results reflect findings that underwent a rigorous analysis process, including familiarity with the data, coding, sub-theme identification, re-theming, and overall theming, all conducted from a constructivist perspective. This approach facilitated a nuanced interpretation of the data, leading to a comprehensive understanding of the experiences of individuals with CFS.

3.3 Findings

3.3.1 The Struggle for Certainty: Challenges of Rigid Expectations for People with CFS.

One of the main findings was that social interactions like work or events with rigid structuring were not accessible to participants. These structures would require certainty to engage with a set amount of hours, when not applicable, would be "*Advised to go part-time*" (**P6**), leading to financial impact "*Your salary drops commerce with those hours*" (**P6**). Frictions between being unable to be certain of continual reliability of health and a desire to not be part-time due to its

implications led participants to attempt full-time work. "*I was worried id have to work part-time forever, so I was like, right, I'm going to try to do full-time again. I went back to a full-time job, and literally within a month, I was like, this is really bad for me, I cannot do this*" (**P4**). Participants incurred detriment to health through these attempts, reinforcing the inability to remain in rigid schedules. "Tried it, and it was a disaster" (**P5**). The Impacts of rigid structures became a visceral experience that saw the development of fears about being in them. "*I am afraid of going back into a very structured office environment or a career-type job because, erm, I'm afraid, what used to happen, I would be okay for a few months, and then something would happen. And I'd be so fatigued*" (**P1**). Participants who tried to manage full-time work had to counteract the energy expenditure of work by changing other aspects of their life, some being extreme. "*I love my job; I loved, I had to move next to my work to keep working*" (**P2**). While others deployed convenience to avoid taxing home activities. "*I skip my jobs in the house I wouldn't do the pots or anything like that. Or when I was at work, I still work at the moment, but I used to, just have a meal at the canteen so I wouldn't have to make anything when I got home*" (**P3**)

The ability to perform within rigid schedules was seen as expected of people, leaving little regard for the challenges people with health conditions might encounter when trying to do so. "*I guess it's also the things society assumes you are able to do, and really, we are as a society we are set up on assumptions that people can do a lot of these things that are far more challenging to people with health problems*" (**P7**). Challenges could come down to social situations requiring certainty of the bodies within them to maintain a level of interaction and speedy attitude so as not to be disruptive. *That is one of the areas, where I really suffer from its really tiring to me, social situations [...] I just remain quiet, especially when you know your slow conversation can be disruptive* (**P3**). The challenges could amount to social interactions that require being within a set location leading to a decrease in maintaining social connections. "*There are people I have had to stop visiting because they live further out of town, and I cannot go and see them*" (**P4**). The inability to be certain and participate in social gatherings in set times or plac'es was viewed as an extension of having the condition. "*People met in the park, and I was not invited. I would have said no but was not invited, whereas previously, I would have been there, so yeah, that is one form of exclusion. It would have bothered me a few years ago, but now I think it's almost like a symptom, it's almost like a medical symptom of having the diseases*" (**P2**).

3.3.2 The Uncertainty of Health and its Impact on Social Engagements.

As established, social rigidity was a core problem for participants who incurred health impacts, social reduction and financial reduction. Participants lived in a continual experience of health uncertainty that had directly correlated with difficulties in event planning. Participants wanted to plan for future events with friends, yet unforeseen health changes could render the plan unattainable. "*Sometimes if I plan a trip far in advance, a hiking trip or something, I am really excited for it, but then that week has been really hard for me, erm, I might not be able to go*". (**P1**). The unexpected change in health meant social plans would either be cancelled or followed through with at the expense of health worsening. "In the past, I often just agreed, and the day comes, and I'm completely wiped out, and you force yourself into the thing, and you feel awful or cancel last minute" (**P5**). An experience that led to no longer making plans. "*Especially in the last months or years I don't make plans*" (**P5**). Which was attributed to a guilty experience of impacting others when cancelling. "*I don't make many plans. I have to say I feel very bad about letting anybody down in any sense*" (**P6**).

There were points in which uncertainty in health could be at its highest, meaning no planning would take place"*It's worse when I have periods, that's a major, so I know that week of the month I can't do anything, and there is no point me committing to anything*" (**P4**). Blocking off months or weeks to not make plans or to manage control of energy to decrease uncertainty on being able to attend events was commonplace. "*I would try and avoid having more than one thing like that a week, id have an awareness and id base the rest of my time around making sure I'm able to make that. Erm, so yeah*" (**P7**). The reduction was formed to have more control over health fluctuations. "*If there is something very important, inverted commas "book" that and what I will try and do have a count down to it,[...] cut down all extraneous activity, even if it is just housework and self-care and just cut it all down in order fingers crossed to be in the best, possible shape to make any engagement*" (**P6**). Participants did not always have a choice in managing the uncertainty of health in relation to what plans they could and could not make or budget energy for. "*It would be great if you could go by ear [...], but we have to plan everything ahead, at least a week or two ahead; you sometimes can't predict how you're going to feel the next week*" (**P4**). Planning with friends was equally seen as more beneficial if able to be done in the moment rather than with certainty in plans that relied on a level of commitment. "*I can't commit to something weekly or regularly because I have to do so much [...] moving things around*" (**P5**). Revealing further that

commitments or rigid plans contrasted with health that was an uncertain living experience.

Participants had uncertainty about the activity of a plan that could cause an impact on health, requiring further detail as to make informed choices "*There is a lot of going to other peoples houses, and kinda standing around and talking and that's the absolute worst thing for me. So I kind of, have to gauge what an event was before I would go to it, like do you want to come around and id ask well what are we going to do? Is it a sit-down, things like that.*" (**P5**). Uncertain of the of plan's environmental factors equally became an important aspect to participants in their plan-making. For instance, finding out about the ambient sound or light of a location became important as to assure comfort when in social settings. " *I really struggle with noise [...] and lots of lights [...] I often feel restaurants these days don't have any soft furnishings they don't have curtains or carpets and stuff like that, hard floors and hard walls reflects a lot of noise I find that challenging*" (**P6**). It could leave participants having to communicate with relatives so they would understand the need for environments that do not exacerbate the condition. "*The light can affect my eyes, or noise. Any bit of bang or noise can really go right through me. Erm, just it's reminding family. Even my family don't understand how it can affect you. You feel you're having to explain yourself*" (**P3**).

3.3.3 Optimal Times for Managing Health Fluctuations.

Control over time and when activities would occur was optimal in maintaining uncertain aspects that came with health fluctuations. Participants had learned an understanding of optimal times when they would be most effective at conducting set tasks. "*My most productive time is kind of half eleven to half three*" (**P2**). Health impacts were at their lowest at set points in the day. "*If I could pick my peak hours to work, it probably is between 10 and 2, and then after that, I start going down again*" (**P4**). Outside these times increased the uncertainty of the impact on health and ability to conduct set activities. However, even these predicted optimal times were never certain and depended on various factors. "*I do best in the mornings, if I can get up and slept the night really well, id say like from seven till noon*" (**P1**). These factors meant participants had only a tentatively certain time to get activities done "*I think of myself as some type of flower that starts to die off in the mid-afternoon*" (**P6**). Meaning they would normally require to be home once they felt their optimal hours where running out. "*I have a four hour window [...] after half 4 I start slowing down, so I always plan to try not have social engagements or being around people and*

that I am back at home" (**P2**).

While some health impacts occurred in the afternoon, others found these to be better times for them. "*Worst times for me are the mornings. I probably say afternoon or evening are better times for me*" (**P3**). A shared sentiment by (**P7**) "*Often I will sort of improve throughout the day erm. So yeah, it's later in the evening when I am feeling sharper*". Times among participants denoted when certain social activities would take place. "*If anyone wants to have any meetings with me, erm, I will do that late afternoon, just before lunch*" (**P5**). Demonstrating the evident individuality of when and how social activities should occur regarding times of health fluctuations or even if they are able to take place "*Other times it is not possible*" (**P2**). Predicting optimal times was important, as being stuck in a specific place as health declined was detrimental. "*when I got to the office it was kind of like I need to predict 40 mins before I'm going to crash. And that's when I need to leave because [...] there was absolutely no way am going to be able to get home safely*. Being safe was apart of understanding when and how health would decline and the right space to be in when it does occur.

3.3.4 The Health Benefits of Flexibility in Work and Social Schedules.

Covid-19 offered insight into the benefits of having flexibility in work and social schedules while living with CFS. Morning routines such as getting dressed and commuting was noted as impacting health factors alleviated during the pandemic. "*You are not travelling to work or getting ready for work; you can just go take a nap, I suppose, if you want in the day. Then start back at work again*" (**P5**). The structure of being at home offered abilities to manage health, such as with naps happening when needed.

Lockdown and the sudden stop of social rhythms were deemed a blessing by (**P4**) "*That first month of lock-down. Was just so welcome for me, I was starting to feel I was at breaking point again, and I had that first few weeks working from home was such a relief*". A sudden change to the rhythms exacerbating health decline became the difference between having and not having a relapse.

Alternative symptoms arising from CFS were reduced because of less pressure towards social participation. "*Ironically, the lockdown has released me of social anxiety because people are forcibly not allowed to interact. I would not say I have enjoyed it, but I have not missed having that anxiety*" (**P2**). Though seen with its consequences, the anxiety reduction was deemed a welcoming experience.

Participant (**7**) who was not working found the flexibility others had experienced

during the lockdown as a valuable factor in their everyday life. "*I am quite able to adapt my time to how I am feeling or what my priorities are*". Adaptability meant control of time and tasks and allowed for more control over health.

3.3.5 The Impact of Relapse on Social Participation.

Having control over self-rhythms, identifying optimal health times, and planning and managing the consequences that came with rigid expectations were purists to avoid what is known as a relapse. Sometimes it was predicted through physical triggers "*When a flare-up is coming very specifically; I get pain in my lymph nodes*" (**P3**). Moments such as these would have biological impacts on cognition and fatigue, giving a sense of declining health. "*I just feel genuinely really tired and I get memory problems more than usual*" (**P3**).

It was a time that directly influenced participants' ability to continue with aspects of their life, "*The certain feeling, that you get when you just think you need to stop for a bit now*" (**P5**). The time in which relapse would occur could be uncertain and sporadic. "*If I wake up one morning and I know I am going to have a really bad day*" (**P2**). Relapsing meant there was a sense of uncertainty about when recovery might occur. "*It takes me a long time to recover from anything like that; it can go on for months*" (**P1**). Along with an understanding that one might be due at set times. "*I can sort of be okay, for a while like months at a time, when I say okay I am always low energy. I can manage, then every few months il have a pretty major crash*" (**P4**). The temporality of recovery from the times of relapse meant a person could be bound to a set space. "*On a really bad day, I would not get down the stairs at all; I would not leave my bed*" (**P5**).

Relapsing could occur at any given time and impact social plans. "*If that pain was coming on and I was due to meet a friend or family member, id start getting in touch and saying it's not going to be possible*" (**P6**). This was because relapsing had its own temporal merit, unable to perform in any social activities regarded as rigid or structured. "*I need to be able to step away from that structure. And just you know break, so its kinda tricky so their needs to be flexibility in the structure to break*" (**P1**).

3.4 Eight types of Uncertainty.

The results of this study laid out core themes. *Rigid expectations of certainty*, *Uncertainty around social interactions*, *Optimal Times*, *Health benefits from Flexibility* and *Relapsing time*. Based on these core themes and the discussion

within them eight types of uncertainty (**U1-U8**) are identified. Representative of the discussion participants had around social interaction, time and health. The list is laid out to highlight the social event and interactive needs of people with CFS, but also to allow for a generalisation for HCI research to consider the scope of temporal experiences with regard to notions of uncertainty. The first two aspects (ATTENDANCE, DELAY) capture the **subject of uncertainty**: can I attend partially or at all?; U3 and U4 (PRIORITIES, LOCATION) indicate **reasons for uncertainty**; and U5-U8 (EXPECTATIONS, JUSTIFICATION, COMMITMENT, ALTERNATIVES) capture **social aspects** related to making decisions and communicating uncertainty. Each of these aspects can be expressed as a set of questions to which a person has to find answers in order to create certainty. If people can not it helps raise the question of challenge's people with CFS and beyond might encounter in social planning that strives for certainty and rigid planning. The eight types of uncertainty are presented as a set of questions, if unanswered, a persons experience or situation remains uncertain.

- **U1—ATTENDANCE:** *How likely is it that I can attend this event, at all?* This is probably the most common and most general aspect and involves a single event planned with peers. In our interviews, participants mentioned a variety of—sometimes unexpected—reasons that would prevent them from attending an event at all. In most cases participants had the intention to attend but had to cancel last minute. Reasons for a cancellation included work "*I am really excited for it, but then [the] week has been really hard for me*" (**P1**) and other everyday activities "*waiting for a bus*" (**P5**) that eventually cause fatigue. Especially in cases where the event had been planned a long time in advance, communicating (and **arguing**) for uncertainty has been reported as a challenge, often resorting in cancelling, pressure to "*Go through with it*" (**P1**) at the cost to health. Families and peers not familiar with the respective situation of the person, their avoidance to commit to a particular plan can sound odd due to lacking understanding.
- **U2—Need for DELAY:** *In the case I can attend, will I be late? How much will I be late? When do I know that I will be late?* The careful consideration of how late they could be for an appointment was a common experience among participants. For example, they discussed how fast they could walk with muscle pain and how it led to uncertainty regarding their time of arrival "*If that pain was coming on and I was due to meet a friend or family member I'd start getting in touch*" (**P6**), also see LOCATION). Equally, participants discussed sudden needs to go home, as they felt the onset of fatigue, which created uncertainty about the time they would leave

work, in order to make it home before the fatigue was too strong. Similar to cancelling attendance, participants voiced uncertainties about the right moment to contact their peers (see JUSTIFICATION).

- **U3–LOCATION:** *Do I have the energy to reach that location? Am I able to reach it in time?* One common reasons for cancellations was the uncertainty of reaching the location of the event in time. This was mostly due to efforts in travelling and the required time to recover "*I had to move next to my work to keep working [there]*" (**P2**). Reaching friends who lived far away was challenging due to uncertainties of what would be a good day to travel that distance, and if meeting up would impact their health. Planning for alternatives could equally cause uncertainty, such as the potential of getting lost. Even with a carefully planned trip, uncertainties still arose, "*If I had to make a trip to town I would plan that into a weekend and [if then] I couldn't do it [I would think] then, okay, next weekend... and it'd be a month, and I hadn't done it yet!*" (**P5**). Besides, matters of distance other priorities (see PRIORITIES), and environmental factors such as levels of noise and brightness, whether seats were available or whether parking was close to the venue, also played a role.

- **U4—PRIORITIES:** *Given my current condition, is this event part of my priorities? Is it better to rest and recharge my energy?* One reason reported for entirely canceling attendance, was that "recharging energies" was a better use of participants' time than attending an event. In particular, if other duties still required energy and time "*Even if it is just housework and self-care*" (**P6**). Prioritisation thus became a common strategy to reduce uncertainty. Participants encountered blocks in weeks or months when symptoms were more impacted by other events such as work, leading to an understanding that no social commitments outwith work could be made. It meant participants could only have one major event occurring at any time, as seen with (**P7**), who prioritised an event by reducing all other activities. Prioritising between health and important events was deemed within the lens of a hierarchy of importance. Energy expenditure was carefully considered and directly related to time spent on any given event or task. However, participants would incur health impacts to participating and try to factor in rest time after or before a prioritised events.

- **U5—ALTERNATIVES:** *If I cannot attend, when would be an alternative time to repeat the event? Are there alternatives for me not attending?* When alternatives are uncertain, (**P1**) explains, they *"either try to push through it [...] or, I cancel everything"*.

- **U6—COMMITMENT:** *I am fine now, but how will my situation be when the event approaches? When will I know? When do I have to decide? When can I commit to something? How long should I commit? Can I even commit?* Uncertainty in health meant commitments to reoccurring interactions could be problematic when those (health) conditions could change anytime "I can't commit to something weekly or regularly because I have to do so much [...] moving things around." (**P5**). Other participants expressed fear of committing to events due to consequences associated with not attending: (ATTENDANCE, ALTERNATIVES) "*I don't make plans [...] I feel very very bad about letting anybody down*" (**P6**) and "*It's really frustrating when you have to cancel, it's that shame element*" (**P1**).

- **U7—EXPECTATIONS:** *Would the other(s) mind if I skip? Whom of the others is (likely to) attend anyway? How likely is it?* Participants discussed the need for mutuality. When making plans, not understanding each other's situations, such as their health condition and circumstances, could cause problems to arise. For example, (**P5**) reported that their singing group was supportive when they needed to skip a session. However, they still had concerns: "*I still think [there] is the week where they tell me I can't come any more because I have missed too many [sessions]*" Expectations where regarded as social and placed upon people that could be challenging to people experiencing health conditions as mentioned by (**P7**).

- **U8—JUSTIFICATION:** *How am I going to explain that I cannot attend / I am unlikely to attend?* Justifying oneself to others was a daily experience; participants would have to explain why they could not respond fast enough and why they were unsure how they would feel the next day, week or month. When justifying the inability to attend, P4S encountered uncertainty around how much time and energy the justification could take "*It's too much energy to continuously text people, phone people [...] I find phoning more exhausting, so I try texting but actually text conversations are really exhausting too, cause people then want to talk for ages* (**P4**). Further uncertainties could arise from peers not understanding the extent of the condition (CFS) and how people might be perceived after CFS symptoms arise during social interaction. Furthermore, participant's could end up being required to justify themselves or remind others of their condition as with (**P3**) and their family not understanding.

3.5 Discussion

3.5.1 Re-framing certainty, Temporal Uncertainty considerations

In this research, there have been identified problems in the expectations around people's requirements to have certainty in rigid social encounters. Moreover, the findings highlight a need for agency in when and how certain activities occur, aligning more closely with the temporality of health regulated by symptoms. This insight highlights that health uncertainty can complicate the planning and commitment to both personal and professional social events, often leading to signs of exclusion. These findings extend previous work on identifying dominant temporal narratives and the "infrastructures that sustain them" (Pschetz & Bastian 2018, pp. 174). Furthermore, they align with Crip time literature, which emphasises the need to represent the diverse temporal needs from the disabled perspective centred around social concepts of time (Kafer 2013*a*, Katzman et al. 2020, Sheppard 2020, Samuels 2017).

The following discussion begins to structure this framing, highlighting the need for Temporal Uncertainty to be recognised as a lens for considering inclusive interventions in HCI. It builds on Abascal & Nicolle (2005)'s call for flexibility to be woven into the design of HCI products. Our findings show that people with Chronic Fatigue Syndrome (CFS) need flexibility in time. In the context of HCI, there is also a need for further exploration of flexibility in allowing people to express diverse notions of time, such as Temporal Uncertainty. Drawing on Nicolle & Abascal (2001), this should not be approached as merely an accessibility issue, but rather by intentionally designing outputs that do not solely centre on certainty but also encourage the option to express times of uncertainty. Our work brings Temporal Uncertainty to the forefront as an important concept for HCI to focus on in nurturing new notions of inclusive design and practice.

Previous studies on Temporal Uncertainty in HCI have mainly focused on real-time processes within systems and the timing of events (Cicirelli et al. 2005) or the variability of time for packets travelling between networks (Hsu et al. 2012). Temporal Uncertainty can also be subjectively encountered by users when system response times are elongated, leading to a psychological approach to the perception of time and uncertainty (Schaefer 1990). To date, and to the best of this thesis's knowledge, Temporal Uncertainty in the context of HCI has been concerned with the uncertainty produced by processes within computing systems and people's uncertain experiences of them. This thesis aims to provide a novel understanding of Temporal Uncertainty in HCI. Through the findings of

this study, it is revealed that Temporal Uncertainty is a lived experience for people with Chronic Fatigue Syndrome, arising when their experiences are at odds with dominant social uses of time. The following discussion will explore this topic in depth.

Social Expectation of Being Certain—Participants had to engage in social activities in various ways, such as working or meeting with friends and family. Scheduling, planning, or committing to social or professional events was a challenging experience for participants. Health uncertainty conflicted directly with social plans or schedules that required certainty, lacked flexibility, were too far in the future, or involved times or locations unsuitable due to health. Expectations of conformity to established social infrastructure time practices have previously been shown to affect the education of children with CFS (Sankey et al. 2006). Furthermore, the use of clock time by institutions exacerbates inequalities (Katzman et al. 2020).

This research correlates with similar findings, highlighting that work hours were not accessible and participants incurred financial instability due to uncertainty about their ability to adhere to set working hours. A desire to keep their job or work part-time led participants to attempt to participate in rigid working structures, which worsened their health and resulted in an inevitable loss of hours and money. The rigidity of the time used at work was seen to exacerbate health issues and created a fear of structured environments. Kafer (2013*a*) explains that the clock should be inclined to match the temporalities of disabled people; however, participants had to adapt to rigid work schedules, such as relocating or reducing their social circles to conserve energy for work. Rigidity was a common and undesirable experience for participants that marginalized or affected their health.

Therefore, these insights suggest a need for HCI researchers and designers to consider that **expectations to orientate bodies and minds to certainty can be an exclusionary narrative**—This should be expanded to consider how tools are used to enforce certainty and whether this excludes certain demographics. By centring this thinking, it may support technologically inclusive interventions that accommodate people's temporal experiences and needs. Participants had to consider how **U6—Commitment** impacted their lives with CFS. Thus, asking for a person's certainty or rigid commitments should be followed by considering how a person with CFS might be impacted by such requests.

Temporal Biological Experiences—Participants' temporalities were closely related to their adaptations to health symptoms. Researchers and designers in HCI could consider health as a regulator of when, how, and in what way social activities take place. Unlike clocks, calendars, or schedules that set social

actions to quantified units, health does not. Supporting the times and ways social activities or planning occur, regulated by the temporalities of health rather than quantified time, could demonstrate innovative temporal designs focused on orchestrating social interactions from a health-centric perspective. This would further support the need for **U4—Priorities**, as it would allow participants to regulate their priorities in relation to their biological experience without feeling they must hope their symptoms are manageable when an event arises.

Fluctuating Health Uncertainty—Participants managed their health better when they controlled their own flexible schedules or when activities were planned for times when their health was at its peak. In other words, to "*go by ear*." They also faced various uncertainties based on aspects of an event, such as **U1—Attendance**, **U2—Need for Delay**, or **U3—Location**. Therefore, consideration should be given to events that offer not only certainty or cancellation but also options to navigate different experiences of uncertainty. Additionally, the ability to communicate uncertainty about event start times, end times, locations, dates, etc., could provide novel insights into how events can be modular with regard to uncertainty experiences. Designs could also consider **U5—Alternatives** around plans, such as locations that are not noisy or flexible event start times. These suggestions could support the need to avoid cancellation and instead use technologies to allow for alternative scheduling, such as moving events online or adjusting plans to fit changing symptoms.

Low-Cost Energy Designs—Participants experienced severe health relapses, leading to **U2—Need for Delay** and often necessitating an immediate cessation of activities, extending to social interactions and events. Participants had no way of predicting when and how long a relapse would last, so current suggestions could be adapted to support these impact moments. Additionally, participants described the need to contact others, which took considerable energy and effort—resources they could not afford to lose during such times. Therefore, any design should include features that are cognitively and physically low-energy. Quick and easy communication without pressure to follow up or provide **U8—Justification** would help participants focus on their health and efficiently communicate their uncertainty without social pressure.

Uncertainty Communication—Participants faced challenges with what they felt might be expected of them from social encounters that otherwise disregarded their abilities or needs. Communication interventions thus appear necessary. Designers should consider enabling users to communicate with others and adapt events, express concerns about elements of a plan, and collaboratively make an event suitable for everyone while still allowing for uncertainty about the event, so as not to pressure them with **U7—Expectations** if their health fluctuates. Fur-

thermore, considering how to achieve this without highlighting only one person's uncertainty but rather everyone's might make others feel more comfortable with their experiences of uncertainty.

These insights lead to a high-level critique, suggesting that an inclusive HCI proposal would be to **Re-frame Dominant Narratives Away from Temporal Certainty**—and instead **Re-imagine the Importance of Temporal Uncertainty**. For HCI designers and researchers who focus on technologies that strive predominantly for orchestrated certainty, it is important to consider shifting the focus towards uncertainty as a primary concern. Not to reduce or eradicate certainty, but to position uncertainty as a necessary and inclusive element for people with CFS. This approach might also be extended to consider wider audiences.

3.5.2 Future work.

This research highlighted a critical theme: experiencing uncertainty is a conflicting position to experience when many social interactions or processes are governed by an idea to guarantee certainty. Furthermore, health regulated participants' temporality at friction with inflexible notions of time usage. This work laid out an important call to move focus away from a predominant demand for temporal certainty and re-imagine the importance of the lived experiences of temporal uncertainty. It is within this call that future work suggestions follow.

Limitations and future work.

Consider alternative and specific health conditions with regards to Temporal Uncertainty— This research worked with people who have CFS. Future work should consider the perspectives of Temporal Uncertainty in social planning from alternative groups of people with different health conditions. Research exploring this suggestion could challenge our own findings and find different uncertainty requirements based on the needs of the person and their condition. Nevertheless, it could corroborate our findings and strengthen the need to support temporal uncertainty. The U1-U8 list could be used to explore how others might respond to each of the listed uncertainty points and if, for instance, they also need to justify their uncertainty and or health. How would using this expand inclusion and push HCI understanding of Crip time experiences at frictions or not at frictions with dominant social discourses? What alternative temporal perspectives are uncovered? Plenty of work is still required in bringing Crip time to the inclusive scopes of HCI, this research provides a set of future thinking so that researchers might explore these avenues and bolster Crip time importance in HCI research.

Inclusion of other experiences of Temporal Uncertainty— The narratives surrounding people with CFS have provided insight into the concept of Temporal Uncertainty from a health perspective. This study has demonstrated the importance of considering Temporal Uncertainty in understanding the narrative of social inclusion for people with CFS. The next step is to explore deeper understandings of Temporal Uncertainty from the perspective of people who do not have CFS. To frame such a study, it will be important to engage individuals without CFS who use time to organise social events or engagements, both professionally and personally. Since this research aims to contribute to HCI, it will also be crucial for these individuals to use technology in some form for social planning. By exploring Temporal Uncertainty from this perspective, it is anticipated that comprehension of Temporal Uncertainty.

Temporal Uncertainty design implementations— Future research could implement one or more of the design insights provided within the discussion section. A limitation of this study was that the revealing of Temporal Uncertainty was novel and insights on how Temporal Uncertainty designs might look, be implemented, along with the benefits and implications for the people who use them are yet to be explored. Designers could use the U1-U8 list to consider design features that represent Temporal Uncertainty and aim to answer this future work gap. Furthermore, research could critically approach ways time certainty is portrayed in technologies currently and try to understand if that certainty could exacerbate exclusion for certain people.

Grounding an exploration into a broader understanding of Temporal Uncertainty.

A need to explore broader experiences of Temporal Uncertainty is where this PhD's future work takes place. The concern of inclusion is to broaden the scope to initiate an understanding of who else might be impacted by an uncovered problem, which in this case is notions of temporal certainty. As findings suggest, social scheduling, planning, and the impacts caused by certainty and rigidity stress the need for participants to be able to communicate their uncertainty to counteract the pressure to "Push through" with social interactions. This study revealed a need to consider a potential social problem that might not only be an experience of people with CFS, therefore,

Q2• *What insights are produced from a broader audience when given the ability to communicate temporal uncertainty?*

This question closely follows its consideration of a broader audience, with the advice of /sum not to follow a single-axis approach. The research aims to

expand its reach and gather a broader perspective of temporal uncertainty. Our discussion section listed U1-U8, drawn from our findings. This list is modified to generalise to other social groups and scenarios beyond people with CFS. The motivation for this is to explore the following research question presented above.

3.5.3 Conclusion: Exploring Temporal Uncertainty and Inclusion in the Context of Chronic Fatigue Syndrome

Following Crip Time Theory and Temporal Design Guidelines, this study has led to a time study in the context of CFS, health and social interaction. The research question Q1• *"In what ways do people with Chronic Fatigue Syndrome experience time in regard to health and social interaction?"* has been answered and revealed novel insights that act as the foreshadowing prompt to explore Temporal Uncertainty technology and the attempt to expand inclusion throughout the remainder of the PhD.

The results suggested that rigid social aspects, such as work and social life, with respect to the need for certainty from participants with CFS can be detrimental to health and personal requirements. Uncertainty was understood as a prominent life experience that had conflicts with any personal or professional social event that required uncompromising commitment to be certain. Participants had personal optimal hours when health uncertainty was less, and activities were considered to take place within these brief windows of time. However, optimal time may only occur when not relapsing or if factors are aligned, such as good sleep and the ability to rise in the morning. In addition, it has been found that total agency in scheduling benefits health management, which was a discovery by participants during the Covid-19 pandemic or retirement, both scenarios where rigid structures and demands were reduced.

Therefore, do these findings only relate to people with CFS, and in what ways might others relate to needs for technologies or features that support the communication of uncertainty? How else are others affected by our revealed notion of dominant certainty, and how can design exploration be done to reveal alternative and diverse perspectives of temporal uncertainty? Our findings suggest that considering expectations of certainty from people with CFS is a potentially exclusionary narrative. How else might others be excluded? What novel insights about inclusion are produced if exploring alternative experiences of Temporal Uncertainty? What role does technology actually play in suppressing expressions of uncertainty in favour of certainty? Supported by Q2• *What insights are produced from a broader audience when given the ability to communicate temporal uncertainty?* this PhD positions its exploration from these curiosities.

With the goal to expand the understanding of inclusion within the landscape of HCI research.

In summary, this work dealt with the importance of revealing dominant notions of time according to the framework for temporal design and the crucial importance of reflecting Crip time narratives around HCI lenses and revealing a dominant social use of time that could have wider implications for broader sections of society and the technologies within that society. To end, this work demonstrated an avenue for inclusion based on the core finding that rigid social structures and schedules can conflate into frictions when times of health uncertainty are experienced.

Chapter 4

Exploring Uncertainty in Digital Scheduling, and the Wider Implications of Unrepresented Temporalities in HCI

4.1 Motivation

The previous chapter explored the experiences of time for individuals living with Chronic Fatigue Syndrome (CFS). Insights were gained on how certain social time-related practices influenced their health. Time is often used rigidly to create predictability in life events such as work or socialising. However, findings from the previous study revealed that individuals with CFS experienced personal and social impacts due to these rigid structures. The unpredictability of their health made it difficult to organise around fixed schedules, leading to uncertainty when engaging in work or social plans. This uncertainty about their health, combined with the rigidity of time structures, led to the core finding that participants with CFS live with a notion of temporal uncertainty.

The following will investigate if Temporal Uncertainty is an experience among individuals who frequently use time-based tools or technologies for planning social interactions. The sample will therefore consist of individuals who use tools like digital calendars as part of their social planning, including work. Equally, the study requires participants taking part to not have chronic fatigue syndrome. This will be to broaden the understanding of Temporal Uncertainty from the perspectives of people without this condition. Moreover, the sample of participants must also be over 18. More details about the participants can be found in the 'Recruitment and Participation' section.

To investigate if Temporal Uncertainty is an experience among individuals who frequently use time-based tools a speculative prototype was designed named Haze. This speculative tool and user interface supports uncertainty-based scheduling scenarios. Haze is a digital calendar that enables users to express their uncertainty about time, place, or attendance of an event. Unlike conventional digital calendars and other technologies for social event planning that require certainty, Haze challenges the dominant narratives of certainty that can exclude and harm those who struggle with rigid and strict schedules, such as people with health conditions or caring responsibilities. A qualitative methodology is created to investigate how Haze supports those who are most affected by Temporal Uncertainty. It is discussed how Haze contributes to the understanding of temporality and the moral and social responsibilities of design and HCI.

The prevalence of the 24-hour clock and 7-day week calendar provides examples of how quantified *clocktime* has become a fixed framework for coordinating work and social activities. We adhere to working hours, set our alarm clocks to specific minutes, meet deadlines, align with schedules, and plan around meetings at predetermined times, places, and durations. To support these scenarios, digital calendar and scheduling applications have become increasingly ubiquitous in our digitally-mediated lives. They implement this temporal framework and guide us towards efficiency in planning, for example, when applications propose meeting slots with fixed lengths and send timely reminders. In this way, digital event scheduling tools support, nudge, and even constrain us to operate by the clock while ensuring that *certainty* is the primary concern.

However, there are many situations and social groups whose *temporality*, i.e., their understanding, experience, and priorities of time, conflict with such certainty. Families operate on “baby-time” (e.g., Bartlett 2010); different cultures have unique ways of coordinating social life and rituals (e.g., Iparraguirre 2016); illnesses may impact one’s mental and physical abilities (e.g., Pemberton & Cox 2014); and social factors and milieus can influence our understanding of time (Ferrie & Wiseman 2019).

Tools and applications offer limited opportunities to express uncertainty in responses, support flexible scheduling, and plan under uncertainty. For instance, MS Outlook (2021) provides an *I’m-running-late* shortcut and allows users to mark meeting attendance as *tentative*, but this does not challenge the event itself. Overall, there is a considerable lack of understanding of the types and circumstances of temporal uncertainty as well as its implications on the negotiation of social events, and how this can inform the design of scheduling tools.

This research was inspired by our own efforts to understand how people with Chronic Fatigue Syndrome (CFS) experienced time and social interaction with

fluctuations in their condition. Through interviews with seven people with CFS (Chapter 3), it was found that uncertainty was a daily experience that caused problems in social interaction and communication with others. From these interviews, eight aspects of uncertainty were formed (U1-U8), such as deciding on *priorities*, making a *commitment*, or *justifying* one's uncertainty, which informed the design of a mobile application and user interface probe called Haze (Chapter 4: Section 4.2). Embedded into traditional digital calendars, Haze was envisioned to allow events to be added based on uncertain times, dates, and locations, making respective uncertainties visible to peers so that they could be negotiated.

Haze was used in interviews with 14 participants from different demographic backgrounds and to support a discussion about the possible normalisation of uncertainty in social digital communication and scheduling scenarios (Chapter 4: Findings). The study helped reveal people's experiences, concerns, and desires for communicating Temporal Uncertainty (Chapter 4: Findings). It revealed the varied ways in which participants relate to and often conceal their experiences of uncertainty, their concerns regarding clock time, and potential moral judgments associated with living with uncertainty. Eventually, future directions for designing social event planning tools that make uncertainty more visible and normal were created, particularly to support empathy and inclusion (Chapter 4: Discussion).

4.2 Creating the speculative probe HAZE.

Informed by U1-U8, I designed a probe—Haze—which provided concrete scenarios to explore perceptions and implications of normalisation of uncertainty. The aim was to help people visualise the idea of uncertainty and understand the implications for the design of tools that could better support it.

Haze resulted from an iterative design process where several features were explored: personal dashboards, expressing uncertainty towards specific people only, visual encoding for uncertainties such as colors, shades, and circles that changed size in relation to uncertainty levels, sliders for entering uncertainty values, as well as bespoke calendar interfaces and visualisations of multiple aspects of uncertainty (U1-U8) within each individual calendar interface. Eventually, the prototypes converged towards the following three main features in which U1-U8 could be represented within one or more of the features, each referenced by their particular name and explained in the following subsections:

• **Haze Event** is a UI-form to explicitly specify one's uncertainty towards an

event in the future. This aims to address ATTENDANCE, COMMITMENT, DELAY, JUSTIFICATION and LOCATION (fig:haze-haze).

- **Haze Days** is a traditional calendar grid visualisation that allows users to set uncertainty (binary: yes/no) for a number of days, *before* and *after* a given date (fig:haze-days). The aim was to support the management of activities in light of daily uncertainties prior to important events and account for how the event could have an impact in subsequent days. This feature responds to ATTENDANCE and PRIORITIES but also the DELAY and ALTERNATIVES (i.e., seeking an alternative at the onset of a scheduling process/invite).
- **Haze Widget** is a widget at the mobile phone home-screen, providing a visual shortcut to one's own uncertainty with respect to a given event (fig:haze-widget). This is the same uncertainty communicated to peers participating in this event. It's main function is to remind a user they set an event to be certain/uncertain, e.g. to consider how this has been communicated to the others. Haze Widget also allows people to make and quickly change one's commitment (ATTENDANCE, COMMITMENT) as well as to avoid lengthy JUSTIFICATIONs.

The following reviews each component individually.

Haze Event: Specifying Uncertainties about an Event

fig:haze-hazeb, shows the Haze Event form where a user can accept, decline or mark an event as uncertain (ATTENDANCE). They can also make only a specific part of the event uncertain, such as start and end time (B). A person can observe other peoples' uncertainties towards the event, as denoted in (C): red=cannot attend, green=can attend, yellow=uncertain; DELAY, EXPECTATIONS. The amount of blur further indicates the degree of uncertainty. If a circle is half-green, half-orange, it indicates that only specific aspects of this event are uncertain, such as the ability to reach the LOCATION. Clicking a person bubble in (C) reveals these details.

It was important that the designs adopted a fast user input method to communicate uncertainty. The reason for this was that participants in the scoping study reported that unforeseeable decline in health could occur very quickly (ATTENDANCE, DELAY), and that lengthy communication when trying to inform people why they might not be attending an event could worsen their fatigue. With Haze Event, a user could, for example, simply accept an event but haze the event time, and change it later at anytime (COMMITMENT, DELAY).

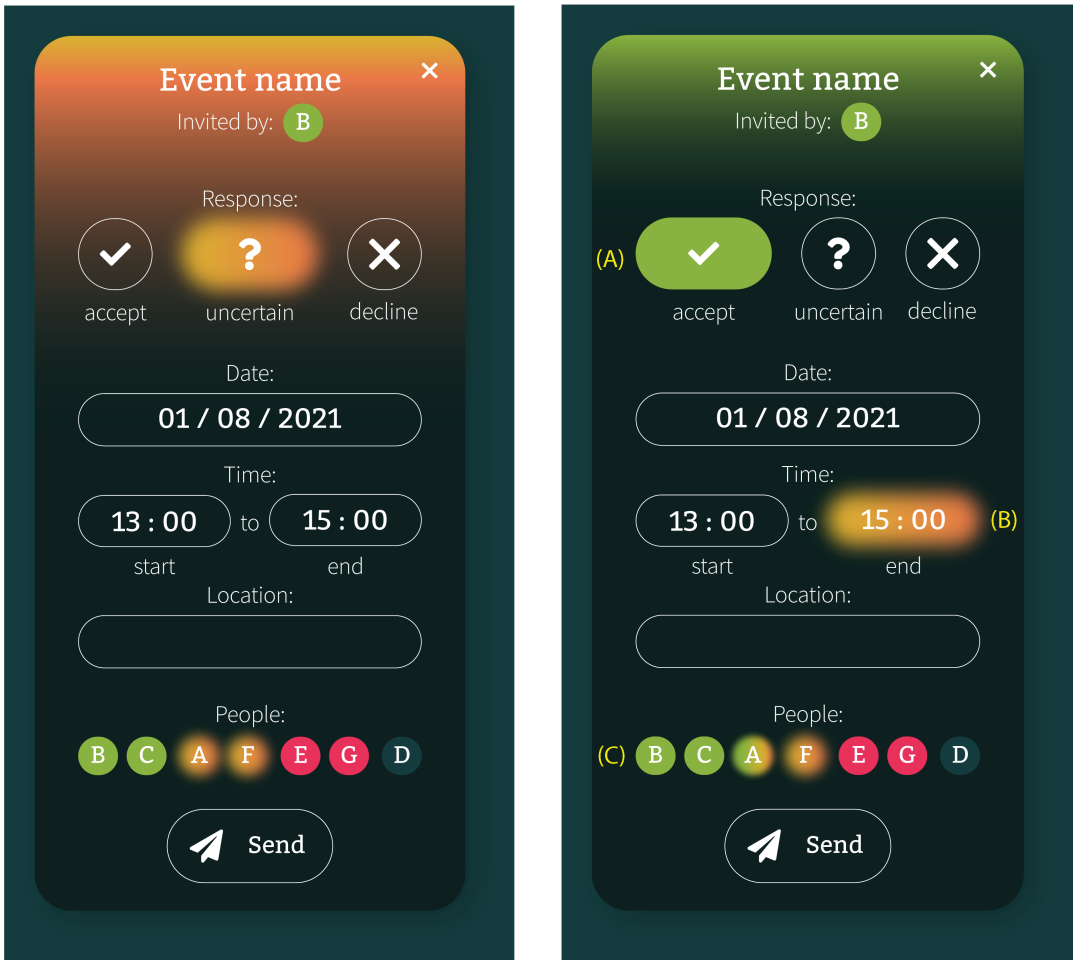

Figure 4.1: Haze Event showing a form allowing a person to specify uncertainty about a event with respect to day, time, and location (blurred focus). The bottom of the form visualises the ability (uncertainty) of other possible attendees of this meeting. UI Co-Designed with Joe Revans

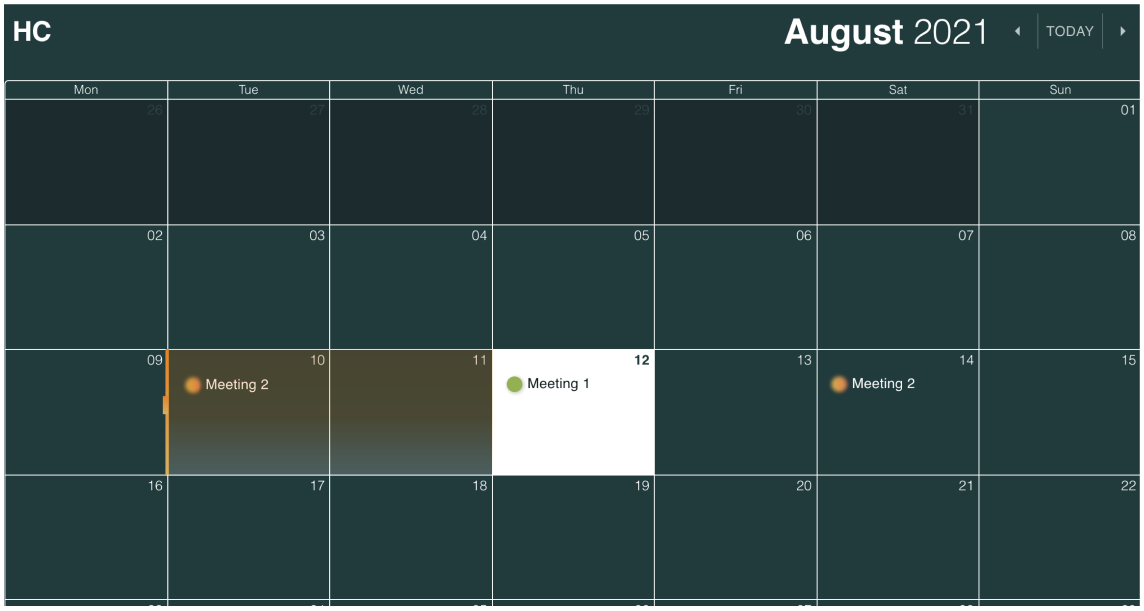

Figure 4.2: Haze Days showing a set of blocked (uncertain) days a around a specific day. All events in the uncertain days will automatically set to uncertain.

Haze deliberately has no text-based or other instant messaging communication option since, as mentioned, text communication back and forth could cause further fatigue and health decline, as described by P4B with respect to JUSTIFICATION. Equally, the blur effect was important as it offered a quick visual option to understand the hazed and non-hazed aspects of an event. This redundant encoding is important during a possible decline in one's cognitive functions, e.g., when reading or understanding information can be challenging. Equally, visualising uncertainty through a *blur*-effect, is a metaphor experienced by our participants and which in fact gave Haze its overall name.

Haze days: Blocking off days

With Haze Days, people can block days as uncertain around a specific date (fig:haze-days). To do so, they drag and drop a "glass pane" onto a day in a calendar grid-view, and drag the left and right sides of that pane across the days that they wish to mark as *uncertain* (ATTENDANCE, DELAY). People who were invited for events on those days will then get a status update in their Haze Event form (fig:haze-haze). In that sense, Haze Days is a shortcut to set many events as uncertain. Haze Days was motivated by the expressed desire of participants to set PRIORITIES, manage their COMMITMENT, and at the support finding ALTERNATIVES, while at the same time, again, reducing JUSTIFICATIONS and and manage EXPECTATIONS early on in the scheduling process.

(a) (b)

Figure 4.3: Haze Widget shown on a mobile home screen to indicate uncertainty about the ability to attend an event: certain (left) and uncertain (right).

Haze Widget: Reminding one's own uncertainties

Besides indicating one's uncertainty for an event Haze Widget, allows users to quickly change the uncertainty of this event, with a single click, from certain (fig:haze-widget-1) to uncertain (fig:haze-widget-2). A person can have as many Haze Widgets for as many events as possible on their home screen. Haze Widget was designed to support setting uncertainty for an event (ATTENDANCE, COMMITMENT, LOCATION) and most importantly to avoid expense of energy on JUSTIFICATIONS for being uncertain or cancelling the event.

Therefore, do these findings only relate to people with CFS and in what ways might others relate to needs for technologies or features that support the communication of uncertainty? How else are others affected by our revealed notion of dominant certainty and how can design exploration be done to reveal alternative and diverse perspectives of temporal uncertainty? Our findings suggest, considering expectations of certainty from people with CFS is a potentially exclusionary narrative. How else might others be excluded? What novel insights about inclusion is produced if exploring alternative experiences of Temporal Uncertainty? What role does technology actually play in suppressing expressions of uncertainty in favour of certainty? Supported by Q2• *What insights are produced from a broader audience when given the ability to communicate temporal uncertainty?* this PhD positioned its exploration from these curiosities. With the goal to expand the understanding of inclusion within the landscape of HCI research.

Moreover, how do HCI communities who consider inclusion in their design

practice gain further inclusive designs by orientating time as a potential factor of marginalisation?

The results discuss the implications of not taking certain practices of temporality into account as a factor of marginalisation and could see problematic challenges in HCI pursuits of inclusion.

4.2.1 EXPLORING TEMPORAL UNCERTAINTY WITH HAZE

Haze was used in a study with 14 participants to understand how it could influence peoples' attitudes towards temporal uncertainty as well as their use in hypothetical use cases.

4.2.2 Recruitment and Participants

Recruitment took place through online social media platforms, such as Facebook and Twitter, and through word of mouth. It was chosen that people with CFS would not be included in this study, this was done to gain new insights and reflections from a wide range of participants to gain insights into the wide impact of a possible normalisation of Temporal Uncertainty.

This study included people with a wide range of backgrounds: a mother of two running her own business, a community carer, an archaeologist, a network store worker, a retired school cook, an auctioneer, two PhD students, a medical prosthetic nurse, an aquatics store manager, a delivery and removal worker, an early years officer, a CAD designer, and a night shift worker. All of which where chosen as in some capacity they used digital tools and technology in their daily planning activities. Participant ages ranged between 18 and 80. Eight participants identified themselves as female, six as male. Participants were not asked about specific health conditions, other than ensuring they did not have CFS, therefore they did not report on any prior to the study. With each participant, a 1h interview was conducted over video call.

4.2.3 Setup and Protocol

Haze was prepared as an interactive demo in Adobe XD.[1] fictitious events were created without titles to avoid priming people about specific event types during the interview. It was made clear to participants that it was not the research goal to be concerned about specific interface elements, but in their perception of scenarios in which they *would* use such features to address issues

[1] https://www.adobe.com/uk/products/xd.html

around temporal uncertainty. With each participant and for each feature (Haze Event, Haze Days, Haze Widget), the following process was followed.

First, a demoed feature with the example events. For example, Haze Days- demonstrated how to create an event and specify uncertainties for day, time, and location. On average, these demonstrations lasted between 2-5 minutes. Then, we made sure participants understood the demoed feature. Participants were then asked a set of questions specific to each feature in Haze:

- For *Haze Event*, interests were on if participants could think about a situation that they have experienced, where they would have used Haze Event to (i) *communicate uncertainty about the location, date, and time or an event*, and (ii) where they wanted to *see other attendees certainty* for attending.
- For *Haze Days*, participants were asked about a scenario where they might have or have wanted to communicate *uncertainty about plans before and after an important event*.
- For *Haze Widget*, participants were asked to describe a past situation or a future scenario when something unexpected happened, which meant that they were uncertain about attending an up-and-coming event as well as if they could envision a future scenario when they might use a feature such as Haze Widget.

4.2.4 Analysis

The interviews were audio-recorded, transcribed, anonymised and analysed using a thematic analysis approach (Braun & Clarke 2006). The transcripts were uploaded into NVivo,[2] and, for each transcript, a line by line analysis by the lead researcher and supervisors was conducted, as a method to start producing emerging codes. Memos were taken during the interviews, allowing the research team to question the data in place and to cross-reference it with emerging codes. Transcripts were analysed one at a time, with initial codes being produced along with annotations of what that code might contextually mean in reference to communicating Temporal Uncertainty. Once all transcripts were coded, codes were shared between different members of the research team to reduce biases and understand if the codes were representative of the data. Codes that were not considered representative were discussed and the coding scheme revised until an agreement was reached.

[2]https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/support-services/nvivo-downloads

The research team initially defined tentative codes for emerging commonalities across the interviews. Codes where then grouped with related codes and themes began to emerge. This was repeated, and once all codes were within tentative themes, another analysis of the data was conducted. This time, instead of going through the transcripts, the focus was on the themes' respective codes and annotations until core themes emerged. This step allowed for the extraction of the data, and lead to the findings.

4.3 Findings

In the study, common themes were found, including how temporal uncertainty is (not) communicated, what moral judgments and implications are involved in being uncertain, how uncertainty relates to health conditions, how communicating uncertainty through Haze can help fostering empathy among people and lastly how communicating temporal uncertainty through an application like Haze could potentially be misused and have negative impacts.

4.3.1 Uncommunicated uncertainty

While temporal uncertainty was a common and everyday experience reported by participants, it was found that the communication of this uncertainty presented various challenges. P9 felt that uncertainty occurred when events clashed, but thought that it was *"hard to communicate to people because you don't want to offend people when you're saying maybe I'm going to come."* (P9) Having to choose one event over another caused pressure, as P9 did not want to let people down, and communicating uncertainty was seen as potentially causing uncomfortable interactions with peers.

P10 discussed experiencing uncertainty about a new job, and although they wanted to communicate it to their boss, they felt apprehensive to do so: *"sounds bad, it's very, very toxic, I suppose I wouldn't't want to appear weak if that makes sense, I don't want to appear as if it bothers me"* (P10). Internalising and not communicating their uncertainty was chosen over demonstrating it, which they felt would make them look "weak". The internalisation of temporal uncertainty, as seen with P10, was expressed by participants in varying social interactions. For instance, P8 had arranged to meet friends, but they were unsure if they would be able to make it due to the event location. However, they thought that asking about the location could be interpreted as interfering with the event details: *"I don't want to feel like I'm dominating any kind of narrative or must be*

changed to accommodate me." (P8) Again discomfort was chosen over expressing uncertainty.

In the absence of an acceptable way to communicate uncertainty, participants sometimes opted for not responding to invitations. For example, P3 was spontaneously invited to an event and wanted more time to consolidate how they felt about it: *"you don't want to say no and you don't want to say yes straight away so you go quiet and then they think you're being rude."* (P3). They chose not to respond because the options of cancelling or accepting demonstrated a degree of certainty which was not representative of how they felt.

Finally it was acknowledged that some people would make an extra effort even if they did not feel comfortable about a particular aspect of a social arrangement: *"There might be things that just aren't going to work for people like the location might be too far, or the trains may just not work, but I think the majority of people put themselves out of their way"* (P13).

Going "out their way", internalising or not replying to invites were the ways participants found to handle uncertainty.

4.3.2 Temporal certainty and the encounter of moral judgments

A theme emerged around the potential of inciting judgment from others by not abiding to specific time-related etiquette. For instance, P11 felt that they where required to be strict with being on time and any alternative would impose judgment on their character, *"you do not want to [...] leave the other person waiting for you, you want them to enjoy meeting you, you want them to [...] think you're reliable, I hate when people are like super late for me"* (P11). P11 was concerned about how others would perceive them, but equally felt resentment towards people who did not meet their expectation of being on time.

Fear of judgment, led P14 to perform temporally in a specific manner that was more akin to the approval of others: *"my brother is always late to everything [...] I can see [...] how my family reacts to it [...] so I'll do my best to not be the same"* (P14). Similarly, the guidance to enact specific aspects of time was seen by P13 as rooted in early years of growing up *"I think there's a lot, you know, expectation that everyone should be on time presents like it's drilled into you from a young age that you should be here by a certain time"* (P13). The teaching of how to enact a certain time was expressed as being instilled through a sense of fear, *"I specifically don't like being late. I think it starts off when you go to school, as a kid. Because at that time you have always got to be there, that you have fear of getting told off."* (P10).

Being certain was seen by P6 as part of their personal obligation to an

event *"I think if you say to someone you're going to be at a certain place. You know there's a commitment you've made there"* (P6). However, the commitment in certainty of time, date and location was shown to not always be manageable and could cause personal discomfort when it was unobtainable, as discussed by P7, *"I don't want to let people down and because I've agreed to come over and I think, watching the clock at least, then I might feel a bit like I'm taking control"* (P10). Watching the clock was a way for P7 to feel in control when uncontrollable factors such as traffic jams during a long trip from holiday caused challenges to attending an evening they have committed to.

Further problems would arise when participants felt they did not fit the expected time narrative, as described by P5: *"people get on to me quite a lot for just being quite slow."* (P5). Which led P5 to question their attitude, despite their embodied experience of time *"I'm wondering if I don't actually want to be a slow person and if I want to be like one of these people that are super on the ball and able to achieve loads of things, but I'm actually quite tired and sleepy"* (P5). The pressures faced by participants to uphold their own temporal morals to stay within an expected time etiquette or to change their whole approach to ideas of time, demonstrated insights of the challenges faced by trying to uphold certainties and time perceptions in everyday experiences of uncertainty.

P9 summarises the issue around the culture suggesting that a bigger shift would need to take place: *"[It] comes down to the culture that we live in and [the] working culture and [the] being-on-time culture. Giving yourself the hundred percent and so on. And, so we've been [...] even raised through our skills or education systems; you are late for school—that's bad! [...] I think that that's why it would need a big change. It wouldn't be just an easy quick change, it would need everyone to change how they look at things."* (P9)

4.3.3 Normalising uncertainty in social negotiation

Haze was seen as a way to talk and be explicit about uncertainty. Speculating upon the use cases, participants discussed a number of ways in which they would use Haze, and the impact it could have in their experiences and communication of uncertainty. P10 who currently experienced challenges communicating uncertainty with their employer saw Haze and as potentially beneficial: *"this in this calendar could be considered to be normal and acceptable with anyone if it was applied in the right way. You could work it with an employer, for example, where you don't know the person, but you could then present that as a way of feeling oh I'm uncertain about that"* (P10). Haze would support P10 to express uncertainty

to those they were not familiar with temporal uncertainty. Speculating on Haze, P9 felt that, if communicating uncertainty was more normalised, new possibilities for social event planning would open up: *"If [temporal uncertainty] was more normalised [...] you have the opportunity for people to actually just make their own decisions about more [uncertainty] and not the way [it is] now by having to say 'yes', and then [...] cancel last minute."* (P9).

4.3.4 Supporting uncertainty imposed by health conditions

Physical health

Participants eventually reported unexpected challenges imposed by health conditions which led to diverse experiences of uncertainty, and social challenges: *"people would be asking where I was, and I didn't want everyone to know I had epilepsy."* (P5). P5 reported that they *"don't feel like I can give stuff like 'I need to rest', as a valid excuse to people for not meeting"* (P5), and usually would *"push myself to try and attend something if possible if people knew that I was going to be there"* (P5). P5 said *"I would definitely use [Haze] to communicate things like unexpected interruptions like seizures and stuff to avoid having to always disclose things I wasn't comfortable with."* (P5). P5 found comfort in knowing they could communicate uncertainty, without having to go into too much detail, giving more time to be in their moment of recovery. In this case, Haze was seen as a way to enable them to focus on their health needs with all the uncertainties that unforeseeable circumstances presented to previously arranged commitments, instead of "pushing themselves" to make it. Similarly, P4 reported: *"with my health conditions, I can feel—I know it sounds a bit weird—but like heavy, just all I want to do is sit or lie on the couch and just not move. I wouldn't just haze the location, I would haze out the time because nothing would change that day, I would haze the entire event! I would just basically haze out of the whole thing as in 'don't count on me being there'."* (P4).

The uncertainty was not only about their condition but also around institutions and appointments as explained by P6: *"the hospital took a lot longer than expected. [Haze] is a handy thing to have because I needed it. It would have helped a lot, because I wasn't able to make it to the upcoming event."* (P6)

Mental Health

Mental health conditions were expressed as equally challenging for arrangement of social events, as stated by P11: *"I have depression and anxiety and [this] causes me more stress. I cancel things a lot of the time, but sometimes I*

physically can't do it. I would like to haze the date." (P11). Here P11 recognised a use case where uncertainty was set against event dates to reduce stresses of having to be certain about feeling better for a certain date. Similarly, P1 described mental health as something that could create uncertainty regarding being able to attend events, in this case an upcoming interview: *"I wasn't mentally able to do the interview knowing that I had the appointment and been through a lot of stress prior to that. It would have been good to know that I had [*HAZE *there in place to say I'm not actually maybe mentally ready to do this because of how I was feeling."* (P1). Having the up and coming interview created anxiety which had ebbs and flows in its tensity. P1 felt HAZEould be used to create flexibility around when the interview could take place based on how they felt that day or time *"You might not be feeling 100%. If you're 100%, you could go to that meeting because you can deal with it, but if you're not 100% that haziness says, 'I might be there, I might not.'"* (P1). This demonstrates that qualitative experiences of anxiety do not run according to quantitative aspects of time.

The participant also explained the impact that social interaction could have on their mental well-being: *"Social interactions are stressful. I hate meeting people that I've never met before. It's always very anxiety-inducing and sometimes that means that if I have to meet someone, I'll have to be uncertain about previous plans in the morning."* (P1) P1 considered using Haze to create temporal uncertainty around their day, and focus on the upcoming evening event that could create an anxiety induced morning or afternoon.

Participants thought that Haze could offer people a way to communicate their personal health in a subtle manner to potentially receive support: *"there's a lot of work being done towards mental health and all that, but I don't think it's natural in our society to be as open [as] 'aw yeah I'm not 100% right now' [...] but having something [like Haze] maybe suggests that, you don't have to outright say [such things]. That would be helpful."* (P13). Here, P13 thought that Haze would help generating empathy towards their condition.

Self care

Burnout from working weeks meant P3 explained they would use Haze to create uncertainty around the weekend as to focus on themselves, *"just to chill, just to relax. The week has been full-on, I've been weighed down, don't want to do anything for the next two days. No, I just want to sit on my bum and do nothing."* (P3). A experience merited by P14 who stated *"If I actually get a random day where I might have a break—it becomes even more important to have a day for myself which is really just what I call 'recharging-the-batteries*

kind of day'." (P14)

4.3.5 Opportunities to foster empathy

Participants considered that Haze could support them to communicate and become recipients of gestures of empathy, particularly due to its ability to communicate one's personal uncertainties and visualise the uncertainties of others. P2 stated that everyday events can have different impacts on different people: *"we're just talking about a simple event, but a simple event can be very difficult for some people."* (P2). In this case, Haze could be an easy way to communicate issues: *"obviously, there are things going on in other people's lives and they've got problems as well and personal issues. Instead of going too much into depth with their problems, it would be good for them to have something for us to see that they're wanting to do, they're wanting to go or wanting to do this, but they find it difficult to make that decision."* (P2).

P13 viewed Haze as an alternative communication, with potential to induce an empathetic understanding from others: *"I think just having a different way to communicate, that there's more empathy, more understanding that comes from a place of understanding of why I may be uncertain for an event. Rather than coming from a place of like 'Oh, you say 'no' to my invite, you said you're unsure, I'm going to take offense to that."* (P9). Haze was seen as a way for P2 to remain in a moment that required empathy with a client's emotional needs *"They would turn around, want to explain what was there and the memories within them [. . .] You can't set a certain time, you can't rush them. Well, you shouldn't rush them, it's not professional, and it's not good for the person even. Sometimes they just want to offload."* (P2). P2 understood these scenarios did not conform to clock time and required them to be in the time of that person.

Being able to visualise other peoples' temporal uncertainties meant P3 felt they could offer extra support to these people: *"for instance [...] 'If you're struggling for a lift, I could pick you up'"* (P3). The communication of temporal uncertainty was seen as a way to empathise, along with generating conversations that were previously unsupported: *"I think if somebody spoke about their uncertainties, or [...] this example of the haze whatever the issue is then you can understand, I think you are able to understand more and probably be able to communicate better what the issue is rather than not saying anything at all."* (P7). P7 felt seeing temporal uncertainty gave them novel understandings of others uncertainties and abilities to open a dialogue: *"It all comes down to communication[...]you can have more of an insight of what's going on in the background and what the issue is with them, why they can't attend, or what they've got going on, etc."* (P7). During

worries of a potentially dangerous sport, P6 felt they could use Haze to open up conversations with their partner and potentially gain reassurance: *"hopefully show some concern about why I'm feeling that way, empathy or sympathy to support as 'well don't worry people have done this 100 times before, that you'll be okay'."* (P1). Certain social situations meant P1 thought Haze would give them an opportunity to see how people felt about an event, *"Would be good to see, to know how they think, and– Because it's hard sometimes because they don't want to upset you and they don't want to hurt your feelings."* (P1)

4.3.6 Remain Uncertain

Being supported to remain uncertain about events was seen as a key use case for Haze: *"It's being able to hit this button and say I'm not sure how I can make it tonight, because this has happened, lets you absolve you of that and lets you go and focus on fixing whatever it is."* (P9)

Haze was referenced as a way to gain affirmation in uncertainty; there was a comfort in thinking that people would think they want to do the event despite not solidifying the commitment promptly: *"keep it hazed until the day before that morning, so that they know that you would like to do that."* (P11). P10 felt observing another person remain uncertain, gave them permission to feel justified in their own uncertainty *"One of them [tells] you 'I'm not really sure about the time'. That makes you feel better because you know that you're also feeling that way."* (P10) (EXPECTATIONS, JUSTIFICATION). Something P14 equally expressed *"At the same time, you know my brother was going to say 'oh I'm not quite sure if I can make it at six' then at the same time, I will be like oh actually me too... so I think it's just that kind of affirmation would actually make a lot of difference"* (P14).

P3 stated that the ability to observe another persons uncertainty around the location of an event, would affirm their own commonly experienced uncertainty, leading to mutual coordination: *"you might be like, 'Yes, I'm thinking the same thing. You know what, I'll just see if they may want to share a taxi, then we could both go, and it will be cheaper'."* (P3) (LOCATION). P9 referenced that a democratic process could occur around the temporalities of an event, if people could be observed remaining uncertain about details of that event. *"I think it's more about the collaborative side of things, because then it feels like [...] working together to make a better event [...]. It's about giving [people] that opportunity to speak up, allowing other people to recognise what the flaws are in the plan. Maybe if it was [hazed] because the other people would use that; you would know that other people aren't sure about the thing as well, which*

would probably help with the overall uncertainty and anxieties and stuff like that within a group." (P9).

4.3.7 Misuse and potential negative impacts

Some participants expressed using Haze in a way we had not previously considered. For example, P2 described the ability to see who Hazed an event meant they could track people's uncertainty with the goal to avoid those people, along with a desire to express their uncertainty about being around specific people: *"one or two people that maybe you don't get on with or you don't particularly want to be there with; you can haze that. That's a way of saying 'Well, I'm not sure about this'. That communication you can't normally do face to face because it creates emotional difficulties."* (P2) (JUSTIFICATION). P13 expressed that communicating uncertainty about days might invite certain people to be opportunistic in taking their time: *"they know that you're trying not to interact with anyone else, so they take the chance."* (P13).

This sentiment was shared by P6 who stated *"maybe, if one of the names on the list I wasn't too keen on—I don't really get on with that person—so [I] haze the whole event, until that person [hazes]."* (P6). P8 mentioned that they were unsure in welcoming Haze, as having people communicate uncertainty might lead people to cancel more and impact them personally: *"my hesitancy of such a system is this worry or fear that if more people potentially communicate their uncertainty about something, it could potentially lead to things like delays, cancellations and [...] not getting the interaction with people [...]. I still massively value the human interaction."* (P8). P8 expressed how communicating uncertainty might hinder them having human interaction due to people openly expressing uncertainty.

These views warn of potential negative impacts of a normalisation of uncertainty, which suggest the need to reach a balance across different needs.

4.4 Discussion

In this section, reflections are on the wider implications of the study findings for normalising temporal uncertainty and the role digital tools and HCI can play in achieving this goal. Where appropriate, reference will be made to the uncertainty aspects produced by the research presented in Chapter 3.

4.4.1 Marginalisation and Normative Temporalities

As discussed in Section 4.1, digital calendars and technologies for social event planning are designed based on the assumption that people are certain about the date, time and location of a particular event. Despite the inclusion of some features such as responding as "tentative" to a suggested arrangement or polling people's availability for an event, these applications often leave little space to express more nuanced notions of uncertainty about different aspects around the event or people's personal conditions. While it can be argued that a certain degree of certainty is essential for events to occur, the inability to express other experiences and concerns helps to perpetuate the idea that certainty is the only and best way to respond to a request for a particular meeting, which limits possibilities of expressing, sharing and designing for other experiences of time.

As identified in our study, participants felt that **they could not openly express uncertainty** with fear of offending others, of being seen as trying to dominate the situation, or feeling they should just personally deal with their uncertainty (EXPECTATIONS). Sometimes they would even prefer to go quiet instead of communicating uncertainty about a particular invite (JUSTIFICATION). Fear of moral judgment was a particularly important concern as participants thought that expressing uncertainty would make them look "weak", receive disapproval from family or leave them viewed as an uncommitted person. They aspired to be like those who are *"super on the ball"* (P5) responding and attending events promptly. Overall it was clear that some attitudes to scheduling were socially accepted and therefore considered "correct" while others were considered unacceptable and therefore "incorrect."

Flaherty (2011*b*) explains that when people 'choose' to enact a temporal expression, they help to solidify it. This often happens unwittingly based on a society's status quo on temporal practice. By leaving little space for uncertainty, and therefore little 'choice' for people to express other ways of reacting to an event, scheduling technologies reinforce the status quo of temporal certainty, therefore contributing to solidify it. Since digital scheduling tools limit how people express their uncertainties, people are left to internalise their experience of uncertainties, which is then classed as 'abnormal', therefore continuing to instill a dominant narrative that certainty should always be achievable.

Society, technology, and personal behaviour all work in unison to guarantee that these norms remain unchallenged. Those who suffer from chronic fatigue syndrome, for example, struggled to participate in full-time employment and social interactions that required certainty (ATTENDANCE). Diverse experiences

of uncertainty (sec:sec3-2) were encountered daily and resulted in concerns or reluctance for planning events (COMMITMENT). More physical decline to health meant prolonged experiences of being bedridden (LOCATION), potentially leading to social isolation or mental health issues. Responsibilities to personal care was met with pressures to be certain to meet all demands presented to them in particular days, months and in some cases years (PRIORITIES). In the second study, it was observed that experiences of depression meant control over events was not possible, due to the unknown length or severity of the condition (COMMITMENT). Physical health onsets such as seizures changed the landscape of feeling certain to being unexpectedly in a situation of uncertainty. Perpetuating certainty as the correct way to respond to others through digital tools can therefore lead to the marginalisation of these people, as they risk becoming alienated from social groups, interactions, identity, or social "normalities" Rimmerman (2013).

4.4.2 Towards a normalisation of temporal uncertainty

By mimicking a scenario in which uncertainty would be the baseline to arrange any event, **Haze invites people to reflect on uncertainty** as an intrinsic part of everyone's reality, therefore challenging the idea that *"everyone else is on top of things and living their best lives; [we] see that, actually, uncertainty is there as well"* (P.) This, in turn helps participants to acknowledge their own experiences of uncertainty and connect to how it affects them in different ways including how it affects the way they see themselves and others (JUSTIFICATION). In other words, the potential of seeing other's uncertainties created an observable normality and participants felt that they could then communicate their own uncertainty too (EXPECTATIONS). This process helped to **engender a form of temporal empathy**, as suggested by Pschetz et al. Pschetz & Bastian (2018) as a byproduct of expanding notions of time. Empathy has been stated as emerging when a person experiences a scenario and recognises someone else in or going through a similar scenario, which can create an empathetic connection Thomson (1966). Participants recognised other peoples' experience of temporal uncertainty as a relatable experience. This empathy went beyond a passive position and sometimes incited people to reach out and offer support to others where required e.g. by offering a lift (P3) or to understand more (P7) about a persons situation.

By revealing temporal uncertainty, Haze supported a better understanding of someone's situation and what is *"going on in the background"* (P7) of their lives, even if it didn't support verbal communication. Overall people assumed that through Haze their uncertainties would be positively viewed. For instance, P2 and P11 suggested that by hazing an event people would say that they *"would*

like to do that" (P11), they are "wanting to do this" (instead of otherwise) they just "find it difficult" at that particular moment. This positive view also **prevented people from taking *"personal offence"* (P9)**if they couldn't make the event at all (JUSTIFICATION, EXPECTATIONS). This shift from a norm based on certainty to a norm based on uncertainty was therefore seen as transformative and in some way **liberating from moral judgement and restrictions** produced by a culture of being on time and *"on the ball"* (P5).

This could help to produce a virtuous cycle where temporal uncertainty is understood, respected and people's own experiences have more space to emerge, be validated, empathised and so on. This way, Haze helped participants to discuss and express perspectives their true experiences of uncertainty, which in turn **affirmed their very own identities**. Owning one's own temporal experience or revealing alternative temporalities that might not be defined as the temporal normative therefore empowers a critique against dominant concepts of time that may not match people's experiences.

This freedom to express their own experiences **led participants to reveal personal physical (e.g. P1, P4, P5, P6) and mental (e.g. P11, P13) health issues.** These conditions were not revealed (or indeed queried about) prior to the study and were by no means part of the recruitment process. The health conditions were mentioned as leading to issues that were out of participants' control, such as the need to wait for a hospital appointment (P1) or simply rest (P5). The temporality of the body requiring rest and there being no way to tell how long rest was required for creates a notion of temporal uncertainty that came in direct friction with narratives of certainty (COMMITMENT). Haze became a way to validate the need for rest without having to verbally disclose sensitive personal information (JUSTIFICATION). This is in line with literature on Crip time Sheppard (2020) where the body or mind fails to conform to expectations of social normatives. Within these normatives, although health can interrupt habitual ways of performing in time, it is not always seen as a valid reason for not agreeing on or joining an event, or a *"valid excuse"* (PP5) to rest.

Calendars and other technologies to support social event planning that gear towards certainty of attending a particular event can be compared to what Kafer Kafer (2013*a*) refers to as technologies that are directed towards fixing potential disabilities, as they, too, attempt to align people with normative narratives. **Technology can not only perpetuate ideas of normality, but also keep people on normative discourses** Taylor et al. (2017).

Instead of trying to fix participants' inability to express certainty, Haze would attempt to support people's own experiences which were often alternative to the dominant notion of certainty. It also allowed participants to discuss transformative

ideas of how the ability to communicate uncertainty could impact them and their social interactions. **Such a process can be empowering** not only for individuals but also for designers, as discussed below.

4.4.3 Perspectives for HCI

This section discusses perspectives on how designers and the HCI community can work with our findings to create more inclusive designs.

Recognise technology's responsibility in creating temporal norms—In this research, it's been observed that the suppression of personal experiences, the creation of moral judgments, and the perpetuation of certainty is potential side effects of current technologies that support social event planning. These findings extend prior work on current trends of time in HCI, e.g., when Rapp et al. Rapp et al. (2021) ask whether there are any *"side-effects arising from shaping the temporality of people through technology"*—based on the findings the answer must be "Yes." Other work has reported that being perceived as a busy person—i.e., a person mastering clock time as well as being mastered by clock time —was generally understood as a moral, social norm, whereas those maintaining this habit (of busyness) experienced negative challenges, sometimes leading to anxiety and guilt Leshed & Sengers (2011). Insights also revealed positive aspects that arose from speculating about the ability to communicate and reside in temporal uncertainty. Once HCI has found ways to embed temporal uncertainty into technology, the normative power of technology can help establish new forms of scheduling and social negotiation.

Realise personal biases—Design that does not attempt to represent the *diversity of temporal experience* risks excluding many and potentially being harmful to people and society more broadly- which extends Papanek's Papanek & Fuller (1972) notion of inclusivity. A good place to start being more temporally inclusive is by questioning our own experiences. How many of us have experienced temporal exclusion or felt unable to express their temporal needs? Designers too internalise their own temporal judgments and need to consider ways to question their own assumptions and temporal biases. We should question *who* and *how* we exclude with our designs and which norms we may be unwittingly implementing.

Towards novel yet simple features for scheduling—The research demonstrates that supporting temporal uncertainty in scheduling applications does not need huge alterations to existing designs or novel systems. However, the difficulty is in isolating the smallest number of effective features and to strike a productive and inclusive balance between certainty on the one hand (e.g., 'this event is set

and will go ahead' or 'we all agree on a time') and uncertainty on the other. As we have seen with Haze, it is possible to produce a range of features that are simple to understand. It's imagined extending the set of features in future design iterations of Haze through, re-scheduling options or degrees of uncertainty, such as 'very likey', 'likely', 'unlikely', etc. Another solution could be conditional scheduling such as 'if this, then this' or the setting of priorities for tasks, events, and people. In these cases, notifications could be automatically sent to everyone involved. Eventually, people might need to communicate uncertainty differently (e.g., with different levels of detail) to different (groups of) people. The health narratives in this study, also demonstrate some uncertainties will require covert and effective solutions for JUSTIFICATION.

Uncertainty needs collaboration—In many situations, the expression of uncertainty simply requires acknowledgment. In other situations, however, uncertainty requires negotiation in order to lead to accommodating decisions. While interface features can support this negotiation process, designers need to think of it as a process of communication: *When do you know for sure* (COMMITMENT)? *When would be* (ALTERNATIVES)? *Where else could we meet* (LOCATION)? *How long could you attend* (PRIORITIES)?, etc. While textual and other verbal communication has been reported laborious and can set expectations for undesired JUSTIFICATIONS, non-verbal, visual, and perhaps even automated features could help the negotiation (e.g., logging PRIORITIES or including relevant bus and traffic schedules (LOCATION, DELAY)).

Mitigate negative consequences of uncertainty scheduling—as reported in sec:sec6-7, visibility of temporal uncertainty can lead to misuse and potential negative consequences. This requires careful approaches to protect individual needs and circumstances. Possible solutions include providing increased agency over who can see one's uncertainty status, and tagged justifications. If, for example, generic uncertainty (e.g., as designed in Haze) gets misused to evade meeting commitments, tagged generic justifications such as *health*, *caring-commitments*, PRIORITIES, *inability to physically attend* (LOCATION), etc. could provide greater accountability. However, more research is needed to understand the (negative) consequences, as well as negotiation strategies that communicating temporal uncertainty might generate.

4.4.4 Limitations

This study was done under specific conditions. Such as it being a demo of a speculative probe of the system which. Though it allowed insights to be gained in a longer-term study, in more naturalistic settings, where participants

would use Haze as part of their everyday scheduling practices, would allow us to gain a deeper understanding of the practicalities and potential challenges of this tool. Furthermore, the study was designed to *provoke* people to consider such scenarios, as a way to inspire discussion on the social and cultural implications of the technology, Full awareness is given to the potential disruption and, as suggested in sec:sec6-7, that this tool, as any, could be misused. These possibilities would need to be taken into account when considering a practical implementation of such concepts.

4.5 Conclusion

In this work, the researchers set out with the question **Q2** • *What insights are produced from a broader audience when given the ability to communicate temporal uncertainty?* This question postioned the exporation of understanding people's challenges and experiences with temporal uncertainty in social event scheduling. This question was motivated by observations interviewing people with Chronic Fatigue Syndrome (CFS) about the challenges of social uses of time, which often led to a feeling of social exclusion. Looking for ways to make scheduling technologies more inclusive, the scope of the research was broad-end towards understanding the implications of temporal uncertainty across a wider audience. To inform our discussions (interviews) with people, an interactive prototype named HAZEas designed, with three features: Haze Event, Haze Days, and Haze Widget. The interviews revealed that, despite being an everyday experience, uncertainty is often not communicated, motivated by discomfort in revealing personal issues, the fear of being judged by moral conventions, or experiencing social stigmatisation. It was found that a potential normalisation around times of uncertainty could have positive implications for a variety of conditions that, partially informed the second study, where participants expressed physical (P1, P4, P5, P6) and mental health conditions (P11, P13). Haze can help alleviate these issues and help people develop empathy for uncertainty and alternative ways of experiencing and living in time. Haze helped broaden the scope around times of uncertainty, social challenges in living with uncertainty, and the ability of technology to support uncertainty when features are curated specifically from a perspective of uncertainty.

Chapter 5

Temporal Uncertainty Toolkit a Method for Generating Uncertainty Technologies.

5.1 Motivation: Understanding the temporal events that uncertainty surrounds.

Exploring the experience of a broader audience with Temporal Uncertainty in scheduling through the Haze prototypes highlights some key requirements, the greatest of which is the need to represent people's Temporal Uncertainty in tools. The inclusion of features that communicated scheduling uncertainty helped create a more extensive discussion from participants' speculations about such tools. The PhD to this point has demonstrated the ability to reveal the notion of Temporal Uncertainty, to link those experiences of Temporal Uncertainty with the guidelines that influenced the creation of Haze, which then supported participants without CFS to discuss their Temporal Uncertainty around social scheduling.

The importance of Haze's representation of uncertainty has become evident. Expressions of uncertainty were morally judged. Haze demonstrated an opportunity to expand inclusion by empathising with others' uncertainty. Participants felt that tools such as Haze could normalise their uncertainty and help to demonstrate the acceptance and support of others living at a time when uncertainty is a predominant experience.

The research presented in this thesis has therefore shown that tools can become a way to support larger social and personal implications when there is uncertainty. It has shown that it can become a means to support people in these times. Haze showed the potential of tools to be used by people as a way to communicate their temporal experiences of uncertainty. Tools that include

uncertainty features integrated into the social experience of time showed a role in normalising diverse lived temporal experiences that are often suppressed by standard, normative concepts of how one should orientate to time. Building upon the concept of tools for managing or bolstering Temporal Uncertainty, I am motivated to explore the potential of other tools produced through the experiences of Temporal Uncertainty.

Furthermore, as stated, (See Chapter 2: Related work) designer's role in design can exclude people, Haze demonstrated that designers having an awareness of diverse temporal experiences could help negate the perpetuation of one dominant experience over another; aligning with an argument made by (Pschetz & Bastian 2018). This concept relies on the idea that utilising additional Temporal Uncertainty tools can not only challenge normative discourse surrounding time, but also assist designers in reevaluating their role in perpetuating normative temporal discourses. This leads to whether designers engaged in discussions on Temporal Uncertainty could actively challenge normative temporalities. The observations on a normative discourse of time as seen in Chapter 3 and 4 can worsen social exclusion and health conditions. Meaning the role designers play in understanding diverse notions of time, as such with Temporal Uncertainty, can be directly supporting inclusion through design. The Ph.D. research, to this point, contributes key insights around the revealing of Temporal Uncertainty; the representation of Temporal Uncertainty; and the ability as well as cruciality for people to discuss their Temporal Uncertainty are all potent Dimensions in expanding inclusion.

As a novel concept emerging from the research presented in Chapter 3 and extended in Chapter 4, Temporal Uncertainty poses a challenge for designing in HCI. Therefore, there are no exact tools or methods currently functioning within HCI that allow designers to further explore the critiques made within this Thesis. Haze was created from guidelines based on what people with CFS discussed, which led to a designer-centric approach. The following Chapter aims to present a solution to the gap wherein no tools, methods, or facilitation guidelines persist to support the exploration of Temporal Uncertainty.

Sheppard (2020) describes Crip time as an experience that disrupts normative temporal expectations, such as the assumption of using time with certainty and predictability. This research identifies Temporal Uncertainty as part of a Crip time narrative, as it challenges these conventional temporal discourses. Therefore, one of the goals of this research is to continue challenging temporal norms by further highlighting people's experiences of Temporal Uncertainty.

To achieve this, the aim of this research is to create a toolkit designed to facilitate discussions on Temporal Uncertainty. This toolkit will enable researchers

and participants to collaboratively explore their experiences, with the goal of generating insights that could benefit others who encounter similar forms of Temporal Uncertainty.

This approach is inspired by the principles of inclusive design, which seek to recognise shared experiences across a diversity of people, allowing for interventions that address the needs of multiple individuals. By engaging participants in discussions on Temporal Uncertainty, the toolkit aims to produce insights that are applicable across various contexts, supporting others who face similar experiences of Temporal Uncertainty.

The concept of Temporal Uncertainty in health and social interaction was introduced in Chapter 3. Taking a similar approach to Chapter 4, this chapter also starts with Temporal Uncertainty. This thesis acknowledges the vital role that tools can have in supporting and normalising Temporal Uncertainty. The following work now involves facilitating participants to think and conceptualise tools in relation to their uncertainty about time. This approach differs from the one discussed in Chapter 4, wherein a U1-U8 list was employed to produce Haze. Now, encouragement is given to participants to use a toolkit containing temporally themed cards to explore various concepts of time and uncertainty. In this context, temporal cards are defined as cards that delve into prompts related to time. Just to name a few cards, there is uncertainty during the night, in certain moments, in the morning, and in the future. These cards aim to support experiences of uncertainty that can be directly connected to and caused by these temporal points or by expressions of time. For example, expressions of time like those discussed in Chapter 4 e.g. the orientation towards temporal certainty caused challenges to people who require living within Temporal Uncertainty. So, what other insights surface when participants are encouraged to mentally connect with time and its relationship to uncertainty? What kinds of tools are developed when facilitated through their Temporal Uncertainty? It is important to note that tools, in this context, refer to any hardware, software, technology, or objects that support a person in their Temporal Uncertainty.

A Toolkit as a method to facilitate discussion was chosen as they have been widely used by designers for various purposes, including engaging participants Petterson et al. (2023), informing equitable design outcomes Petterson et al. (2023), developing the Internet of Things Vitali et al. (2018), exploring new opportunities in electronics prototyping Bianchi et al. (2023), and teaching design processes Tufail et al. (2018). Toolkits can facilitate converting theoretical concepts into practical applications, and are usually designed to address a specific problem or cater to a particular group of users (Petterson et al. 2023, PP 5). As put by Mattern (2021), in the chapter “Tool kitting as a Structure of Relation,” kits are

not just memory aids, management systems, and standard formats for experts to share their knowledge and skills. They also serve as engagement tools and inclusion methods for wider communities Mattern (2021). Mattern (2021) goes on to state that toolkits, like that of Marty Goddard and their involvement in the development of the Rape toolkit, The New York Times (2020) which broke unjust and ignorant barriers in a time when some believed rape could not be proven. Mattern (2021). Toolkits have a wide range of applications, and their purpose and objectives can generate outcomes that promote inclusion, justice, education, and knowledge. They are versatile, can be used and distributed by many people, and are capable of both driving and adapting to change. For these reasons, creating a toolkit was considered one of the most effective ways, as deemed by the studies represented in the following chapters, for designers to facilitate discussion around Temporal Uncertainty and lead to potential tools that expand inclusion.

Therefore, in this chapter, we explore how we can use the creation and use of a toolkit to facilitate discussion that addresses the individual needs and experiences of people facing Temporal Uncertainty. Thus, the contribution of this last study is to explore the following research questions:

- **Question 3:** What is needed within a Facilitation Toolkit to support people and designers in exploring Temporal Uncertainty? *Explored in sections 5.2—6.2*
- **Question 3.1:** What notions and scenarios of Temporal Uncertainty do people and designers want to design for? *Explored in sections 5.4—5.7—6.2.1*
- **Question 3.2:** What tools and solutions do people and designers come up with when using the toolkit to address Temporal Uncertainty? *Explored in sections - 5.5—5.9—6.2.3*

The following section aims to demonstrate the steps, motivation, and process that were involved in the creation of the Temporal Uncertainty Toolkit. It breaks down how a language referring to Temporal Uncertainty was created and the purpose of doing this. Furthermore, it provides information on how the method of facilitation and the finished toolkit were produced. The remainder of the sections in this chapter are as follows:

- **5.2 Creation of the Temporal Uncertainty Toolkit.** This chapter will discuss how the toolkit was made and the methodology behind its creation.

- **5.3 Setup and Procedure.** This section discusses the recruitment and setup of the study, along with the analysis methodology.
- **5.4 Reflective Approach Findings. The Participants used the Temporal Uncertainty Toolkit.** This section is the findings from the participant version, a version where participants reflect on real-time uncertainty. It is centred around designers working face-to-face with participants. 5.5 and 5.6 are also included in this section.
- **5.7 Discussion on reflective version.** This section discusses the reflective version of the toolkit. There are guidelines produced directed towards designers in HCI within this section, and it concludes the first part of the toolkit use case, with future work included.

5.2 Method and Toolkit for Reflecting on Temporal Uncertainty

The collective research of this thesis thus far has demonstrated the need for a toolkit and method that supports the designer and the participant in exploring Temporal Uncertainty and the diversity associated with it. This section discusses Question 3: *What is needed within a Facilitation Toolkit to support people and designers in exploring Temporal Uncertainty*.

As indicated earlier, the discovery of Temporal Uncertainty in the context of this thesis comes from the research process. In this chapter and the subsequent research within it, the design objectives were to reveal Temporal Uncertainty, foster discussion, and position participants as ontological experts who could co-produce interventions. The first two goals are derived from the previous Chapters, 3 and 4 wherein, interviews allowed for the uncovering of Temporal Uncertainty, and speculation supported deeper Temporal Uncertainty discussion and social challenges around the temporalities of health and the Uncertainty that can arise. An example of which was in social event planning, and the pressures to be or feel certain. Therefore, revealing and discussing notions of Temporal Uncertainty are core goals of this toolkit.

Furthermore, discussion requires a form of communication or language; therefore, another goal of the toolkit is to curate a language and method of communication that encourage the facilitation of diverse discussion around potentially complex, uncertain experiences. The remainder of the goals is motivated by interviews with people with CFS, which led to guidelines, which then supported the ideation of Haze. However, as the toolkit is set to explore and facilitate

diverse Temporal Uncertainty, the goal is for participants to consider interventions within one session that are conceptualised by them. This helps reduce a designer-centric approach, bolster participatory design initiatives, and diversify Temporal Uncertainty design outputs.

The scope of this toolkit is as follows.

- **Goal 1**— Reveal a temporal experience of uncertainty.
- **Goal 2**— Invoke a discussion around the experience.
- **Goal 3**— Contribute a language that people can use to discuss the experience.
- **Goal 4** — Position participants as experts and designers of their own Temporal Uncertainty experience.

Reflecting on the two previous studies made it clear that two critical points of the required toolkit were clarified. The toolkit would need to facilitate people to specify an experience of Temporal Uncertainty and then have them discuss it. As previously presented, Temporal Uncertainty was revealed only through a series of questions and was only apparent after the analysis of the interviews was completed. In the second study, knowing the representation of Temporal Uncertainty was essential for people with CFS, which led to investigating if it was important to others who do not have CFS, which deepened discussions about Temporal Uncertainty when able to speculate on a tool like Haze. Therefore, the toolkit was considered to need two qualities: (**One**) to precisely reveal a Temporal Uncertainty early on through the method and (**Two**) to develop discussion and interpretations of that Temporal Uncertainty to reveal implications surrounding the event of uncertainty that occurred.

The toolkit was constructed with an emphasis on achieving goals 2 and 3, which involved stimulating conversation and developing a language for communicating uncertainty, in order to facilitate discussions about Temporal Uncertainty. To do this, the lead researcher gathered the transcripts from the CFS study and the transcripts from the Haze study to find ways people spoke about uncertainty. 15 transcripts were imported into Nvivio 12 [1] for analysis. With the specific objective of identifying ways participants talked about time and uncertainty, a line-by-line coding approach was implemented. These codes were then sub-themed; then the sub-themes led to an uncertainty or temporal meanings; an example of an emergent sub-theme would be participants discussing uncertainty with regard to a specific topic. For instance, codes, where participants spoke

[1] https://lumivero.com/products/nvivo/

about internal health or aspects of their body with regard to uncertainty, resulted in being categorised as 'Biological uncertainty'. For a temporal word an example would be when participants discussed uncertainty with future planning. That code became the sub theme 'future uncertainty'. The sub-theme could also have a temporal language not specific to uncertainty such as 'waiting'.

The codes and sub-themes, such as 'Biological uncertainty' or 'Waiting' were added to a table, along with the quotes that led to the sub-theme. This practice was continued until the transcripts were exhausted. To begin producing core themes, all sub-themes were inputted into a Miro board [2]. Sub-themes were then grouped according to their commonalities, for instance, 'Biological uncertainty', 'Cognitive uncertainty', and 'Physical uncertainty' became a core theme regarded as 'Self', these were uncertainty in relation to the self. For 'Future uncertainty', 'Waiting', 'Momentary uncertainty', 'planned', 'Deadline' where all themed under Temporal. This process was repeated until the following core themes presented themselves;

Self—My uncertainty has to do with me as a person.

Other—My uncertainty has to do with another person or thing.

Temporal—What is the temporal nature of my uncertainty?

Communication—What type of communication do I conduct in this experience of uncertainty? How do I denote my uncertainty?

This process resulted in core themes, and within those core themes a list of sub-themes, e.g. 'Biological uncertainty', which was a sub-theme within the core theme 'Self'. However, the presentation of long lists of uncertainty words was not adequate as a way to lead the participants through the end part of goal 3, "*Contribute a language for people to use in order to discuss the experience.*" and achieve goal 4, "*Position participants as experts and designers of their own Temporal Uncertainty experience.* ". This was because the list in its current aesthetic would have been overwhelming if presented to a participant in its current form, hindering the goals of the biological. It seemed important to separate the list into a tactile method that allowed for a focus on each sub-theme without seeing a lot of sub-themes at once.

Inspired by ***Cards for Humanity***.[3] it became clear that turning the sub-themes and core-themes into cards would be optimal in achieving our biological goals. This was because the list would be broken into individual cards, they would offer participants to only focus on one card at a time and allow for discussion about that specific card without having to trace back and forth through a list

[2] https://miro.com

[3] *Cards for Humanity:https://cardsforhumanity.idean.com/*

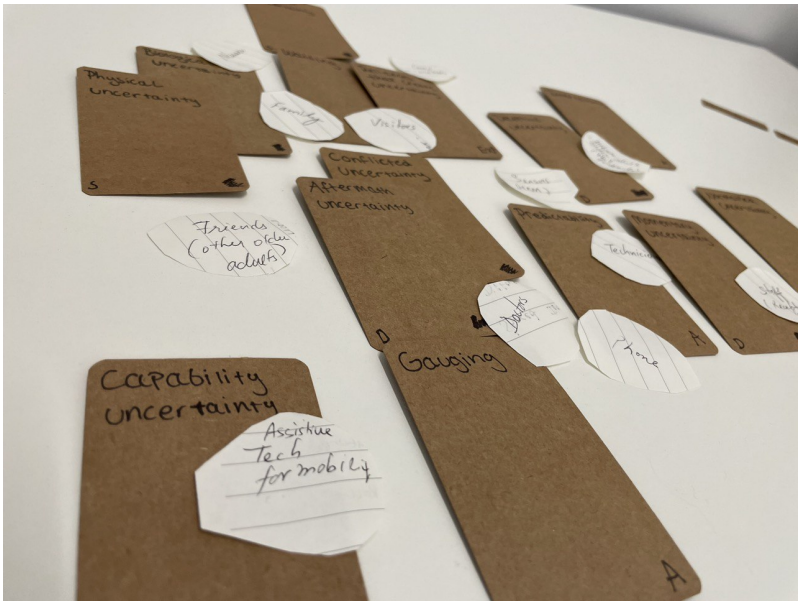

Figure 5.1: Figure 1: Brown playing cards with the sub-themes written on them, plain looking.

of uncertainty. Furthermore, the cards could be infused with illustrations and potential meanings of what the type of uncertainty is and where it came from. Furthermore, it could include various accessible and distribution options. While the initial prototype of the cards, **See Figure 1.** was made of plain paper, the final product was illustrated, black and white, and embossed with braille, **See Figure 2.** The toolkit was designed to be as usable by as many people as possible and to include a diversity of Temporal Uncertainty experiences that would not be hampered by inaccessible methods or the usability of the toolkit.

The research team utilised the first prototype to deepen their understanding of the grouped terminologies previously discussed. Additionally, the team cross-checked each set of cards within the groups to ensure they appropriately corresponded with the terminologies initially established by the lead researcher. If a group category did not seem to fit the cards within that group, the researchers put forward suggestions for a better grouping name. This was done with two of the current core-themes. 'Temporal' changed to 'Descriptions', and 'Communication' changed to 'Actions'. There was a reason the theme 'Temporal' changed. While the sub -themes in the core theme of Temporal remained focused on describing a temporal experience, using the word 'Temporal' as a core theme might have been difficult for others to grasp. As 'Temporal' is not a widely known concept. The theme changing to 'Description' better describes the active sub-theme nature and experience of time, such as 'Waiting'.The self and the external remained. The Core-theme list was updated as follows;

Self—My uncertainty has to do with me as a person.

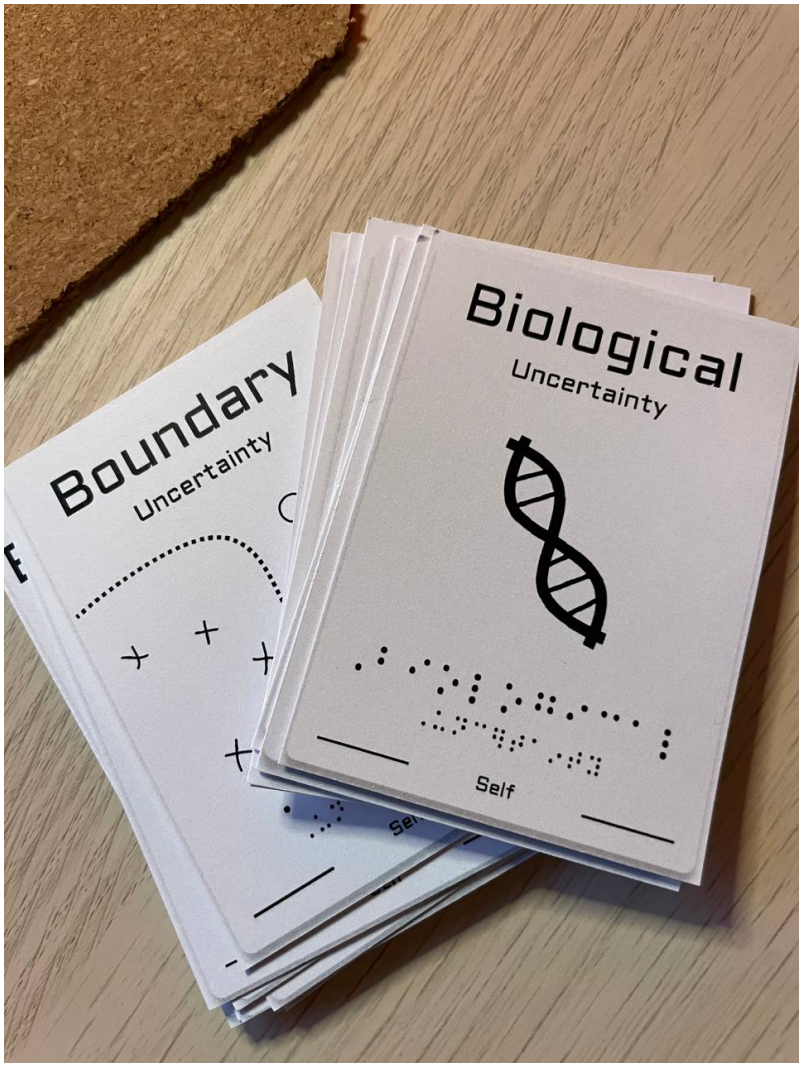

Figure 5.2: Figure 2: The cards are white, Embossed with Braille and depict illustrations of a DNA strand. Illustrations done by Ziqin Tao

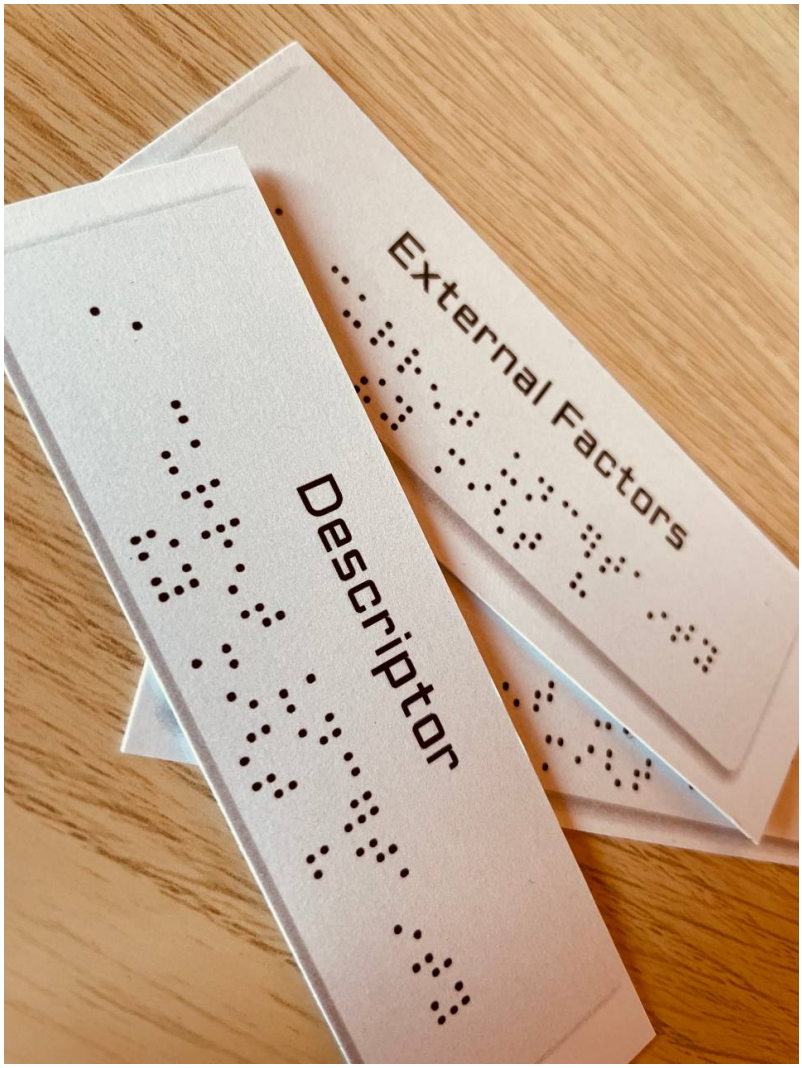

Figure 5.3: Core-theme cards, a white rectangle card with Braille and the Core-theme name (Descriptor)

Other—My uncertainty has to do with the other.

Description—What is the descriptive nature of my uncertainty?

Action—What type of Actions am I doing in this experience of uncertainty? How do I denote my uncertainty?

The core-theme were presented as rectangle style rather than playing card style to distinguish between the cards. (See figure 3:)

The cards were given a second pass by the research team in order to confer on the best groupings for each card and to reduce bias in the main researchers' previous categorisation of the cards. Once this step was completed, the research team worked together to formulate a cohesive set of steps that would best suit the cards if used by the participants. To begin the discussion about uncertainty and to achieve goal 3, participants had to be able to reflect on a time of uncertainty, or event of uncertainty, as to begin using the toolkit

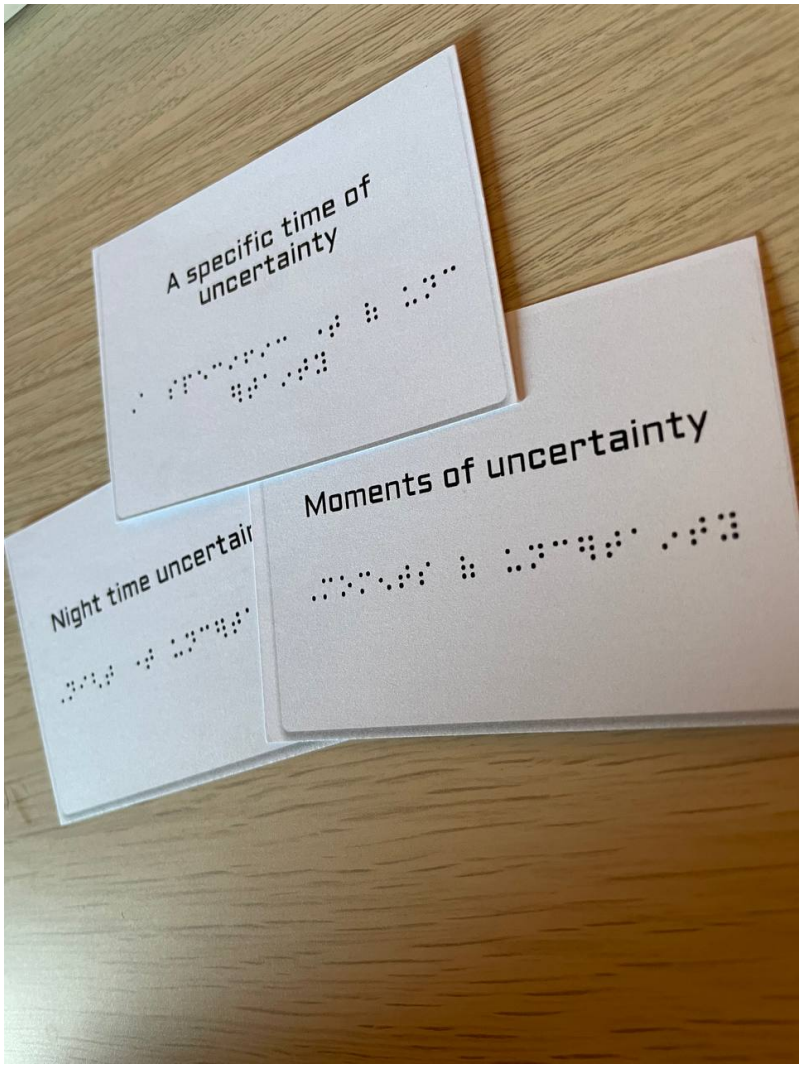

Figure 5.4: Figure 4: white prompts cards, with temporal language written on them.

to explore it. They would need a way to be prompted about the time in which uncertainty was experienced, drawing a way from purely speaking of uncertainty within its own silo and instead grouped with time. For this reason, prompt cards (see Figure 4:) using temporal language such as a 'moment of uncertainty', 'an uncertainty you had last year' and so forth were created. These cards were produced to reflect on a time in which an event of uncertainty occurred.

Tokens became implemented as to identify aspects of the uncertainty, the tokens helped understand the people, environments, objects, tools, etc. involved in the Temporal Uncertainty. This was a way for participants to externalise, reflect, and identify notions of this uncertainty. (See figure 5:)

The steps of the toolkit are as follows:

Step 1— Temporal prompt cards are provided to participants to encourage introspection and help them identify a specific time frame in which they can delve

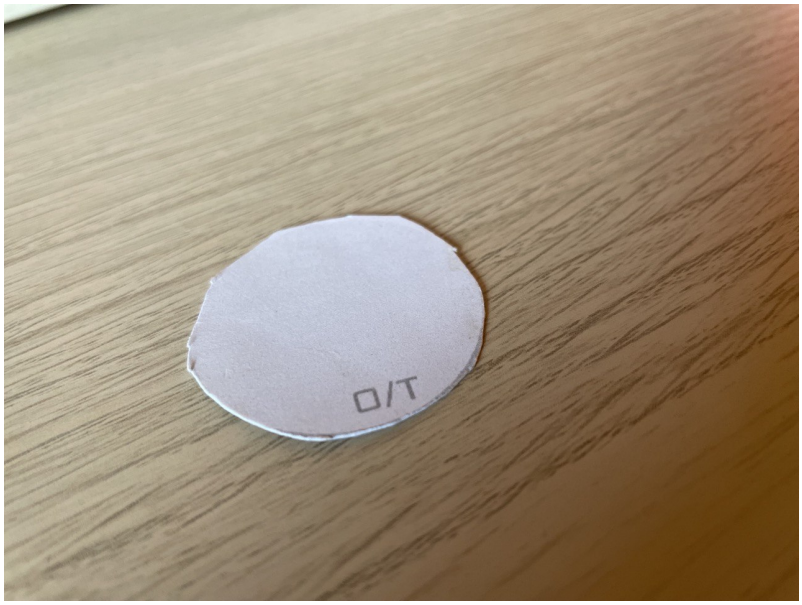

Figure 5.5: Figure 5: A circular white token, with a O/T to symbolise its meaning, object/tool

into and describe their Temporal Uncertainty. It is imperative to emphasise the significance of this step. Encouraging participants to reflect on the connection between time and uncertainty establishes a starting point for contemplation. The Descriptor theme aids the facilitation of Temporal Uncertainty discussion by introducing early in the process temporally themed cards, this initial point serves as a foundation for discussing the connections between Temporality and uncertainty.

Step 2— Participants use the tokens to identify the notions surrounding that uncertainty

Step 3— Participants go through each Core-theme (Self, other etc.) as they go, they select up-to six uncertainty cards they feel might relate to their time of uncertainty.

Step 4— Participants then use the tokens and cards to formulate themes around their Temporal Uncertainty. This is done at a physical table or on Miro depending on whether it is a physical version or an online version. The cards can be moved and tokens can be moved in any way participants choose, and nothing has to remain in its original Core-themes or Sub-themes.

Step 5— Participants are asked to describe the significance of these themes, along with any problems, solutions, or strategies surrounding these themes.

Step 6— Participants are then asked a specific question,"*If someone else was to go through your time of uncertainty what advice, suggestions, or solutions would you offer them?*"

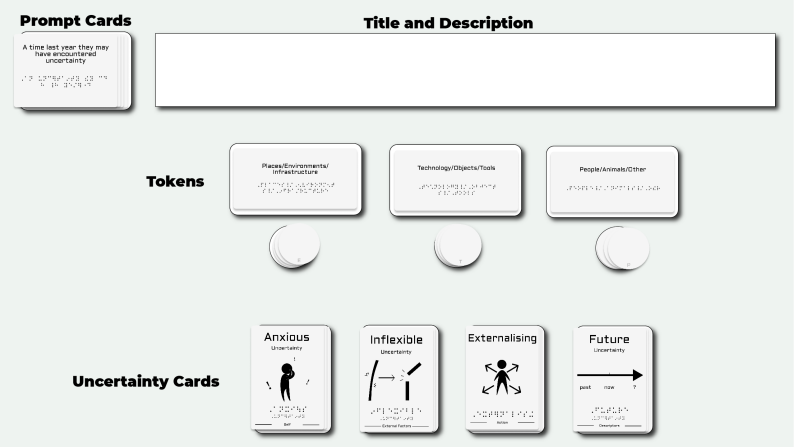

Figure 5.6: A sheet of paper with prompt cards at the top, to the right a title a description section, below tokens and below that prompt cards.

Step 7— Participants are asked to draw, create or talk about a tool, technology, or intervention for their time of uncertainty, something either they would have liked or something for the person they offered advice to.

(Please See, Figure: 6 for optional layout)

In the initial trial of the toolkit, participants were able to reach step 5 but were unable to complete the final step. To address this issue, the research team considered ways to bridge the gap. They encouraged participants to take on the role of experts and to discuss problems, ideas, and solutions within their themes. The team then proposed a specific question, asking participants what advice they would offer to someone facing similar uncertainty. As a result, step 6 was created.

This one question enabled the participant to reach the final step. This is likely due to what Polman (2018) describes as the ‘cautious mindset’ and ‘adventurous mindset’. In a series of studies, they found that “Decisions for others were more creative than decisions for the self” (Polman & Emich 2011, PP 497). The four goals guided the successful completion of a toolkit of this type, and the results are discussed in (Section 5.6).

There were two versions of the toolkit considered. One was reflective manner, in which participants used these prompt cards to reflect and explore their Temporal Uncertainty. The other version was a designer version to provoke speculation of a possible Temporal Uncertainty that the user might encounter (Further explored in Chapter 6). These approaches were named the reflective version and the speculative version. The final toolkit consisted of the following cards.

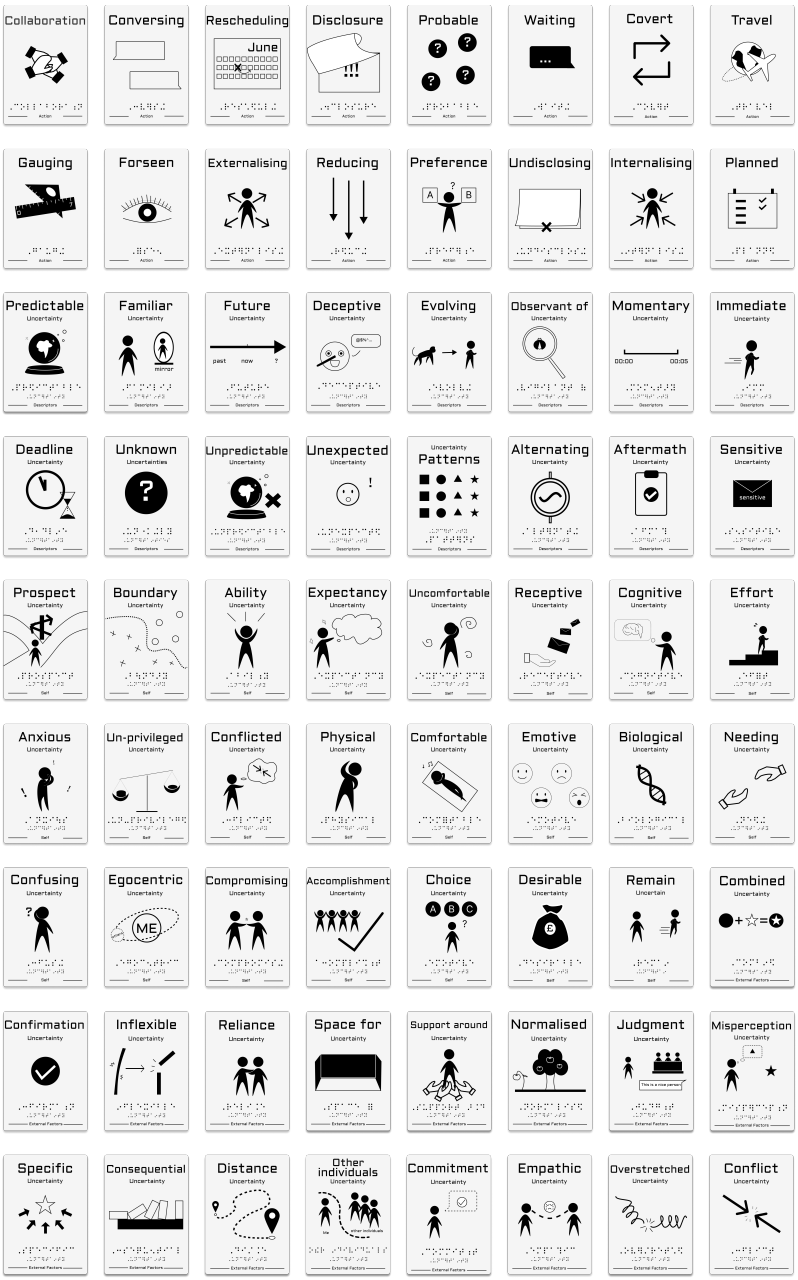

Figure 5.7: A collection of the final look of the Uncertainty cards. Illustrations done by Ziqin Tao

5.3 Recruitment and participants

The objective was to recruit as many people as possible who understood that they had experienced notions of Temporal Uncertainty before. This was explained as a point in time, such as an event, when you encountered uncertainty or uncertainty around or with notions of time. The study was aimed at showing how a variety of people could discuss their Temporal Uncertainty and whether different experiences of Temporal Uncertainty can lead to intervention and tools to support these diverse experiences of Temporal Uncertainty.

The recruitment of participants took place using word-of-mouth tactics and social media posts. The participants varied. Retail store managers, warehouse workers, a grandparent, a director of a business, Ph.D. students, training medical professionals, a person on maternity leave, a lecturer, a freelancer, and a person building their own houses. The participants' age ranged from 20 to 60 years, all participants had some form of employment and resided predominantly in the UK, with the expectation of one participant who lived in the US at the point of research. The participants residing in the UK were citizens of Europe, China, the USA, and the UK. However, participants were not asked for gender, sexual orientation, or ethnicity, as the main aspect of the study was the focus on uncertainty as a topic, and any reference to the latter was provided within the interview by the participants. Participants could participate in an in person method lasting up to an hour, or conduct the method through Miro online.

5.4 Setup and procedure

Participants received participation information sheets and consent forms. In this form, the participants were made aware of what the study was and what would take place during the method. They were informed that it would be an hour long and that it could be done online or in person. They were also told that they would be paid for their participation, a £15 Amazon voucher was given to participants. The ethics was approved by Edinburgh University School of Informatics.

If conducted online, participants were sent a link to a time and place via Zoom, and participants were told that an audio recording of the session, as well as a screen capture of what they did on screen, would happen. If they choose to consent to participate and be recorded, participants would accept the consent window that pops up when recording is initiated. They also gave their verbal and written consent.

If conducted in person, participants were also made aware that they are

being voice recorded and that photos of what they are doing would take place. However, at no point both on Zoom or in person that had people's faces in them. All the data was anonymised once the sessions were finalised to ensure no association between the data and participants could occur.

Sessions took place with only the facilitator and the participant and no other people were involved; this was not a group method, but a one-to-one. As per the method, participants were given an hour, with each step calculated for the time it would roughly take to complete within the hour. Participants followed the given steps (**See section 5.2**). Participants were informed that any tools, concepts, or ideas they produce via this method were the creative rights of them and would not be implemented or created without their permission.

5.5 Analysis

The interactive interview sessions were audio recorded, transcribed, and anonymised; once transcribed, they were uploaded to Nvivo 12 pro. It was at this stage that each transcript was organised. The participants had their own folders, and the designers had theirs. This was due to the two ways they used the toolkit and the desire for the data to be representative of how the study was conducted. Once divided, the participant transcripts were analysed using a thematic analysis approach, following the same analysis method as seen in Chapter 3 and 4.

A line-by-line process was deployed in which each sentence was coded and annotated, and each annotation gave a description of the code and why it was assigned that code, this was for future reference and transparency. Once all codes have been produced, a second pass was conducted and any codes similar in nature then coincided into sub-themes. Once all sub-themes were formed, they were tested against each other. If there were any commonalities, they then became core themes. Leading to an extraction of the findings.

5.6 Findings: The Reflective version; participants use of the Temporal Uncertainty Toolkit

5.6.1 The Source of Temporal Uncertainty

The prompt cards were effective in helping participants identify and address their experiences of Temporal Uncertainty. By reflecting on specific times when they felt Temporal Uncertainty, participants were able to pinpoint the sources of

their uncertainty. Often, these sources were related to sudden disruptions of their normal rhythm, which caused the emergence of Temporal Uncertainty.

For instance, (**P8**) experienced Temporal Uncertainty when a staff member unexpectedly announced their departure, causing a disruption to the normative rhythms of work. Similarly, (**P3**) felt "*Caught off guard*" when a person of authority left their studio space, leaving an expected and regular familiarity no longer present. These examples show that uncertainty can arise when the temporalities one comes accustomed to can change. These could be thought of in the notion of unexpected events occurring when expected events end. That affect participants personally. The source of Temporal Uncertainty here was that a new and unknown temporal discourse was taking shape that was void of the stability provided by specific people being in time and space with the participant.

However, Temporal Sources of uncertainty were not always spontaneous changes to a set rhythm; sometimes the disruption was foreseen, invoking present action to minimize a disruptive change to the normative temporal discourse. As in the case with (**P5**) *"Whether or not to let someone quit their job."* The Temporal Uncertainty from this perspective was trying to keep the person from leaving, so to keep the temporal norm. Yet, in doing so, a sense of consciousness about the temporality of their uncertainty emerged. A person leaving, similar to the experience of **(P8)** and **(P3)** meant the current temporalities, especially those related to work, like rotas become increasingly uncertain. Leading to a desire to maintain the status quo.

In contrast to the themes of (**P8**), (**P3**) and (**P5**) of a person leaving these normative rhythms, people entering normative rhythms equally created uncertainty. *"My morning routine changed, so it gives me uncertainty"*(**P6**). The routine change was due to the fact that their grandchild was staying on a work-week, which was unusual for (**P6**) who considered this routine change an impact on their established routine that did not assure them of getting to work on time.

Reflecting on the severity of the sources allowed (**P10**) to establish how uncertain they were at this time. *"My wife was diagnosed with breast cancer [. . .] that was a very uncertain time for me."*. A drastic and potential life-altering period of time had with it an increased feeling of uncertainty. Normative routines became experienced as uncertain when being able to maintain that routine was assessed on an emerging health condition. *"Before I started getting medication, I was having a lot of like asthma attacks during class. So it was very uncertain whether I could even be able to attend class because I was so afraid of having asthma attacks."* Health in this case had (**P7**) doubts about their ability to stay within the regularity of their educational institute.

Reflecting on a Temporal Uncertainty did not always link to a change in the

rhythms to what might be classed as a normative aspect of one's life; it could also be experienced as a perpetual uncertainty, where it changed day to day due to unstable situation. *"Uncertainty, pretty much every day of my life is with the auction, are we gonna have enough stuff to do the sale."* (**P9**). In this sense, normativity could not be established as **(P9)** reflection conceptualises a space that is always needing filled with items not always available.

Situations being temporary meant that a perpetual uncertainty could be experienced for an extended amount of time about one's future when the end of the event is close by. *"I won't be employed in a few months, in the sense that, my scholarship is ending at the end of this year. So, that is the immediate or maybe medium-term uncertainty"* (**P12**). In this sense, knowing at some point that an event is going to come to an end, and with it the monetary/security value associated with it, leaves perpetual and daily uncertainty.

Sources of uncertainty allow for insight into how the normative changes, and when this happens, uncertainty emerges. On the contrary, a normative may be never established for a personal, situational, or spatial reason. The prompt cards led participants to focus on impactful events or continuously provoking experiences that formulated definitive ideas of uncertainty associated with the source that produced it.

5.6.2 Using Cards, Tokens, and Themes to Dimensionalise the Source of Temporal Uncertainty

The Temporal source of uncertainty allowed participants to attribute the cause of uncertainty to a specific temporality. However, in this step of the method, the descriptions were often brief, general, and open to interpretation. While the source of uncertainty is detailed, its implications or subjective inferences are not identifiable. When participants began using uncertainty cards and tokens and performed the theming task (**5.5**), they showed increased development in their ability to explain more about the personal, social, and environmental dimensions of their uncertainty.

The uncertainty cards provided participants with a way to discuss the source of uncertainty from various perspectives. For example, choosing the (***Anxiety Card***) allowed (**P6**) to explain the emotional aspects of their Temporal Uncertainty: "*The anxiety comes in*" when changes to their routine occur. In the previous description, there was no mention of how (**P6**) felt. The card helped (**P6**) discuss the dimensions of their emotions concerning their uncertainty and further encouraged them to link their anxiety to the (***Effort Uncertainty***) card: "*That's made me realise [. . .] As you get older, the uncertainty of effort, it takes a*

lot of effort [. . .] to deal with all the change in the different patterns". The use of cards enabled (**P6**) to have a discussion about the ontological complexity involved when events produce experiences of uncertainty, leading them to attempt to regulate themselves and their grandchild's time: "*I would always be looking at my watch*". Age and anxiety became factors in handling and coping with events that raised questions about whether responsibilities, such as getting to work on time, could be met.

This pattern of detail not present in the original description continued with (**P5**), who used the "**Uncomfortable Uncertainty**" and "**Judgment Uncertainty**" cards to explain, in commonality with (**P6**), the emotional implications surrounding their uncertainty: "*A lot of the uncertainty pulled around myself, Internalising, feeling uncomfortable, judgments, and they're all quite emotive*". The cards gave (**P5**) the ability to detail the personal impact this time of uncertainty had on them. They continued their ability to isolate the dimensions that constructed their uncertainty with the (**Future Uncertainty**) and (**Aftermath Uncertainty**) cards: "*Most of the uncertainty relates to like one person, and then the others (themes) are sort of like future so aftermath uncertainty.*" The cards, tokens, and themes gave (**P5**) an ability to highlight various constructs about their uncertainty that they did not have in their original description.

(**P10**) expressed more details of the time of uncertainty surrounding their partner's cancer, which became evident when they used the cards (**Expectation Uncertainty**) and (**Compromised Uncertainty**). "*My compromise was to not show that I was uncertain. I would not allow myself to become weak in front of my wife because that would make her more worried. So, I covered that up. I acted the role (. . .) It was an act of uncertainty of expectations*". The language of the cards became part of (**P10**)'s way of structuring their descriptions, which opened up deeper insights about this time of uncertainty they encountered. *Nighttimes when my wife had gone to bed, I'd cry. That's when it would come out*. The cards led (**P10**) to explain the complicated thought processes and uncertainty that accompanied having a partner going through cancer. Using the card (***Individual Uncertainty***), they said: *"You don't know if that person is going to be there for you, and that sounds a bit selfish. But (. . .) they are your life."* Between the individual emotional aspects of personal support and the implications of losing a partner, the (**Prospect Uncertainty**) card was used: "*Uncertainty prospects, well if you've got one off of the incomes gone, there's that, how do you kind of carry on?*". Cards, tokens, and themes supported (**P10**) to construct a very complex scenario of uncertainty and the dimensions of the need to protect the emotional vulnerability of their partner while meeting challenges in their own care and support along with potential future complications

of monetary concern.

The cards (**Momentary Uncertainty**), (**Ability Uncertainty**), (**Future Uncertainty**), and (**Perception Uncertainty**) became an avenue for (**P7**) to consider the implications of an emerging health situation. *"This moment of uncertainty really (...) questioned my capability as a student and as a future professional (...) I was conflating maybe a momentary health issue with my capability within the classroom (...) really surrounding like my perception of ability and other professors' perception of my ability not being seen beyond the health issue"* (**P7S3**). Health was considered across time between the momentary experience and how (**P7**) would be perceived in relation to the future person they were trying to become. Their uncertainty spanned different dimensions of themselves in time.

The awareness that the description of the original source of uncertainty was somewhat "*Very vague, I guess, or very broad*" was a reflection of (**P12**). The use of the card ***Biological Uncertainty*** led them to describe their uncertainty about the job prospects related to their parents' ageing and their (**Location Uncertainty**). "*The uncertainty related to not knowing where we are means that, you know, we don't really know how to negotiate our respective caring responsibilities towards our parents*". Jobs determined the set location of a person; not knowing the job meant the locations could be further away from their impending caring responsibilities. The uncertainty expanded, and their partner became an aspect of their uncertainty, as their partner's parents were also ageing. This meant that **P12** wondered through the card (***Expectation Uncertainty***): "*How will we split responsibilities and can I really afford in a moral sense to live very far from home? [...] I wonder always if this will ever result in a conflict between our respective uncertainties, but like, if anything happens, and we both want to be close to our family*". (**P12**) used the cards to describe a multifaceted situation that involved them, their family, their partner, and the institutional nature of their work.

(**P14**)'s initial discussion of uncertainty was from the perspective of hindsight. They said: *"Yeah, so I decided to quit full-time work (...) and do a sound engineering course. (...) I realised halfway through that I should have done Events Management."* After using the toolkit, (**P14**) selected the (**Privileged Uncertainty**) card. This card led to a discussion about gender inequalities that (**P14**) faced, which were a factor in why they felt they should have changed study topics. They said: "*You do six years of your life, and then there's only so many jobs, which most of the time would be filled by men. And yeah, it would be nice to know those statistics before you go in, or that (...) you have to work harder as a female engineer to try to get those positions."* During the

course, the uncertainty of future prospects was attributed to gender inequality, which (**P14**) wished they had been made aware of before the course.

The original description communicated by (**P8**) was that the uncertainty began within their work. By analysing the themes they created, **P8** realised through the cards (**Uncertain of Capabilities**) and (**Anxious Uncertainty**) that their work uncertainty had implications for other domains in their life. They said: "*Even more time that's going to be lost with home life and spending time with the children and then how is that going to affect them (...) I'm working six days this week (...) the house, it's a mess. The washing needs to be done. The clothes need to be done. The food needs to be ordered, but I have not done anything with those kids all week in terms of like one-to-one time.*" Like (**P5**), the participant (**P8**) used the process to isolate and contextualise, to further understand their own grasp of the implicated dimensions of their uncertainty.

5.6.3 The Branching Nature of Uncertainty: Exploring the Contextual Implications of Temporal Uncertainties

An emerging theme was that participants began to think of their Temporal Uncertainty as moving or changing, calling it "*Ripple effects*" as noted by (**P12**), (**P10**), and (**P3**). The uncertainty became uncertainties, due to the contextual implications the uncertainty had on other parts of the participants' lives. A detailed understanding of this is provided by (**P8**): "*Like if you could put a bubble, you would have like so many branches coming off [...] that one thing, but it is interesting to see how it falls like with the top, then tearing to the next level [...] how it kind of breaks down and affects in different ways*". Breaking down their uncertainty into themes demonstrated a lens through which to pinpoint the expansion of their uncertainty into home life. They said: "*I'm working six days this week. I have one day off, the house. It's a mess. The washing is not done. The clothes need to be done, and the food needs to be ordered, but I've not done anything with those kids all week in terms of like one-to-one time. [...] It was fear of that kind of worsening and how would that affect them?*". The uncertainty of managing diverse times from the house to children became a collection of Temporal Uncertainties for (P8).

During the cancer treatment process, uncertainty was understood by (**P10**) as milestones, each of which formed new uncertainties to consider. They said: "*Looking for the future in terms of Well, the next examination, the next hospital appointment, [...] they all can create uncertainties and if the partner feels uncertain, then you automatically will feel uncertain.*". Uncertainty was considered by (**P10**) as triggered by a set of medical processes that could

change the uncertainty depending on the outcome of the treatment. They said: "*Again, create a great deal of uncertainty, will it work? You know, was the surgery done? Would it be enough? Had it spread, you know, all of these things*".

However, understanding the context of branching meant that the implications of it could be deemed necessary. (**P3**), who understood that it was an essential part of the change, said: "like many important decisions, there seem to be a lot of plural futures you know, like key paths or key decisions that you make a ripple in time quite significantly. So, this uncertainty (. . .) was significant in the changing of paths". Uncertainty ripples could be considered as a projection of self as a future state, which was not always possible given present conditions. *"You are dealing with anything that's chronic, especially if it's not defined yet medically, your entire existence present and future feels uncertain"* (**P7**). Highlighting this ubiquitous phenomenon was understood by (P7) as partly due to the theming that took place during the method: "I have been able to divide it into these three different experiences that I experienced all at once".

Moving or missing items would elicit new uncertainties for (**P9**): "*I get anxiety. I get like full of anxiety because I am like, "aw god where is that away to now" like I will have to remove that thing (from the sale)*" (**P9**). Change in the locations of the items meant that (**P9**) had to stop other activities to find these items and address their uncertainty.

5.6.4 Navigating Temporal Uncertainty: Strategies and Insights from Participants' Experiences.

Strategies during uncertainty became important to participants as they identified them during the end section of the method, considering the problems and strategies they used along with what advice they would give to others in a similar life event. (**P8**) advised an approach of handling the branching of uncertainties by breaking them into "*smaller chunks*". Uncertainties were understood as cloudy, but ultimately supporting them to occur and to remain within them resulted in an unexpected outcome. They said: "*It may continue to cause issues, but, it may be that ended up being the best thing, and you just couldn't see it at the time [. . .] by just taking it step by step. Day by day, you could see that it folded out not too badly. [. . .] person should feel proud of it because they managed a massive situation*". Daily reflection of the uncertainties and letting them occur ended up being centred as a more positive change to the previous source uncertainty scenario.

In contrast to (**P8**) was (**P5**) who felt they could not let uncertainty continue,

requiring an immediate fix. This was due to an unresolved situation that (**P5**) faced: "*As management of a store, [...] It is part of your job role to solve it. So with that being said, I would say try not to like to let it linger in the background too long. [...] get it to be a face-to-face conversation.*" Reducing instant messaging was required for (**P5**), though it caused them anxiety, it was a necessary strategy to gain in-person conversation and resolution. However, controlling dimensions like technology that caused or created uncertainty was a strategy to support (**P4**)'s experience with neurodiversity. They said: "*Coffee to me is obvious. It is like stop doing that.*" Along with getting rid of their mobile, that would cause anxiety. Removing certain things created a support to be at the moment for (**P4**): "*Detach me further, [...] truly come into the moment.*"

However, having control of uncertainty was pictured as "*illusion of agency*" by (**P3**). A strategy to allow uncertainty was an opportunity for success: "*Ultimately you'll be okay. [...] I guess that advice that we talked about was that being comfortable with the uncertain is embracing the serendipity, you know, and if I think about it, everything that I've done in my gut I've succeeded technically [...] So there's something about like embracing that compass*". Uncertainty in this manner was considered as having or taking (**P3**) on a journey toward opportunities that changed their normative, like (**P8**), for the better.

Requiring information about a department they would be working in meant that (**P11**) could prep their "*mindset*", especially during "*Various depressive periods*". Colleagues, as mentioned before, were a key aspect of causing uncertainty. Who they would work with had (**P11**) tailor their personality or try to suppress certain emotions from the views of others. To do this, (**P11**) needed prior information of that working day. Friends with team leads, people who controlled (**P11**)'s location, gave them department information ahead of entering. However, some team leads could hinder their strategy of foresight: "*There are team leads I also do not have a good rapport with, (...) They say you don't really need to know*". This could affect their ability to prepare for entering a specific work location.

Collating information or knowledge was a strategy deployed by (**P15**), who struggled to bring all the components required together in knowing how to build a house: "And yeah, so we basically did an internet search for basically everything, like trying to get almost a step-by-step guide [...] We have written everything down to make sure we have got everything written down, handy websites, written down things that we've found on forums online, what we need to do". However, they found problems in information gathering, as different regions had different building laws: "*There's so many different sites [...] different guidelines or standards, from councils, not even countries it's from different councils*". This meant that information gathering might not always be accurate or specific to

their context.

Grasping the impact of the internal implications that uncertainty can have on a person was deemed important. (**P7**) recognised two parts to a strategy during their method: "*I think you have to be able to identify those uncertainties within yourself emotionally before you can get that kind of help, so yeah that was actually really nice to see that*". Identifying uncertainty meant allowing others to support was more applicable when the consciousness of the emotional aspects of the uncertainty was understood.

In contrast, (**P14**) was aware that internalising could have implications, yet they were also aware it could be a strategy: "*internalising, for sure, as it's not always a bad thing. Being able to know your own patterns, that is also a tool, I suppose. Because you know yourself, that then connects to ability and your choices*" (**P14**). Knowing themselves meant (**P1**) understood they were giving agency to their uncertainty despite uncontrollable circumstances: "Nobody can guarantee you anything so adjust my expectation to lower the bar [...] the future uncertainty is caused by myself and for the visitor Center, this is something I can't control.

5.7 Outputs: Subjective Interventions

Once participants had gone through the method, detailing their life events of uncertainty, they were then asked to look at their themes, their strategies, their problems, and think about their solutions. Participants were given a few minutes to complete this task before being asked to consider what technology they could think of to support them at this time. It could even be fictitious. Participants were asked to draw or explain their technology, whatever was most comfortable for them. The technology could be for them in their specific scenario, or they could imagine it for someone else. In the following, this research addresses the following **Question 3.2:** *What tools and solutions do people and designers come up with when using the toolkit?*. All drawings presented in the following section were done by participants.

5.7.1 Temporal Uncertainty App and Features for partners of someone with Cancer.

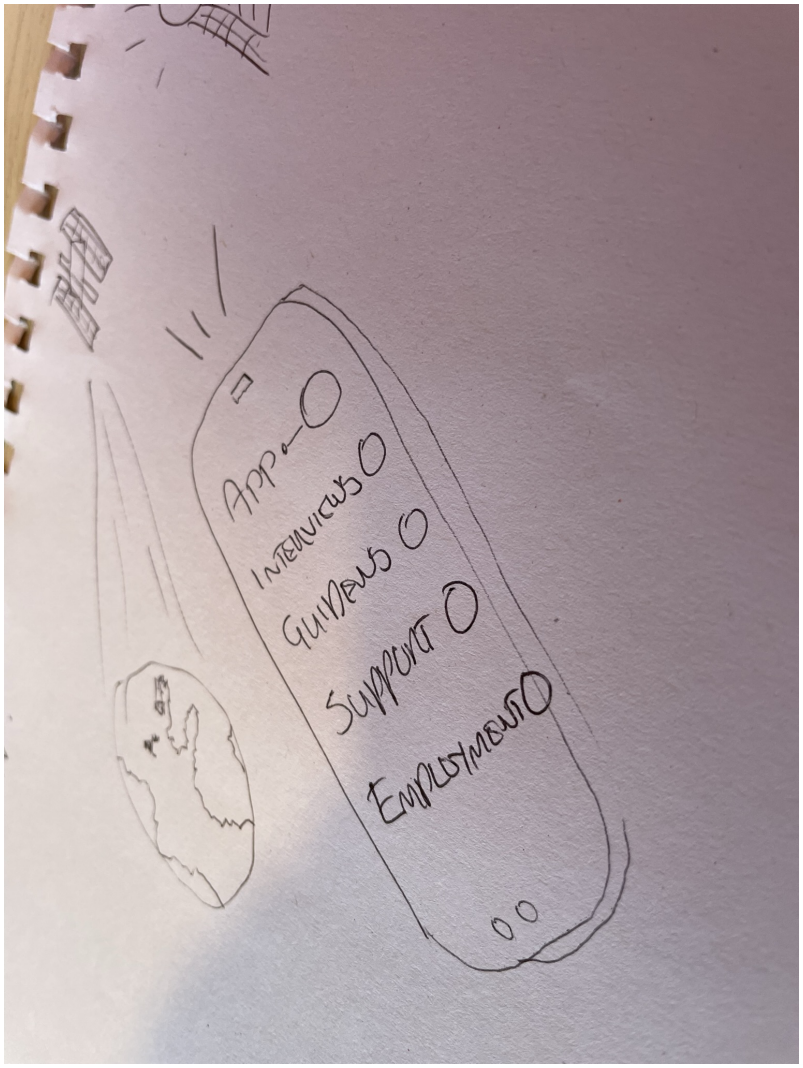

Figure 5.8: Cancer support app: An app that shows detailed content about other partners who have gone through or going through the uncertainty of a partner with breast Cancer

As the partner of someone with cancer, (**P10**) felt a lot of uncertainties tied to the temporality of the future. This involved concerns for their income, their employment, their emotions, and their relationship. They wanted to find a way to bridge the future unknowns that come with potentially losing someone so close to them, with knowledge from those who have already been through such a journey.

To do this, they considered an app to help them navigate their own feelings with the future. They said: "*My technology would be to create an app [...] interviews with people that are going through uncertainty as a partner with cancer or partner who's got cancer. [...]. Different interviews, talking to people that have gone through it, [...] so that they can self-actualise their feelings.*" (**P10**).

Others having gone through a variety of milestones that come with a cancer journey and contextualising them from the partner perspective was seen as a benefit in supporting **(P10)**'s present uncertainty.

This life event for (**P10**) was novel and led to evolving uncertainties as different temporalities unfolded. Such as that previously discussed, with each medical event creating new forms of uncertainty. Grasping a sense of community and knowledge of the journeys others went on would help **(P10)** understand how they are feeling and how to relate to others who had experienced a similar event. The app had features that recognised that each cancer type has different temporalities, different appointments, risks, futures, and challenges. All of which created different uncertainties, and all of which created different impacts for both partner and person with cancer. They said: "*Every different one has a different perspective to it.[. . .] skin cancer, that's more cosmetic [. . .] breast cancer, you might lose a breast again. [. . .] Now that doesn't just have an effect on the person, it has an effect on the partner*" (**P10**). Cancer is exampled here to change the biological and physical discourse of life.

(P10) further seen the app as a way for others to understand the changes one might see in the outlook one has on life. **(P10)** expresses that a distinct passage of time from being in work pre cancer to returning to work post cancer can change a person. Requiring others to understand such a personal journey. They said: "*On the app there would be a section for an employer to be able to click on it and potentially look at how their employee coming back to work is going to feel you know what potentially could support them they might need some kind of empathy towards how they are feeling*" (**P10**).

As someone goes on the journey with their partner, the app would suggest specific videos for different temporal points in the cancer journey: "*your partner's got cancer, so this is how they're potentially going to feel. It is an interview about someone that has gone through that*" (**P10**). This app was considered because of the implications mentioned above and acted as a reference point for people in a life-impacting experience.

(P10) realised that with Cancer comes unique Temporal Uncertainty, about the future, the present, and the evolution of one's self over time. Their app was a reflection of the wealth of temporal knowledge one gains through such an ongoing impactful event like cancer. Their app aligned information relevant to specific temporal points a person will find themselves on during the multi events that arise with the discourse of cancer. But further recognised that each cancer is different and requires different support depending on the present uncertainty a person is in.

5.7.2 Reflexive Uncertainty Journey technology.

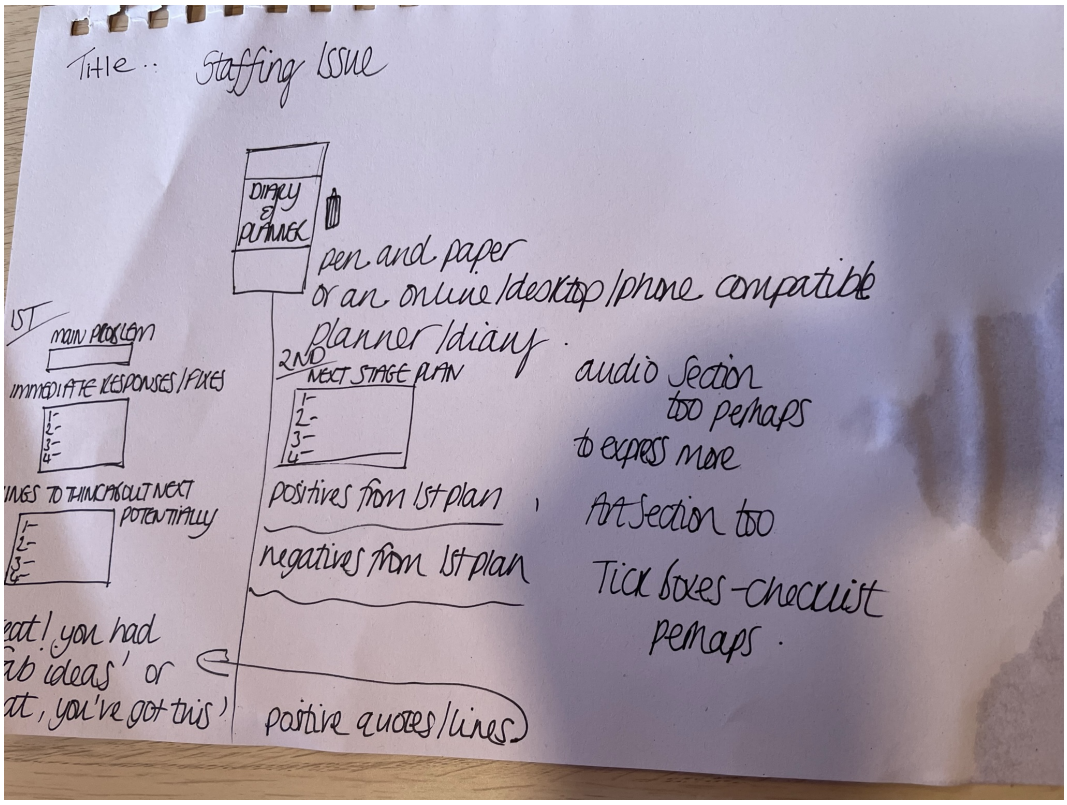

Figure 5.9: Reflexive Uncertainty Journey technology

After **(P8)** and their experience of home life and work disruptions being seemingly impacts, (P8) considered a tool that would track the temporal change of the feeling of uncertainty. Their technology started as a *pen and paper or some sort of online version may be a desktop or phone compatibility* (**P8**). The way it functioned was that a person would write down their current or "*near future*" issues and uncertainty, starting with the "*Crucial points we're going to have to address and put things in place to resolve or solve*". (**P8**).

This approach aimed to reduce the wide idea of the future and bring it closer to a more manageable lens of the near future. (P8)'s method reflected their feeling that uncertainty lived in the temporal plane of the future. Interestingly, it was the goal to mentally remove that future uncertainty and bring it into the present. Equally, to remove it from the mental model of the future and represent it in the present reality. They said: "*I've already got it written down, and I've already got it taped up sort of thing, I know it's there. I don't need to keep going around this over and over in my head because this is not going to make me well or healthy or anything like that*". (**P8**).

The goal was to reflect on temporal stages of uncertainty by breaking it down week by week, as each week uncertainty can change for better or worse.

"*A one to four-week plan. I've done this. I've done that, I've done that and that's happened [...] what has happened positively or what were the negatives"*. The temporality of uncertainty was understood to not be linear and requires technologies to have reflexive considerations: "*you could do another review, right? This is what I was planning to do, but actually, my second list is now going to be this. So I'm going to slightly adapt it. Because obviously, change constantly happens, and we can't predict what's going to happen.*" (**P8**).

The technology would allow people to reflect on the evolution of uncertainty by using time to reflect and re-adjust as the uncertainty evolves. With the goal to alleviate how a person thinks about their uncertainty. They said: "*Although at the time, it's like, oh my goodness, what's going to happen? It may continue to cause issues, but it may be that ended up being the best thing and you just couldn't't see it at the time*". This tool demonstrates that time masks the true implications positive or negative of uncertainty, and only through time, will uncertainty change, but might require conscious interaction with such feelings.

The tool positions uncertainty not as something to reduce or embrace but rather looks at it in each stage, breaking it down from the context in which it is considered at that moment and to see that it could be an opportunistic experience that was not previously privy information when the source uncertainty occurred.

The inputs of the tool were also considered. They said: "*Perhaps an audio version because some people do really struggle to put pen to paper or keyboard to computer sort of thing or typing they might people spend more time focusing on spelling etc"* (**P8**). However, implications were addressed with this technological suggestion: "*The only thing with that is sometimes you could be a little bit more rambling, I suppose. And not compress it as much*." (**P8**). Breaking down the events that caused uncertainty was a vital, key part of the technology that could be disrupted if people could audio record for an extended amount of time. Nevertheless, the voice was seen to give a more "*General*" sense of how you're feeling at that point in time, supporting a revisiting of the past moments to incentives the present moment. They said: "*I was feeling like that at that time. And look how far I've come now my second stage sort of thing. So, add a bit of kind of depth to it and a bit of meaning behind just the words. So perhaps an audio*" (**P8**). Which would then use machine learning to automate key points on one's voice recording.

How people interact with their reflection of Temporal Uncertainty was a big part of (**P8**)'s technology. They suggested using "*art or something that they could draw to show how they're feeling about the situation"* (**P8**). This artwork would temporally change according to the subjective feelings of the uncertainty

situations. They said: "*I mean through art if someone's really struggling [...] You wouldn't expect the piece of art to be very bright or happy, but you'd expect eventually for that to change somewhat, even the slightest bit of change or happiness and that would help and they'd be able to look back on that*" (**P8**). The purpose of the technologies was to support a reflexive and broken-down approach in which uncertainty or situations manifesting in the mind are removed and formulated into tangible things. They said: "*We kind of mentally try and sort them all out. I think by putting it all down a seat in front of us. We can kind of digest it all and kind of look back and think I did it sort of thing. I managed to do that*.

5.7.3 Uncertainty Time Machine

Figure 5.10: Uncertainty Time machine

(P12) grappled with a profound sense of Temporal Uncertainty, stemming from the ambiguity of their future work location and its potential impact on their life. This uncertainty, deeply intertwined with both time and space, manifested as they contemplated the possibility of existing in two places at once to seize career opportunities, including potential overseas assignments.

The crux of **(P12)**'s challenge was the concept of being physically present

in two locations simultaneously. This was driven by their separation from their ageing family members and the desire to maximize the quality of their shared time. **(P12)** expressed this sentiment, stating, "*An easy way to make everybody happy, probably will be inventing time travel*".

This hypothetical time travel technology, though fictitious, emerged from **(P12)**'s struggle as a foreign student. The institutional expectation was to relocate wherever work demanded, but the prospect of effecting structural changes within the institution seemed daunting. **(P12)** reflected, "*I mean, it's weird that structural changes are so difficult to imagine that it is easier to imagine that we invent time travelling*".

(P12)'s "structural conditions of uncertainty" relate to the temporalities of graduates, which hinge on the academic institution's responsibility (or lack thereof) towards diverse personal temporal needs such as caregiving. **(P12)** elaborated on their time travel concept, "*This way I will keep being productive for the academic system and also be home when my parents need it*". This suggests that time travel could enable P12 to fulfil the academic system's expectations while also attending to personal responsibilities.

P12's sense of responsibility, spanning various geographical locations and personal temporal challenges, underscored the difficulty of managing time and space. They felt torn between their obligations and expectations in different locations. Time, for **(P12)**, became a currency spent on fulfilling responsibilities in one area, which they perceived as taking time away from another. P12 noted, "*It's a space issue. But it's the time because if you get time to something that requires attention, then you're taking it away from something else*".

The uncertainty of where they would be spatially and how they could allocate time to different responsibilities, such as work and care, added to P12's Temporal Uncertainty. This resonated with another participant **(P9)**, who also envisioned a fictitious cloning technology to address the need to exist in two different spaces and times. Saying, "Clone myself, I'd clone myself [. . .] I will then be able to then support that (colleague). And basically, that would then release me to go and work in the warehouse" **(P9)**.

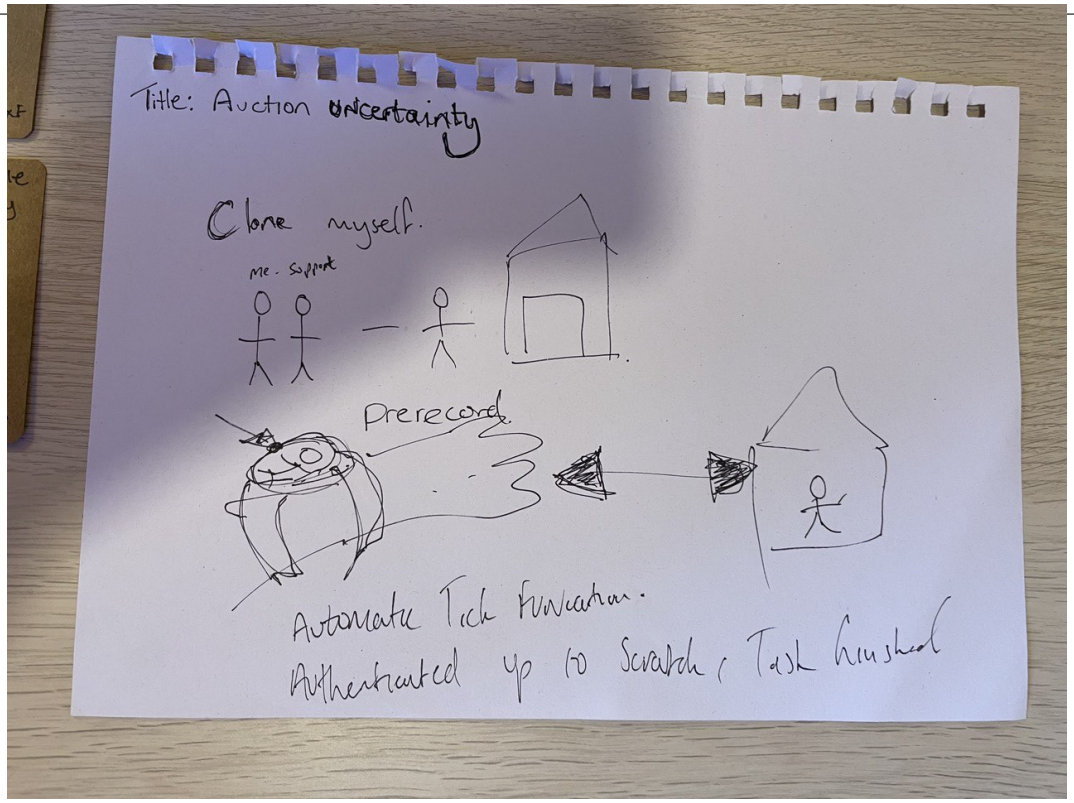

Figure 5.11: (P9) Cloning to manage Temporal Uncertainty

Recognising the impracticality of time travel, **(P12)** explored alternative ways to bridge time and space and to feel present in other locations. They found solace in music, which helped them feel connected to others. **(P12)** shared, "*We just send each other music, Alright, and I just went I listened to it. I'm like, you know, it's just much more present in a way that it would be if I just see his face. And I listen to music and I think of him*". This suggested a potential shift in remote technology towards a musical format that could evoke a sense of presence in different spaces, offering emotional support.

In conclusion, **(P12)**'s narrative illustrates the challenges and uncertainties that arise when one is caught between time, space, and the temporal responsibilities associated with work and care. While an ideal scenario would involve the academic institution acknowledging and addressing these struggles, **(P12)** found a semblance of solution in music, using it as a tool to navigate their Temporal Uncertainty and offer emotional support.

5.7.4 Uncertainty Boundary technology

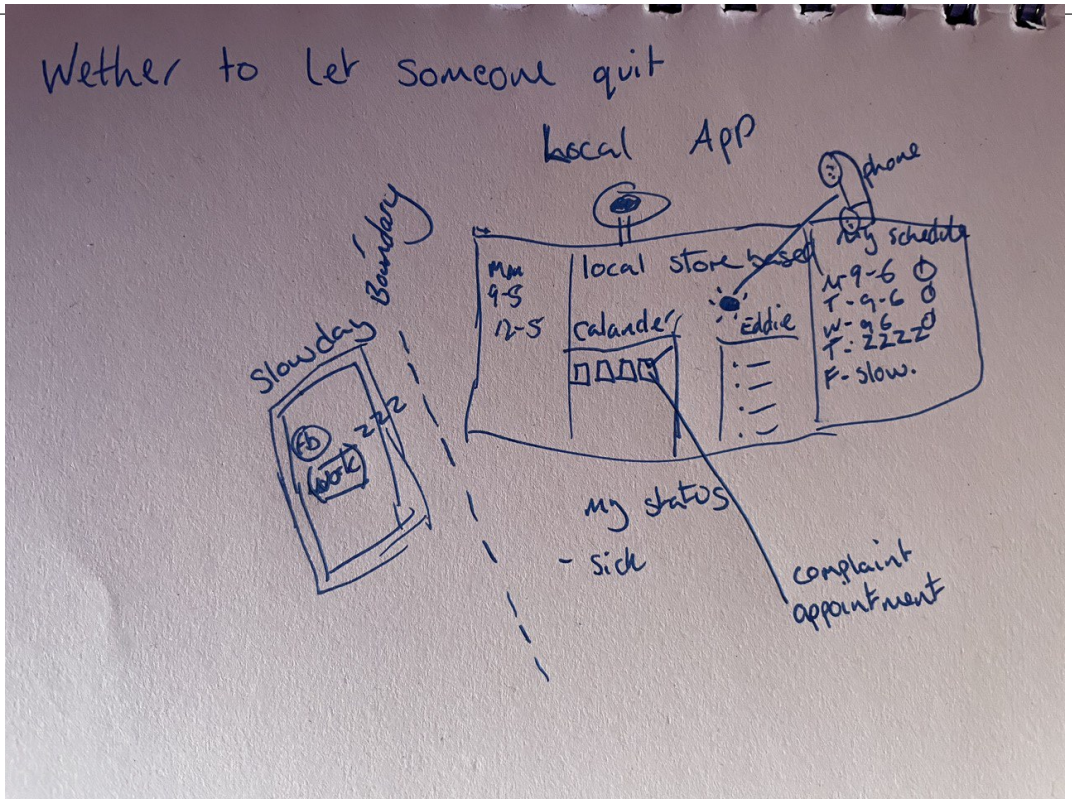

Figure 5.12: Temporal Uncertainty Boundary technology

Work-related issues often intruded into **(P5)**'s personal time, blurring the boundaries between work and leisure. As a manager, (P5) was the first point of contact, leading to interruptions even on their days off.

To address this, **(P5)** envisioned a tool that would establish temporal boundaries, determining when work issues could encroach upon their personal time. This decentralized app would "*Keep track of say complaints made find out if there's a common factor*" (**P5**), allowing **(P5)** to identify patterns in the frequency of issues arising during their off-hours.

The tool would also track temporal themes, such as when complaints were made, and could monitor the temporal patterns of people's time off. **(P5)** stated: "*Like there could be positive things [...] 'I noticed that you work Monday mornings. But then you are sick the next day like actually would something like a later you know, time, help would an earlier finish help with that*'" (**P5**). This would enable **(P5)** to manage when issues intruded into their personal time, track patterns, and offer more temporal choices to colleagues.

However, **(P5)** acknowledged the challenges of tracking patterns: "*I am conflicted in this cause* [...] *I think there can sometimes be an issue when you try and figure out algorithms of human people's.* [...] *there are things like mental illnesses that throw like spanners in the works of what an algorithm would actually do. Like you cannot predict actions all the time*". The tool aimed to assist in recognizing patterns, but not to assert absolute truth about these patterns. It was designed not to reduce Temporal Uncertainty, but to understand

whether the uncertain times at which events occurred had any emergent themes.

The tool would also allow **(P5)** to choose when to address work issues: "*You know, you can put in your schedule (. . .) certain times*". It aimed to filter when and how work-related conversations could enter personal time: "*So that when it popped up* [. . .] *you can see that they've like tried to contact you* [. . .]*I can look at my phone see immediately if this was a personal issue. See if it is something to do with work or if it's just an application from an app that would like aid in setting boundaries as well*" (**P5**).

Uncertainty could arise from certain communications. By adding temporal boundaries, the uncertainty could be realized at a specific point in time, such as when returning to work, rather than when at home and removed from the source of the uncertainty. However, this required the tool to filter content based on its relevance to the individual's time: "*We've got this new product in like look at this like that's a workplace thing. It's something that Yeah, might want to know, but it's not necessarily like important for my time. Whereas if someone was phoned in sick, maybe on a day off, they could set a different priority to it*" (**P5**). The tool could filter topics depending on the person's location and feelings at a given time: "*I don't actually need to deal with things that actually require my attention there and then. If I chose like if it's a slow day, maybe I could just accept all messages*".

The tool featured a sleep mode for high-priority events: "*you say you've got appointments or something you could just like have it slept*" (**P5**). However, if a topic was deemed important, it could bypass this filter: "Unless it's something that desperately required your attention" (**P5**). These filters would be managed using status buttons: "*Possibly have a like a separate thing like a status button so that as soon as you've selected like sick, it would automatically like push through*" (**P5**). The tool aimed to support boundaries for when and how certain types of conversation or information would be presented, only within the appropriate time to handle those topics.

This technology was conceived in response to **(P5)**'s struggle with managing a staff member who used social media to gossip, causing uncertainty throughout the workspace and in **(P5)**'s personal life. The technology aimed to construct boundaries to manage how specific types of information would be presented at the right times, leading to uncertainty only when temporally appropriate.

5.7.5 Photo points uncertainty

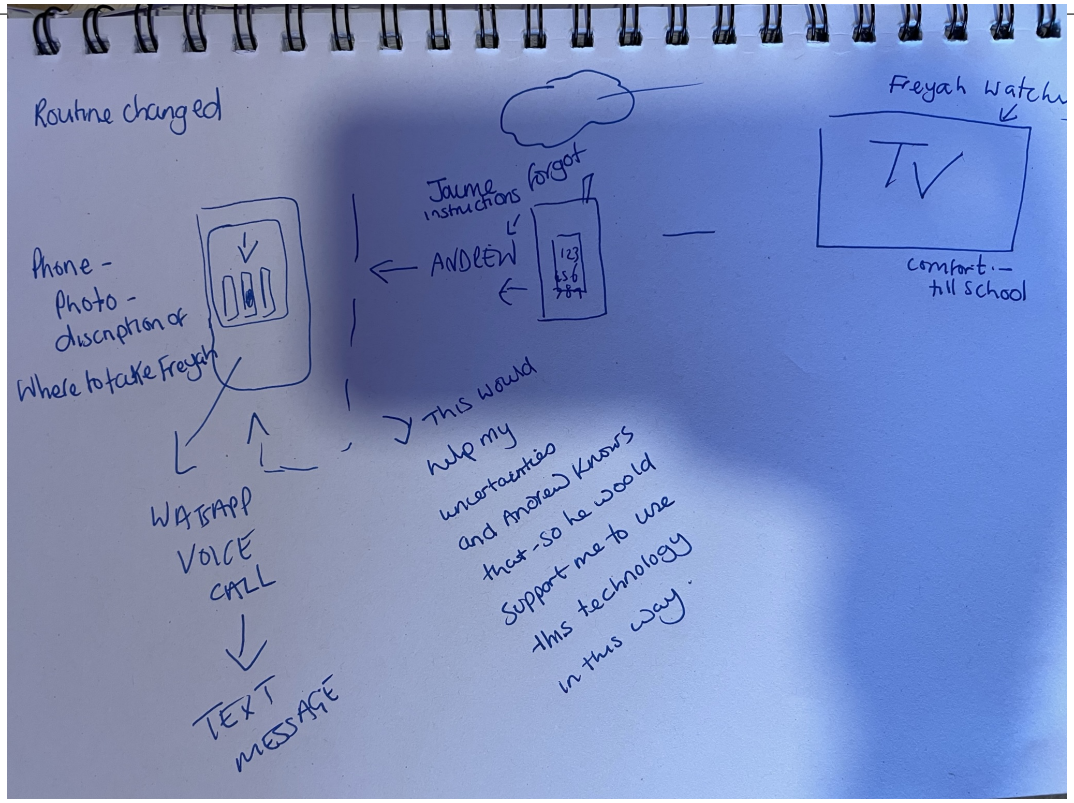

Figure 5.13: Uncertainty Photo points uncertainty

(**P6**) experiences of a routine change meant new challenges arose. Due to frictions with their own temporal requirements to be at work before the school hours began, it meant they could not personally drop off their grandchild at school. Meaning the grandfather was charged with taking the granddaughter to school, which increased (**P6**)'s uncertainty around the temporal and spatial knowledge of if **(P6's)** partner would get their grandchild to school on time and if the partner knew where to take the child.

The challenge for **(P6)** was having little control over the ability to ensure the child arrived on time and in the right place, and exchanging such responsibilities to someone else. A control over temporal discourse being in the hands of someone else meant uncertainty manifested in **(P6)**. This was paired with the inability to be certain the grandchild got to school on time, or to the right location.

P6's uncertainty arose from the strict expectations for punctuality in schooling. **(P6)** acknowledged the influence of being in the wrong place on punctuality, as well as the challenge of predicting their grandchild's timeliness, leading them to contemplate the use of a photo map as a beneficial tool.

The photo map tool highlighted key spatial information for their partner to get their grandchild to the right area of the school and on time. They said: "*I'd use a phone to take a photo to know where she's going, and so I could show him, so that would work*" (**P6**). One main feature was interconnecting different

mediums of information to guide another person to the precise location. They said: "*You could do a message call so they don't forget to go this way and that (Child) goes in at nine o'clock*" (**P6**). Rather than a tool for their partner, (**P6**) was considering this technology as a strategy more for themselves. They said: "*I think that just helps me. This helps me get a message so far, even though you know, the (Husband) would probably get a little annoyed because he thinks I don't trust them. I do trust them. This helps me, it's my mindset. So I think doing that, you know he supports me by allowing me to do that too*" (**P6**). The pressure for **(P6)** to conform in terms of time can also impact their partner. According to **(P6)**, questioning their partner's ability to understand social cues about time may lead to frustration. By implementing tools to maintain rigorous schedules, individuals can strive, as with **(P6)**, to encourage others to follow the same time restrictions. The photo map was intended to help the husband be punctual by identifying locations accurately. Additionally, it had the secondary function of **(P6)** trying to maintain control over time by guiding others, when they could not physically do it.

Photo map therefore channels Temporal Uncertainty as managing uncertainty by trying to have a form of influence of getting others to a set location on time. While it does not aim to remove or encourage uncertainty, it acts a way to have temporal control over a situation that physically one does not have control over, leaving the attempt to control uncertainty through the control of time. Moreover, the expectation was that **(P6)**'s husband would employ this tool to assist **(P6)** in coping with their Temporal Uncertainty.

5.8 Method Prompting Temporal Uncertainty Revelations.

The toolkit and method revealed thoughts and feelings about their time of uncertainty that participants had not realised before. "*I know like I deal with a lot, but I did not realise like, like, looking at that (their themes) there is a lot there Like that one person has to deal with*" (**P9**). The process helped uncover what a person going through uncertainty might endure internally and physically. The toolkit was useful in drawing insights that participants found surprising. "*I had no inclination that it will draw so much out of me*" (**P10**). It was also a way to inspire ideas. "*This is inspired by the cards; I didn't have that idea before those. I think the cards are a good tool to evoke thinking for inspiring*" (**P1**)

The toolkit provided novel perspectives on the uncertainty that were not visible

to the participants before. "*Actually, just clicked when I was laying out. Yeah. I would not have looked at it that way*" (**P8**). Similarly, (**P11**) said, "*It did get me that I didn't consider colleagues [...] at first [...] of actually being the main uncertainty driver*".

Exploring uncertainty related to real events that often had emotional components. It led a participant to compare the process to "*like a therapy session*" (**P12**). That could support describing the uncertainty through its application. "*I suppose. Yeah, if you have something that is like a current uncertainty, then you could sound it out with this and then rationalise, it is really good*" (**P14**). Having a way to talk or "spell" out a scenario of uncertainty was an attribute of the toolkit. It also supported self-reflection. "*I've now consciously become aware at the end of this that its more to do with personal development.*" (**P11**). The toolkit was a way to communicate with oneself or others. *"The prompts and everything would give me a base to be able to use those words [...] having the prompts there to help me realise I can talk to the person too"* (**P6**).

5.9 Discussion on Participant's Use of the Toolkit.

In this section, a discussion will be conducted on the findings and will address Question 3:1 along with novel insights produced with regard to the toolkit and method.

5.9.1 Contextually Subjective Uncertainty.

Addressing **Question 3.1:** *What notions and scenarios of uncertainty do people want to design for?*, all participants could identify a scenario that generated **The Source of Uncertainty**. However, participants' interventions did not focus on the source specifically; instead, they focused on one of the uncertainties that branched from the source or one dimension of the uncertainty. This meant that although some sources of uncertainty were similar, such as an event of a person leaving, (**P4**), (**P5**), (**P8**) they all had different interventions. This could be due to the toolkit and method that allowed participants to discuss the source of uncertainty from a subjective perspective, in which the interventions were also represented. It also meant that every **Source of Uncertainty**, while similar in theme, became a unique and subjective scenario when understood through the toolkit, as each branch "*Affects in different ways*" (**P8**).

This implies that calls in HCI to embrace (Soden et al. 2020), (Soden et al. 2022*a*), or reduce (Hogg 2000*b*), (Christensen & Ball 2017), (Paletz et al. 2017) uncertainty could be complicated if following rigidly only one intervening

or conceptual approach to designing around notions of uncertainty. Temporal Uncertainty highlights this complexity and diversity of temporal experiences, which can encompass various notions of uncertainty. The findings showed that although the themes were similar, the individuality of the person and their classifications of normal rhythms and routines were unique to them. In other words, events that produced times of uncertainty, while potentially collective in experience, were **contextually subjective** and required **contextual intervention** that fit the subjectivity of the person and not a generalisation based on a collective theme.

Therefore, designers must **investigate thoroughly people's contextually subjective uncertainty**. Generalising a person's uncertainty or generalising the concept of uncertainty with 'reduce' or 'embrace' could intersect with notions of exclusion when trying to include others. Designers can expand uncertainty inclusion by being aware of **Contextually Subjective Uncertainty**.

5.9.2 Solution commonalities among interventions for uncertainty

Although an argument has been made for understanding **Contextually Subjective Uncertainty**, it is important to note that the interventions, as concepts, share commonalities. For example, while the sources of uncertainty for participants (**P8**), (**P9**), (**P14**), and (**P11**) were different, their interventions shared a common desire for features that supported the exchange of temporal and uncertainty knowledge. (**P14**) wanted knowledge exchange between female engineers at different stages of their careers, while (**P10**) wanted knowledge exchange between partners of people with cancer at different stages of treatment for specific cancers. These topical times of uncertainty are different and require different contextual interventions, such as cancer knowledge apps. However, the exchange of knowledge remains a core requirement for both.

The toolkit interventions allowed for an understanding of the subjective expressions around common feelings of uncertainty. For instance, both (**P8**) and (**P3**) felt that uncertainty impacted their normative experiences positively and wanted interventions that provided reminders and reflection on how uncertainty is not always negative. Therefore, interventions with common characteristics can be grouped by their commonalities to other uncertainty requirements. While certain tools and interventions produced by participants are unique to them, deductions can still be made about the co-designed interventions to streamline the most important features for people during these times.

In this case, designers can use the interventions to identify commonalities in demographics and solutions that promote the fundamentals of inclusive design

without compromising the individuality of someone's experience. As previously stated, generalising someone's experience might exclude rather than include them. It is within this space that inferences about the inclusiveness of a tool can be made.

5.9.3 Revealing the Conscious and Sub-conscious.

The toolkit demonstrated that the participants were aware of the **Source of Uncertainty**. The uncertainty description in this step was positioned from a holistic and high-level nature, which means that while it was clear how the uncertainty began, the specifics of the uncertainty, its implications, or subjective views were negated from the initial description.

The components of the toolkit supported the reconstruction of what formed the holistic expression of the **Source of Uncertainty** by participants dimensioning the uncertainty revealed details, subjectivity, context, and even the evolution of the uncertainty into other types of uncertainties. In doing so, participants, as per their commentary on the toolkit, revealed their sub-conscious experiences surrounding their time of uncertainty and became further "*Conscious*" (**P11**), resembling the toolkit to be like a "*therapy session*" (**P12**). This might have been due to the Temporal Uncertainty cards, which allowed participants to "*Sound [..] out (the uncertainty)"* (**P14**). Along with the theming approach to support participants to "*Look at (the uncertainty)* differently" (**P8**).

Considering this, designers in HCI concerned with Temporal Uncertainty, or uncertainty of any manner, might want to think of the temporal events which cause uncertainty as the conscious, high-level holism to an otherwise series of dimensions yet to be engaged with. These elements make up the **Source of Uncertainty**. However, do not make it into the discussion, either because participants cannot yet speak about it, because they do not have the language, or because they are yet unaware that it is a dimension of the overall **source of uncertainty**.

It means for designers that importance should be placed on the method and approach in revealing and exploring times of uncertainty, as participants might have a holistic conscious idea of their uncertainty that they describe, but need assistance in revealing the sub-conscious aspects or views of their uncertainty they had not previously considered or realised; which is important as participants did not design for the source, but rather the dimensions of their time of uncertainty. Although in no manner is this guidance to denounce participants' conscious agency, the sub-conscious revealing can further support participants' interventions "*To evoke thinking for inspiring*" (**P1**), or self-realisation, "*There is*

a lot there Like that one person has to deal with" (**P9**).

5.9.4 Time and Uncertainty

The **source of uncertainty** was connected to a perception of temporal change, whether this was a routine (**P6**) a change in an environment (**P9**) or a relation that an imagined future might not be what was originally thought (**P7**), (**P14**). Time and uncertainty were intertwined, in the case of most participants, and focused on a "non-trivial" (**P10**) event, as this was seen to change that person's normal experience that then brought on the experience of uncertainty.

Branching uncertainty stretched across time and space, considering different uncertainties for different notions of the present and future self (**P14**) or spatial uncertainties that emerge in new environments such as the family home (**P8**). The interventions became temporal tools, often linked to people in a temporal stage of their life, career, or health. The need to be in two places at once to juggle a variety of uncertainties meant that time machines (**P12**) and cloning (**P9**) became envisioned, with commentary on the institutional or environmental challenges. Specific temporal points of health that trigger specific events, as with cancer, meant tools to understand those events before happening placed (**P10**) and their tool as an extension of, what can only be described as temporal knowledge. A specific time, event, or moment that a person encounters, forms knowledge and passes it to another person in a different temporal situation, all within a common experience, e.g. cancer. For (**P8**) and (**P3**) uncertainty was seen as an essential process to disrupt normatives and create new opportunities.

Designers should understand uncertainty as a material associated with temporality, in which uncertainty acts as a way to re-define normatives, and provoke agency, action and knowledge. It manifests inspirations to be in two places, stretching self across time and space (**P12**), (**P7**), (**P9**). It encourages a desire to be in the moment and to accept the uncertainty (**P4**). It looks to enforce reflection and self growth (**P8**). Or to encounter varying milestones within an event in accordance to the biological changes of health, (**P7**), (**P10**). It is waiting for bureaucratic systems (**P1**) and considering that when taking a new job, the type of uncertainty that one will experience should be part of the job journey map (**P11**). Considering uncertainty with temporality is to understand uncertainty as an essential part of the evolving and ever-changing aspects of human and social experience. It is neither negative nor positive, rather a complexity of two interwoven phenomena experienced in a contextual and subjective manner.

5.9.5 Key Takeaways for Temporal Uncertainty Tools and Interventions

Based on these findings, the following key takeaways are generated on the way designers can explore Temporal Uncertainty as a way to lead to generative tools to support notions of uncertainty that are contextual to various life events, times, moments, futures, and experiences.

Identify the Source of Uncertainty

- Use reflective methods or prompts to ask participants to consider a time of uncertainty.
- Have participants describe in their own words the time of uncertainty.
- Do not generalise the uncertainty even if it's thematically similar to another participants, it is important to treat each uncertainty as specific to that person's ontological and subjective experience.
- Treat this step as the base layer of the uncertainty, the starting point of the investigation.
- Finally, ethically be aware of the revealed time of uncertainty and make sure that participants are comfortable to reconstruct this chosen time.

Reconstruct and Dimensionalise the Temporal Uncertainty.

- The initial description is to be treated as a start-point.
- Importance should be given to the recreation of the time of uncertainty by identifying the important **Dimensions** of the uncertainty.
- Factoring in people, the environment, infrastructure, technology, and objects is one way this can be done. However, as long as participants can reveal **Dimensions** of their Temporal Uncertainty, it could potentially be done with any category regarding the design of the research goal.
- This is a step that allows participants to re-engage with the uncertainty in a reflective manner, time should be given to this step.
- By participants dimensionalising the uncertainty the individual, ontological and subjective aspects of a persons' life begin to emerge and the context in which the time of uncertainty situates becomes clear, both to researcher and participant.

- Support participants to be able to discuss and describe these dimensions to their uncertainty. The uncertainty cards can support this.
- Prompt participants to identify, problems, solutions, or strategies associated with their time of uncertainty now that it has been **Dimensionalised**.
- Be attentive to any realisation participants had that were not originally there.

Understand how the uncertainty, Branches Uncertainties.

- Consider that the **Source of Uncertainty** is one type of uncertainty.
- Once dimensionalised the uncertainty might become understood as different uncertainties with regard to different dimensions of the time the uncertainty occurred in. For instance, an uncertainty that occurred at work could create novel uncertainties at home.
- Understand that this produced new contexts to the uncertainty and is based on the subjective, ontological aspects of a person's life and their uncertainty experience.
- Do not expect the participant's design intervention to be a solution to the **Source of Uncertainty**, rather it might be to do with a specific context associated to the **Branching Uncertainties** that have come from the **Source of Uncertainty**. This is okay, as participants will decide what is contextually key to them during their time of uncertainty.
- Do not assign uncertainty to one concept of, positive or negative, reduce or embrace, consider it as multidimensional with each dimension and each branch contextually subjectively and ontologically within different frames. For instance, one branch of the uncertainty might be deemed negative, but another deemed positive, all within the same time of uncertainty.

Consider thematically similar interventions to expand inclusion without compromising the subjectiveness of uncertainty.

- Understand that interventions might work for one person as it's specific to their context and might not work for another.
- Consider how different temporal uncertainties produce interventions thematically similar; this could demonstrate tools and features that expand inclusion.

- However, while a feature might be similar to the needs of others, their context in which such a feature is used might change the application or output of the feature.
- Do not assume that the design will work for all. While interventions might have similar themes and indeed expand the inclusion of many by one feature implementation. Find ways to understand how such a feature or tool might exclude others.

5.10 Future work

- While a deduction on common traits of tools can be made about the interventions, future work might find it more effective to expand inclusion and reduce exclusion by assessing the interventions or features produced across multiple demographics.
- Future work might explore alternative use cases for the toolkit.
- This could involve adapting the prompt cards to focus on specific research areas, such as Temporal Uncertainty experienced by nuclear reactor operators. Although this research addressed various types of uncertainty, modifying the uncertainty cards could provide valuable dialogue for others experiencing uncertainty, revealing dimensions, branching uncertainties, and subjective interventions.
- Researchers could use the toolkit to gain a better understanding of uncertainty phenomena beyond a design focus. While this research offered novel insights into uncertainty within the context of design and temporality, further research could push the limitations of this toolkit into alternative research fields and domains.
- Designers might consider if the toolkit can support participatory research that, while not explicitly oriented around Temporal Uncertainty, could still address and manage uncertainty within the design process.
- Future work could utilise the toolkit to assess Temporal Uncertainty regarding novel technologies, tools, or features developed within HCI from an empirical standpoint.

5.10.1 Conclusion.

In this work, the researchers aimed to create a toolkit to better support people during times of uncertainty. The resulting time of uncertainty toolkit and method explored Temporal Uncertainty, positioning the participant as the expert and leading to the identification of implications and production of interventions.

Our findings showed that the toolkit effectively revealed the **Source of Uncertainty**. Participants were able to reconstruct their uncertainty by adding **Dimensions**, allowing them to discuss both **conscious** and **subconscious** aspects in detail. They began to view their uncertainty as a collection rather than a single type, leading them to identify implications and produce diverse **Subjective Interventions**.

The toolkit revealed that uncertainty is **subjectively contextual** and should not be generalised. Interventions shared common features that could expand narratives of inclusion, but care must be taken not to exclude others. Our findings suggest that uncertainty should be treated as multidimensional and contextually specific. Through the use of the toolkit, participants revealed subconscious experiences about their uncertainty, leading them to understand novel aspects and considerations. The researcher finalised guidelines for designers to explore Temporal Uncertainty while being attentive to subjectivity and diversity. Finally, the study accomplished its goals on producing a method and toolkit that would effectively help designers explore people's diverse ranges of Temporal Uncertainty.

Chapter 6

Speculative version of the Toolkit for Designers.

6.1 Motivation.

The Temporal Uncertainty the participants in Chapter 5 chose was positioned in reflection as opposed to speculation. This could be because participants could draw out real, subjective experiences where they felt an impact by the uncertain time they chose to discuss. The reality that can be explored with participants and their uncertain experiences means that the intervention results had contextual links to the required needs of that participant.

However, throughout this research and from the predominant importance of the first study, it was realised that not every person has the energy to participate in a one-hour workshop. Although these versions of the toolkit were implemented as physical and online tools to open up people's accessibility to the interactive facilitation process, it is widely noted that the length of the workshop might not be accessible to all. Furthermore, designers might not have access to participants for an hour or might not be able to get to certain locations in repeated succession.

With this consideration, it was increasingly important that the lead researcher make two instances of using the toolkit. The previously discussed sections **(5.2)** are what we call the reflective version; this is where a designer will work directly with a participant in real-time. The second version would become known as the speculative version, discussed in this Chapter. In this version, the designer speculates about a user's Temporal Uncertainty, either drawing on a speculative design challenge or choosing from a design or research project currently engaged with. The concept of the latter attempts for designers to have a toolkit that supports them to facilitate a speculative discussion around Temporal Uncertainty

from alternative perspectives.

Chapter 4 argued for the key considerations designers must take to not perpetuate their own temporal bias within the technologies they create, which has become another inspiration for this version of the toolkit. To expand our understanding of diverse temporalities, including diverse times of uncertainty, the same research questions presented in Chapter 5 were used. These questions fulfil the same investigative requirements but from a different perspective.

By using this toolkit speculatively, designers create a hypothetical user and a potential concept of Temporal Uncertainty, then explore these in a manner similar to the reflective approach. As themes emerge, the goal is for designers to gain insights into users' Temporal Uncertainty from a speculative yet deeper perspective. Ideally, this would enable them to facilitate more meaningful discussions with real-world users about Temporal Uncertainty. This approach aims to significantly reduce the time and effort participants would otherwise spend exploring their own uncertainty, thereby supporting the primary objective of this version.

This way, designers can fact-check their speculations and still support the design-for-all ethos in exploring Temporal Uncertainty hypotheses to test with future participants. Overall, this version aims to generate novel perspectives of Temporal Uncertainty. Using themes and language created in Chapter 5 to engage and prompt conversations about Temporal Uncertainty without having to put a participant through a one-hour exploration task. The following chapter covers the following:

6.6 Speculative Approach Findings. The Speculative Temporal Uncertainty Toolkit This section lays out the second version of the toolkit, in which designers use as a speculative tool to explore a user's speculative time of uncertainty.

6.7 Discussion on speculative version. This section presents the discussion for the speculative version of the toolkit. Provides guidelines for designers and future work.

6.2 Workshop/Toolkit for speculating on Temporal uncertainty.

Both versions of the toolkit and workshop are functionally the same except for how the prompt cards are used and the overall motivation (See section 6.1) leading to a speculative approach as opposed to reflective. It allows more flexibility for designers to engage with Temporal Uncertainty narratives, and consider Temporal Uncertainty Tools, if and when they cannot, for whatever

reason, engage with real-world participants. One such example, and the reason for this version, is people not being able to participate in a one-hour workshop. It means designers can gain speculative insights into their user's uncertainty, with the future goal of working those speculations with participants in what would hope to be shorter research sessions. Potentially reducing user time, cognition, and energy requirements to perform within a workshop setting. The toolkit aims to give designers a language, a way to speculatively theme and gather potential insights into a user's Temporal Uncertainty experience.

To achieve this, the alterations to the original version (see Section 5.2) are as follows.

1— Designers are first asked to consider a demographic, user, stakeholder, or individual they would like to focus on, they could be from a past project, or could be someone fictional. Write down the perspective persons.

2—Designers then use the prompt cards to speculate on a time of uncertainty that the user might have encountered, instead of the prompt card saying "*A moment of uncertainty*" as the previous version did, it would now be altered to "*A moment of uncertainty that they encountered*". A small alteration, but one that allows for speculation to take place.

Every step from here on is the same as the reflective version, but instead treated as speculative.

6.3 Recruitment and participants

The objective of the recruitment was to find a variety of designers from different design fields who would be willing to use the toolkit and workshop to explore a speculative approach to designing temporal uncertainty tools. The study aimed to understand how designers might use the toolkit to speculatively explore a user's time of uncertainty, to identify problems and suggestions along with intervention concepts.

Recruitment took place within Edinburgh University, specifically within the School of Informatics. Participants were invited by internal mail or by word of mouth. Participants were selected from a variety of design fields, comprising engineering, data visualisation, architecture, service design, system design, robotics, and product design. Participants were all postgraduates within their respective fields.

6.4 Set-up and protocol

The design participants were sent a participation form and consent form, which ensured that participants understood the purpose of the study and why it was being conducted. Furthermore, it stated that they would receive payment for their participation. It explained the toolkit and what would be expected of them within the workshop. Also, it stated how their data would be captured and stored and that they had the right at any point to revoke their data or leave the workshop at any stage. Participants were informed that any material produced within the workshop was their creative property and would not be implemented without their strict consent. The workshop was conducted either in person or online and required both audio recordings and photos/screenshots of the material produced in the workshop. Participants were informed that anything produced within the workshop that had been captured for data would be anonymized at the point of transcript and analysis. The sessions consisted of myself and one designer, with each session lasting approximately 1 hour. Participants were informed how long each step should take approximately, to stay on track for the hour.

6.5 Analysis

The interviews were audio recorded, transcribed, and anonymized; once transcribed, they were uploaded to Nvivo 12 pro. At this stage, each transcript was organized. The designers' data was uploaded into a specific folder. This was due to the two ways the toolkit was used and the desire for the data to be representative of how the study was conducted, reflectively or speculatively. Once divided, the participant transcripts were analysed using thematic analysis in the same manner as prior studies within this thesis, See (Chapter 3).

A line-by-line process was deployed in which each sentence was coded and annotated, and each annotation gave a description of the code and why it was assigned that code. This was for future reference and transparency. Once all codes were produced, a second pass was conducted and any codes similar in nature were combined into sub-themes. If there were any commonalities, an inspection of the sub-codes was performed to formulate a singular overall theme or insight. After conducting this process with all sub-themes, the process led to overall core themes.

6.6 Findings

6.6.1 Constructing a time of uncertainty.

In a similar instance to the first use case of the toolkit, designers used prompt cards to envision a potential Temporal Uncertainty that their stakeholders might encounter. These stakeholders were considered from previous projects the designers had engaged with or fictionally created around a topic they were currently interested in, such as ageing and care. The process occurred exactly as it did in the previous version, only this time from a speculative angle.

Like previously, the cards attempted to prompt the designers to explore Temporal Uncertainty. However, unlike in Study 4, Chapter 5, designers struggled to pinpoint Temporal Uncertainty. Instead, the discussion largely overlooked temporality and focused more on the general concept of uncertainty within the areas of uncertainty and design.

Reflecting on this, I suspect the issue arises from the speculative nature of this version. Since designers are not familiar with Temporal Uncertainty, speculating about it might have been challenging. Consequently, participants defaulted to discussing the more familiar concept of general uncertainty. In contrast, the reflective version, while also dealing with an unfamiliar topic, allowed participants to anchor their discussions in real experiences of Temporal Uncertainty. This concrete grounding likely made it easier for them to engage with the concept compared to speculating about hypothetical scenarios or events.

The insights into Temporal Uncertainty are clearly more profound in the reflective version compared to the speculative version. This is evident from the solutions generated by designers in the reflective version. While these solutions, such as time travel, were indeed imaginative, they were supported by a strong understanding of Temporal Uncertainty. For example, the concept of being in two places at once effectively addressed the challenge of managing the uncertainty of caring for parents while juggling work and future life constraints.

In contrast, the speculative version's solutions, though present, often lack a fundamental grasp of Temporal Uncertainty, which diminishes their relevance.

This discrepancy likely arises because participants in the reflective version could explore the deeper meanings of their Temporal Uncertainty more effectively. Simply because they had lived it. This limitation in the speculative version suggests a potential flaw in its design. As highlighted by the following findings, which show a greater emphasis on general uncertainty rather than Temporal Uncertainty, a redesign may be warranted.

The discussion of the uncertainty of building in a specific location (**D1**)

combined the language of the cards to offer a deep context about the implications they faced on one of their previous projects. **(D1)** used the **(Predictable uncertainty)** card to describe the time complexities associated with this design space. "*In Greece, we have earthquakes*" meaning buildings had to be dug deep, yet, deep excavation of sites for building unearthed *"Remnants [...] and then the archaeological team comes in [...] If they're of significance, the construction stops"*. Further use of the cards exemplified parties would be **Gauging the uncertainty** or experience **Waiting uncertainty** *"If an unpredictable, unexpected uncertainty comes up, you're gauging that stage, you're estimating what's going to happen."*. (**D1**) demonstrates that a project has milestones where various uncertainties can arise. The **Cautious uncertainty** card led (**D1**) to demonstrate the challenges faced not only when dealing with stakeholders but also other members of their team. "*I just kind of remember whenever I had to meet the lead architect, [...] I was trying to be cautious [...] How I'm going to phrase something, you know because he's my boss,*"

(D2) constructed their themes around a person's use case of technology. Using the **Anxiety Uncertainty** and **Cognitive Uncertainty** cards, they formulated a discussion on emotional responses to technology. "*If the participant doesn't have that much knowledge, or being savvy with technology topics. I think it's very normal for them to feel anxious and also to have like, this cognitive maybe overload, like, Okay, I don't really know how to use this how to use a touchscreen, for example*" (**D2**).

While speculative, the themes and cards helped to build narratives about potential issues participants might encounter in specific moments of uncertainty, and what contexts were surrounding those uncertainties. The cards helped **(D2**) to formulate this context and build a world around their speculative person that led them to interesting insights, which can be seen in the use case of the (**Familiar uncertainty**) and (**Remain uncertain**) cards. "*It's an estranged relationship because, on one hand, you (Speaking as the target user) have your cell phone, you know, your family communicates through it, or they use a particular app. But at the same time, I think that they can feel excluded. So they remain with that uncertainty, but at the same time, they learn how to live with it*".

The theme discussion led to a deeper community concern that was inspired by the use of the (**Empathetic uncertainty**) card. "*It can become like an empathic uncertainty, because if other people in this area are facing a similar situation, or they are having trouble accessing certain services or features within particular apps, I think this can lead to repurposing this uncertainty into something different*" (**D2**). Uncertainty in this retrospect became sighted as a reusable concept from

a personal perspective to a communal perspective where technological access was not just down to savviness but also infrastructural challenges. "*Infrastructure of the context and different conditions around it might not be the best [. . .], but you can craft new perspectives around this, this particular uncertainty*" (**D2**). The theming around a need to be communal about uncertainty led (D2) to consider the externalizing of uncertainty by a person as a positive solution. "*Otherwise you know, just stay with the doubt or with that uncertainty or, or lack of confidence, because you don't know how to express it to other people. So maybe by this process of externalizing, you can come up with better ideas or more. Yeah, more interesting ways to address a particular problem*" (**D2**). Though this was seen as a solution, using the **Judgment uncertainty** card, deeper insights on challenges around not being able to use technology as an individual were expressed. "*If you, if you don't know how to use a technology that most people are familiar with, you can face judgments, but you can be judged by them. And at the same time, this would make you feel less confident about using it, like, Okay, I don't really know what I'm going to do, if I face this particular situation*" (**D2**).

The themes constructed by (D2) shaped a deep understanding of a user who might be going through times of uncertainty with a particular technology, leading (**D2**) to **Dimensionalise** the speculative participant and insightfully consider challenges along with solutions.

Participants mostly constructed speculative participants around areas in which their design focus was currently. Kathy became an older person that **(D3)** used within the workshop. Using the **(Waiting uncertainty)** card, a story began to emerge about the uncertainty Kathy might be encountering at that moment in time. "*Say, Kathy, is, you know, feeling a bit uncertain about her health, and she's waiting for somebody to come to check on her because she's alerted say the nurse that she is having trouble walking, for example*" (**D3**). The cards allowed participants to take experiences such as waiting and uncertainty to assist them with potential real-world scenarios a person could encounter. The (**Biological uncertainty**), (**Physical uncertainty**), and (**Reliance uncertainty**) cards were used to explain infrastructural issues Kathy might be encountering. "*Then that goes into biological uncertainty and physical uncertainty. But there is also a lot of waiting involved. There's a lot of waiting involved in hospitals [. . .] that uncertainty and waiting for someone else to come help you. [. . .] Like you do have that uncertainty because of your condition, probably, but then the waiting and the Reliance itself might cause and accentuate that uncertainty*" (**D3**). These cards formed a deepening story about Kathy not only internally experiencing health uncertainty, but the knock-off effects that occur when health does impact a person who is dependent on the support of others.

Uncertainty became seen as "*It's never been linear. It is never logical uncertainty [...] it can build up*" (**D3**). Similar to participants, the uncertainty was not seen as a singular concept, but rather that it would adapt and change within the context it's considered. Kathy's situation, using the (**Conflicted uncertainty**) and (**Aftermath uncertainty**) cards, allowed (**D3**) to explain that internal uncertainty can speculatively become a challenge in health scenarios. "*It can go into conflicted uncertainty [...] when you are probably going through some health issues, you end up making stories about what that issue might be. [...] the uncertainty of like, how this seemingly benign thing that maybe she's having trouble lifting her leg [...]she's thinking is the worst case scenario of like, [...] something much bigger and might, so there is like the aftermath uncertainty*" (**D3**). However, the technology around Kathy, using the (**Predictable uncertainty**) and (**Gauging uncertainty**) cards, allowed **(D3)** to construct how Kathy became adapted to assess their own health. "*Predictability can also come in where either you know your tools around, you know, your heart rate monitor, or like the gadgets that you have, so that you're checking yourself, she's gauging herself*" (**D3**).

However, the predictable uncertainty became seen as a potential problem for Kathy. "*Okay. And that the predictability might be working well, in this case. But [...] when it isn't predictable or when you know, an event happens. And you're not able to do certain things that might change the way you interact with these things. And that's where some of the momentary uncertainty comes in*". The (**Momentary uncertainty**) card meant (**D3**) could complex something such as gauging health into the notion that predictability if no longer predictable can become an uncertainty in itself. Uncertainty is seen as shifting perspectives "*So something that is predictable and mundane initially can maybe after an episode or after something, become a sense of comfort, [...] It makes you super uncomfortable or makes you comfortable in knowing that whatever you were taking for granted is now you know there is a different relationship like something telling you that yes, you are. Your heart rate is normal. After an episode*" (**D3**). Kathy (**D3**) exampled how people through a temporal experience of uncertainty can formulate new normals, such that a person might have a new heart rate which becomes their new normal.

The cards helped (**D4**) realise the challenges a small Hong Kong shop owner might face when suddenly fluctuating with customers. Speaking about a real project (D4) was involved with, they considered how a small KOL (Online Influencer) could partner with small Hong Kong businesses to incentivize people to come to the small business. "*Cause when I use these cards I think if they come to shop, maybe a small shop [...] but maybe the KOL has some influence*

and there are so many fans come to the shop and the shop is small.[. . .] So there has the uncertainty of waiting. And the rescheduling [. . .] the small shop is the main user, but the small shop has a little space. So maybe I just know the Reschedule and waiting for problem" (**D4**). Using the (**Waiting uncertainty**) and (**Reschedule uncertainty**) cards, (**D4**) constructed how a small shop might not have the infrastructure to support an influx of people suddenly coming to the small shop. Based on the potential of this **Future uncertainty,** (D4) considered a solution to fix this problem. "*Future uncertainty, is we want to use design to get a small shop to connect to a so small KOL*" (**D4**).

However, this was also deemed a potential issue if one of the parties involved grows faster than the other. "*The future, the KOL will be more famous, or the shop is more famous maybe say they have not, not have the balance. So maybe they have some future uncertainty problem in the co-work situation*" (**D4**). The temporal growth of two parties not being equal was deemed as a potential issue, even though both parties began as small. When it came to the equality of both parties, how a KOL would be hired by a shop came into question due to potential covert practices. "*KOL in China, they will pay some money to buy some fake FANS. Oh, they are not real fans. You know, the bots? He wants to let himself say, I have a lot of fans and the small company will say "oh this KOL has so many fans so many followers". [. . .] The shop pays some money or pays for some free bubble Tea. And after the small shop pays. [. . .] No new audience come to my shop*" (**D4**). This concept was also considered in another vein where the shop cheated the KOL. "*The small shop maybe not has good quality food or good quality product [. . .]So maybe the KOL will lose their fans too situation*" (**D4**). These themes demonstrate the balancing act of uncertainties that could be required when bringing a KOL and business together.

Considering a toolkit for designers was the target user for D5. **The Future uncertainty** card gave (**D5**) away from describing how designers in their practice should "Decide how they define that uncertainty, [. . .] in their work or in their future" (**D5**). Being able to define the uncertainty and understand it was seen as a way to be creative through it. "*It's not a problem. It's trying to find the positive things from the uncertainty and try to convert them into some useful things for the designers*" (**D5**). The **Ability uncertainty** card was used to demonstrate identifying uncertainty and how to use it as a positive was down to one's abilities. "*It depends on their ability. Like they should have the skills to, to look at the depth of the uncertainty and try to find out something they can use for their work*" (**D5**). Uncertainty in this sense was a time in which designers aimed to identify and understand the ways in which that uncertainty can be used within their design thinking or practice.

Having an understanding of the nature of uncertainty was seen as a (**Collaborative uncertainty**) when using this card. "*I think the collaboration one is very important. [...] they should do some research, do some interviews with some other designers [...] to know their thoughts [...] about it, the uncertainty [...] people around them would give the designers some feedback or something*" (**D5**). It meant that feeling uncertain as a designer was used as an idea of positivity, but also as a space to educate and understand the uncertainty with the help of fellow designers. The pedagogical approach (**D5**) used within their themes was to make clear the need to learn through uncertainty, rather than dismiss or reduce it. Training in handling uncertainty was seen as a way for a designer to have **Foreseen uncertainty** and **Predictable uncertainty** that can produce design outputs and thinking. "*Is foreseen is predictable or unpredictable, or future uncertainty, I think this one theme. [...] I think it is its point that if the designer could realise something or it could really solve some problems, it could enlighten people about some new topics or new thoughts in the future. If they (the designer) can really realise them, it is the designer should have the ability to foresee them*" (**D5**). In this sense, the uncertainty themes involved the designer's abilities in handling or using uncertainty as a tool to foresee future concepts, ideas, or happenings that can influence their creative process and produce novel insights into these uncertain futures.

The discussion of an older user who is having to deal with the uncertainty of death became an exploratory topic for (**D6**). Using the **Emotive uncertainty** card, it explained the challenges the older man will encounter in speculative terms. "*Like the old man maybe become emotive uncertainty when he's facing his families or have dinners with their families. And he might be thinking of how their families would live after his death and feel unsteady about what the future will be*" (**D6**). Using the cards to formulate this story (**D6**) painted a vivid scenario that the older man might be currently feeling about life after he is gone. This thought was considered because the old man was currently in the hospital. "*He will also feel uncertain about the future of whether his health conditions will get worse or better, this time maybe it's like an externalising is a good way for him to get away from the illness*".

Using the (**External uncertainty**) card, his feelings being expressed was seen as a positive for the older man. As (**D6**) was designing for technological funeral concepts within their own project, the older man became considered within these technological narratives. "*They will feel they don't know [...] how to deal with this technology. And also this service will. He will give a confirmation or commitment to the website and this will also cause uncertainty*" (**D6**). Giving commitment to a novel technology was seen as uncertain when the older man

might not understand what they are giving commitment to.

The (**Judgment uncertainty**) card demonstrated how the older man might face challenges when dealing with novel milestones in their life. "*Judgement around uncertainty, because maybe the old man facing with people is unfamiliar with, like the funeral doctors, the solicitor and other people from the other parties, and he will think about what others thinking of him*" (**D6**). Life events being novel such as planning a funeral meant the older man might enter new spaces and meet new people that might treat him with judgment. Specific environments were said to perpetuate the consideration of death and therefore uncertainty. "*Specific space for this topic for to arise his feelings about death, and that's the graveyard or headstone has stolen or something related to that will cause him to think of the death*" (**D6**)

Thinking of death was also prompted by the (**Conflicting uncertainty**) card. "*Because children are young and they have so many possibilities and life for an old man is certain. [...] and become a comparison between the young and the old and will give maybe conflicts uncertainty The older man seeing young people makes them think about their life has become certain, but the younger people have much more possibilities*" (**D6**). The cards created a strong theme and insight into a speculative story, someone, closer to death, might feel and encounter how uncertainty plays a role in this specific time of a person.

Focusing on their real user, animal welfare educators (**D7**) who incorporate animal robotics into education felt that exploring this user's uncertainty was important. Using the **Familiar uncertainty** card (**D7**) explained the normative experience of uncertainty. "*A theme of like, with the people and both like children and teachers, that you can't really predict how they're gonna act but you know that that that's quite familiar[...] It's like very dependent on their age. So that introduces a lot of uncertainty.*" (**D7**). The uncertainty of different environments and places and the unknowing of what might occur in each of these events while uncertain was a familiar normative for animal welfare educators.

The tools educators use became an important aspect of the educators along with their requirement to adapt to the uncertainty of each environment they end up in. "*Even though it's within a rigid scenario, and they have that sort of flexibility to adapt, rearrange, things do things slightly differently. But the tools need to reflect that*" (**D7**). How each year of school practised time meant the rigidity would be different. "*Schools are so are so rigid, practice their lunchtime, now. They are going to do this. Now. There's some, I think. So this is particularly in a primary school. Primary schools are less rigid. [...] It's more flexible than the secondary schools*" (**D7**).

The **Aftermath uncertainty** card was used to describe what uncertainty arose

after a class. "*Aftermath uncertainty of Yeah. How did it go? I mean, is it a sort of education? activity, you know, did they learn anything? How did things go? How can you tell whether this activity has changed their perspective*" (**D7**). It was important for educators to feel how much of an impact they had yet not entirely sure where those impacts occurred. Furthermore, sometimes where certain activities took place were not decided until the very moment of the day. "*Also that there is some sort of like, hinge point, uncertainties like the classroom playground. Where, until that is settled, it is really hard to like decide what you are going to do. You, yeah, design your activity. But that can be uncertain up until, like, you know, you arrive at the school[. . .]or weather dependent, you know. So it can be quite different*". The educators in this scenario would encounter various uncertainties when it came to teaching that changed with regards to the environment, class year and even seasons. "*They do things with the seasons [. . .] there's kind of that uncertainty, but I guess, very predictable, you know, that. You know, the, probably at one time of the year, you might spend this five minutes talking about what to do when you find a baby bird*" (**D7**). While the experience was predominantly uncertain for educators it seemed often that this was a predictable type of uncertainty.

6.6.2 Shifting Perspectives on Uncertainty.

In various ways, the toolkit had an influence on the designers to consider novel perspectives around uncertainty and design. One such example is (**D2**) explaining how and in what way the toolkit supported discussion. "*It's a good way to discuss topics around something more [. . .] systemic,[. . .] I mean, to understand how not all uncertainty is negative [. . .] these adjectives around uncertainty, I think it gives a different meaning to the word itself, and it helps, it helps, it would help me as a designer to approach the concept from a more Yeah, maybe a more positive light, you know, like, okay, there is this empathetic uncertainty or this support around uncertainty*". The toolkit facilitated language and themes that (**D2**) were seen to give a novel meaning to the concept of uncertainty, changing their notion of uncertainty into a more positive consideration of how uncertainty might be or need to be considered from the perspective of their user.

Previous mindsets of uncertainty were re-evaluated when using the toolkit. "*What I might have done previously. I might have gone in and tried to see right, where is uncertainty? How can I reduce it, or replace it eradicated? But now I'm like, No, everything is uncertain in the space for this demographic. How do I normalise it? So it's almost like it's a shift in my perspective. [. . .] how and in*

the uncertainty lives how do I add value?" (**D3**). A shift in seeing uncertainty as something to be removed was reassociated with something to normalise as the workshop changed (**D3**) perspectives on their demographic who would benefit better from normalising their perpetual experience of uncertainty. In a similar context, (**D4**) understood that the designer approach could be reformed to include the time of uncertainty consideration "*I think for my future design process, I should consider more users' uncertainty. Because, before, before participating in this workshop, [...] just consider some touchpoints, user's emotion and workflow. [...] So I think the uncertainty part can join the user journey map and we can find more opportunity points.*" (**D4**). Exploring uncertainty added value to the designer workflow and opened up opportunities to understand the user's emotions that might be incorporated within their experience of uncertainty.

Designers gained a new grasp of what uncertainty can mean when considering the language of the cards. "*Actually the conflicts uncertainty I never thought before. That's a brand new concept to me [...] they will become more uncertain about how they make the choice and what consequence it will cause so the conflicts are something new for me to think of in another new way.*" (**D6**). Gaining novel insights changed how designers were considering the meanings of uncertainty with regard to their target users. The process as a whole was deemed interesting. "*It's interesting how you were building blocks. And in the end, [...] you can actually have such creative results*" (**D1**). Creativity was seen as part of the outcome of the toolkit. Other outcomes were changing how uncertainty might not be a scary topic for designers. "*I like this. This is a really interesting experience. Yeah, looking at all these different uncertainties in thinking about how they apply. And I think also it makes it less scary for a designer, [...] my tendency is to sort of desperately try to control for all these uncertainties [...] thinking a bit more about the way that animal welfare educators do it, and like work with uncertainty has been sort of quite Yeah. It is useful to not try to make something that's unbelievably rigid for them*" (**D7**). How (**D7**) would go on to design for their demographic was considered as potentially different after the toolkit compared to how they thought about the topic of uncertainty prior to the toolkit.

6.6.3 Interventions

With clients not understanding the uncertainties that can arise when building a new home and the issues mentioned above (**D1**), a concept of role reversal technologies was considered. "*One thing that came to me, while we're discussing the sense that it might be interesting, if the roles are reversed in through a*

game or something [. . .] a game of breaking the boundaries, breaking the ice or whatever they would like to name it. I'm not sure if people would agree to take part" (**D1**).

This technology was considered as to, "*Reverse the roles and so that the client can actually feel the difficulties that the designers are facing, and understand how difficult that is in some cases to accommodate the client's desires*" (**D1**). Role reversal was seen as a way to elevate an understanding from the client towards the designer on the uncertain challenges that occur during certain requests, or if building is halted due to unearthed artefacts. The game had the potential to give clients novel perspectives. "*They might actually manage to be more empathetic because they have to be in the other person's shoes*" (**D1**). This technology or game would be centred in "*Augmented reality*" and would allow you to feel one another's "*Pain*" (**D1**). The designer considered how the ability to empathise with another person's situation of uncertainty could extend to other areas of life and social interactions. "*I was thinking, how cool is that? If when I go to the doctor and tell them, you know, that thing, that part of my body is in pain, and they, they might discard it, because they don't really know how bad it feels. And how cool would it be? If they could empathise more with me? They could actually feel the pain*?" (**D1**). The exploration of design situation **(D1)** had been in before, and the temporal points of uncertainty that arise during this time, allowed **(D1)** to consider problems and solutions that ended up resulting in an empathetic AR tool to understand the uncertainty that surrounds the life/event of another person.

(**D2**) rather than a single tool became concerned with a way of design thinking that was influenced by their exploration of the potential uncertainty their users might encounter at a given life event. "*This lens of good design [. . .] maybe co-create technologies or a way to, to frame the situation, [. . .] in the particular context of this semi urban areas, or limited infrastructure, how maybe alternative technologies for communication could be deployed or created*" (**D2**). The designer in this situation was left asking more questions than when they went into the session. Based on the positives of sharing uncertainty noted by (**D2**), they considered ways to bind community around technological challenges and uncertainty. "*I think I would try to craft something around, like collaborative methods to teach around these technologies, of course, using the technologies themselves, like, I don't know, some kind of workshop with that could be run by the most savvy members of that community*" (**D2**). The uncertainty exploration linked well with the designer's research interests and gave novel perspectives for the designer to consider. "*This collaborative communities and how to use technology in different ways. It's something that I'm really interested in. Is, it's*

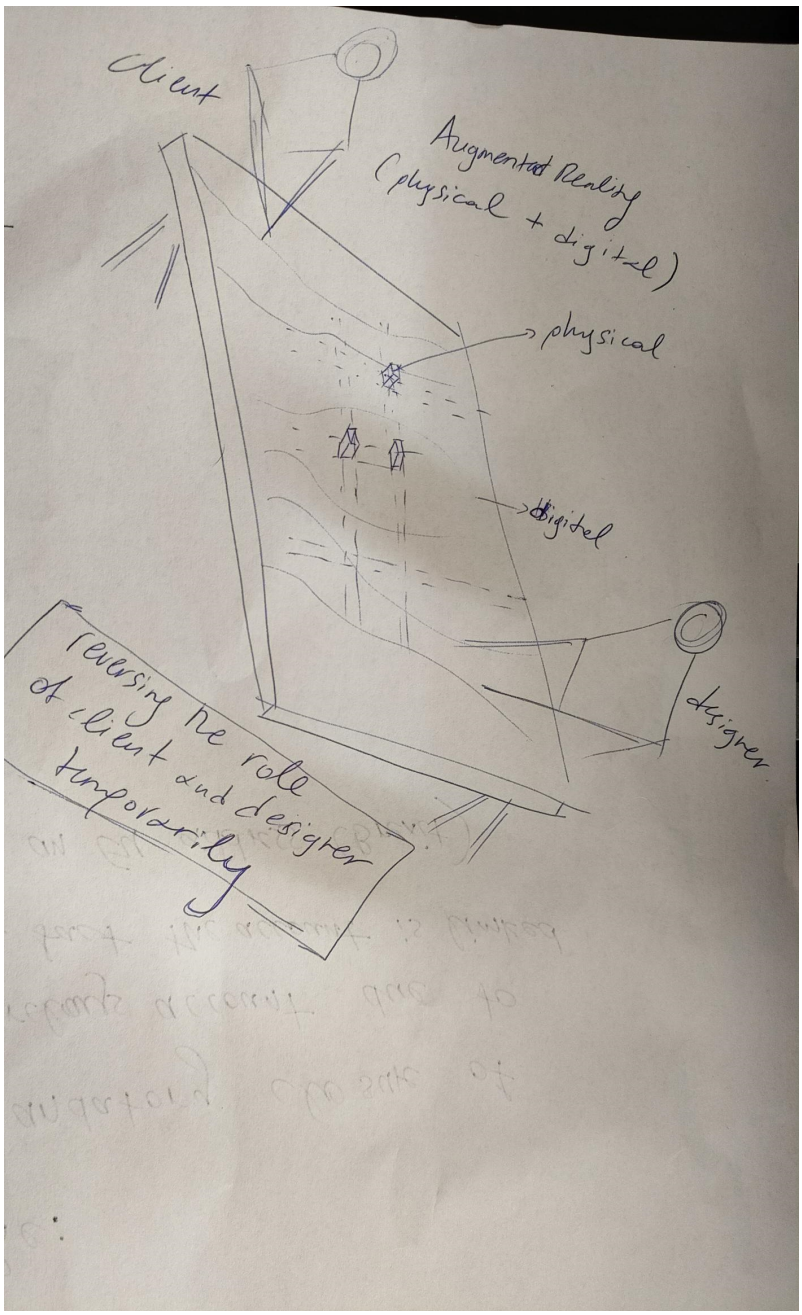

Figure 6.1: empathy reversal in VR to understand uncertainty

kind of related to my, my research topic [. . .] I really think that having this, this concept of the different kinds of uncertainties is really, really helpful.[. . .] Okay, we have this uncertainty, but we have a community, or we have this problem. But again, it's something that we can tackle, or we can think of a different way to address it" (**D2**).

In a similar respect to (**D2**), (**D3**) did not see their solution as a technological one. "*Maybe it's not even a tech solution, maybe it's [. . .] like maybe a recreational programme it then fosters the community and takes away like, individual uncertainty in ways that like, the time you might be spending, worried about something is the time you then actually are spending with a community*" (**D3**). Community was seen as a way to converse about uncertainty and not internalise it that could have challenges for the older adult (**D3**) had been considering. Continuing to use the language of the cards, **(D3)** explains the journey a person might go on, if a designed recreational programme was implemented. "*Aftermath uncertainty, momentary uncertainty of like, are we internalising as well and then puts more focus a bit on actually, it takes away from capability and certainty and then probably can foster more sort of reliance, which then builds that sense of autonomy, a sense of community and all that*" (**D3**). Reliance is one of the problems identified early on in the workshop meant (**D3**) seen agency as a priority in not controlling uncertainty but having a community who can rely on one another and themselves in times of uncertainty. In this sense, uncertainty was seen as a very "Human problem" in which technology could only aid around the context of the uncertainty, such as health. "*Technology can assist in ways that you've seen it here like sensors, technicians and like in managing that gauging, maybe yeah. But if the problem is around, feelings of uncertainty, I would try to tackle it through that community*" (**D3**). It was deemed community was the best approach, as technology could be the very source of someone's uncertainty. "*Technology that also then causes isolation and causes more uncertainty and all that*" (**D3**). The approach was a disciplinary concern and would be required to be approached by a designer in "*Organisational design or even service design*" (**D3**). The designer considered themselves working in this project and the workshops helped them to realise their role as a designer when designing for people, especially when considering their times of uncertainty. "*Maybe here's where the sensor can fit in or, you know, like I'm not in that mindset, which I might have been before this. Maybe, I don't know. But going through that actually putting myself in an uncertain place as a designer myself, has helped me understand, I guess what my role is within this*" (**D3**). This insight means that **(D3)** is considering how they situate themselves in designing spaces or life events that might have experiences of

uncertainty within them, requiring different approaches, not only technological but human interventions.

(**D5**) Considered how to make a designer become more supported in advancing their confidence in uncertain design situations. More so from an educational perspective. "*I think it could be like something like Wikipedia. For the designers to know that some basic knowledge or basic design tools or methods like the new designer or know how to carry on, like how to carry on a workshop*" (**D5**). The technology had "*He can define the area who wants it get research like you want to do? Do research about students he knew that his users are students, he can employ that information*"

The technology would use a virtual assistant to aid a designer in progressing their confidence in user encounter techniques, such as with interviewing. "*There could be a virtual interviewer talking with him, and he can input some questions you want to ask him and maybe this figure would talk with him*" (**D5**). The virtual assistant would be a trainer, for the training designer, to help support them in technologies they might feel uncertain about. Over time, the designer could track their learning process and see how they did the year before. "*Maybe one year before that would show what he did. Yeah, maybe he did an interview with two people. And he received some feedback. And maybe one year later, he also did an interview. But this time he got more feedback that are useful, useful to them or where maybe he learned something from it. And he could seek, maybe this system could give him a score or something*" (**D5**). Feeling uncertain about progression and gaining a sense of progress were the fundamental core components of the designer's design.

The older man in (**D6**) story encountered different experiences of uncertainty. One notable one would be interacting with websites and technology that might be used to engage with the designer's product, which was funeral-type services. A companion design was considered in this instance. "*It's this robot it can accompany the old man and can interpret the complex information from our website and talk, talk into an easily understandable language*" (**D6**). The complex information was to do with potential jargon surrounding the experience of funeral planning. "*The dog will interpret the information from the web into an audio*" (**D6**). It would also include an online version of the dog. The language of the cards was once again used to discuss the challenge with current information in relation to uncertainty. "*Nowadays, people will face more choices. And the more choices they are, there will become more uncertain about how they make the choice and what consequence it will cause*" (**D6**). Therefore, the dog was considered as a way to help people make simpler choices when complex decisions were present. As the older man was prior considered encountering human interaction

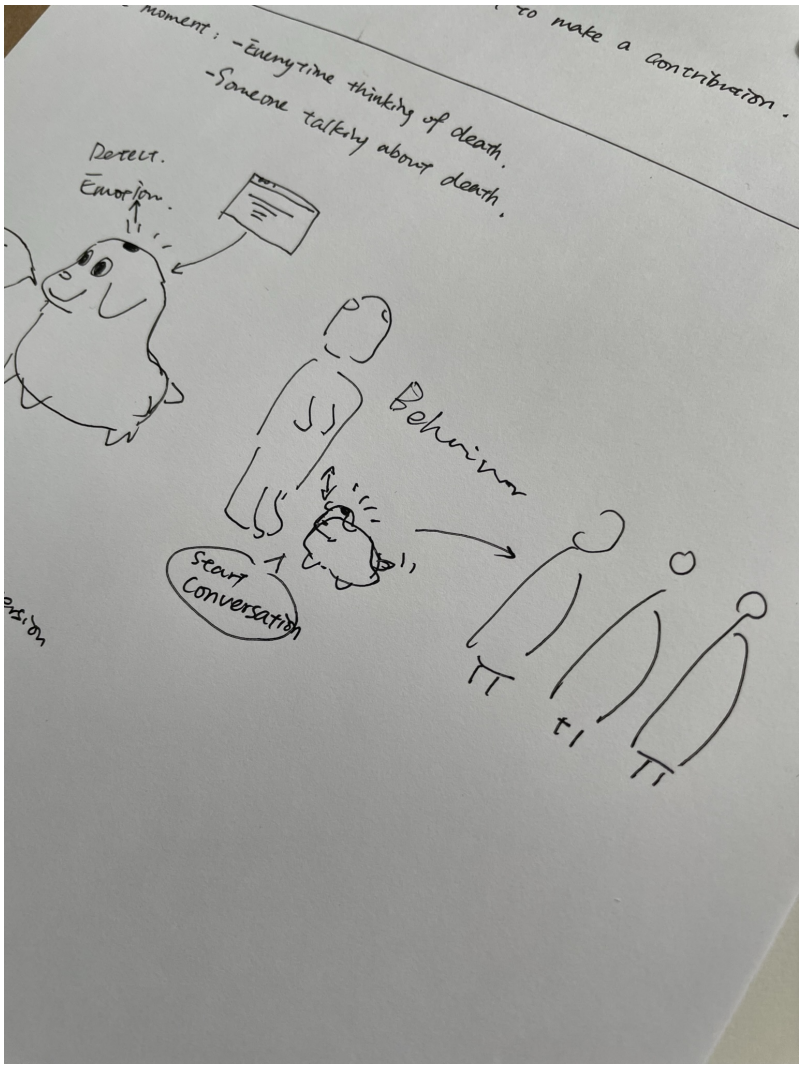

Figure 6.2: Uncertainty Emotion detecting Robot dog

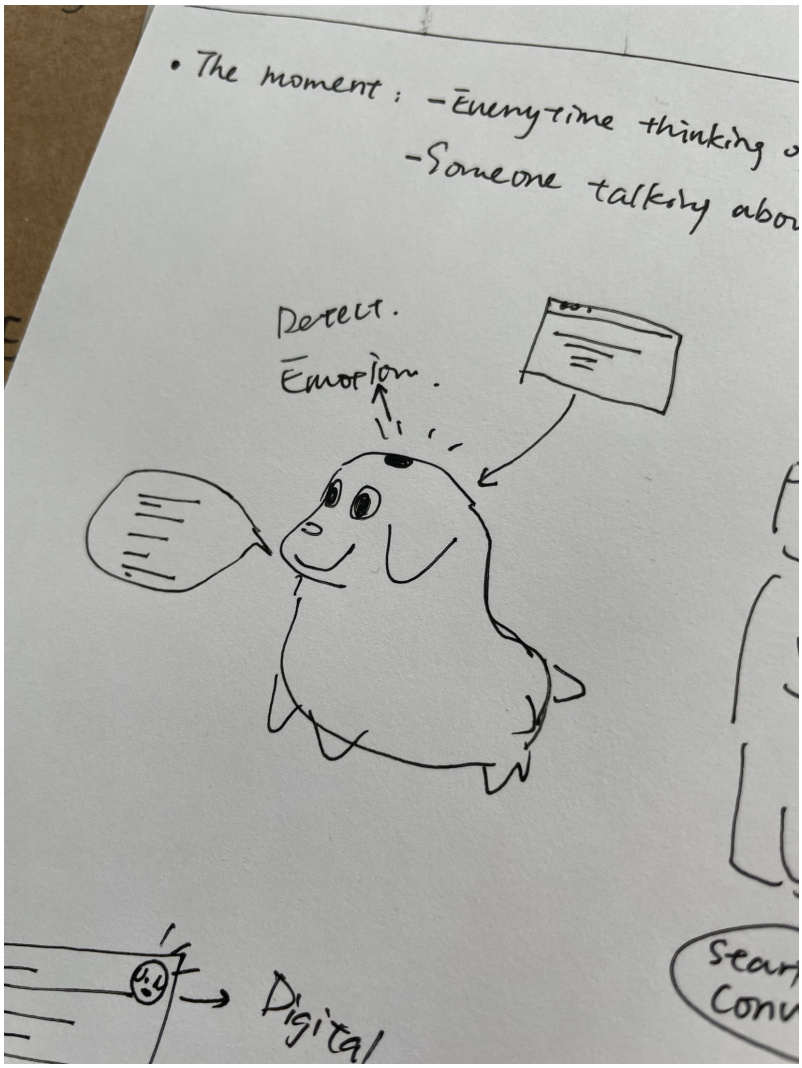

Figure 6.3: Uncertainty Emotion detecting Robot dog

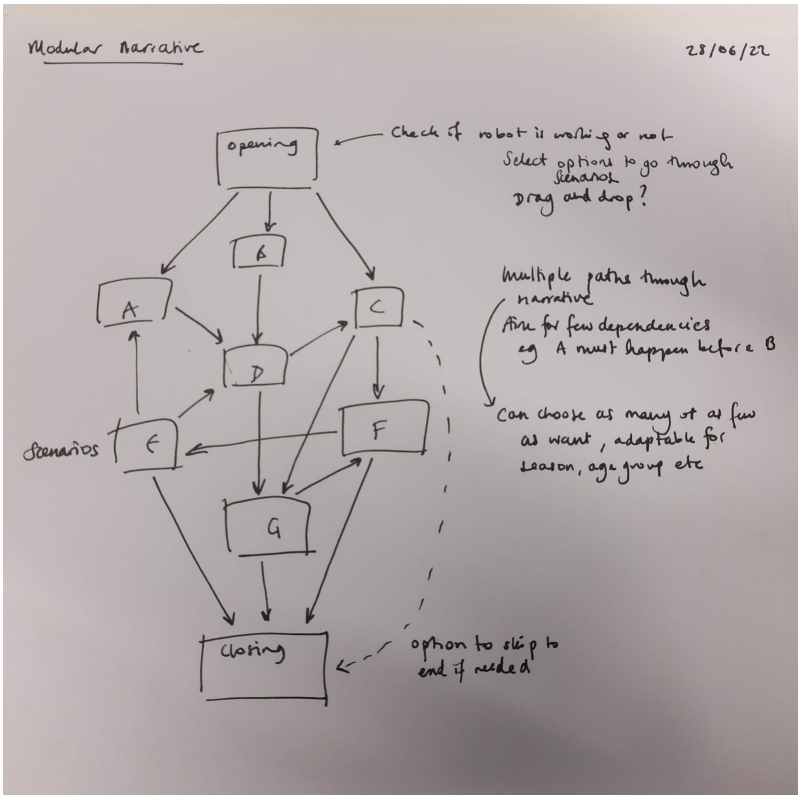

Figure 6.4: Modular narrative

scenarios that could be difficult, the robot would support in these scenarios. "*The dog can detect the emotion around the people around, and we'll give the opportunities for the old man to have appropriate communication with the people around*" (**D6**). The robot companion would support challenging conversations between people that came with a lot of emotional uncertainty.

The times in which uncertainty was encountered by animal welfare specialists were within the educational aspects of their jobs. **(D7)** felt the specialist required a modular class plan, that could adapt to their encounters with uncertainties that surround a schooling environment. "*I think particularly with, with time uncertainties, so having things that are, like, extendable, contractible, modular that, that you can serve easily. Extend, truncate, and aren't, you know, times down to the minute*" (**D7**). The school has an element of rigidity to them meant the flexibility of a plan was seen as beneficial and that can adapt in scenarios where required. The modular plan had different journey points that could be extended or reduced depending on the moment. "*If you're trying to do a robot, and a narrative.[. . .] make it so that it's not a fixed length that you can end early? [. . .] you can prioritise here that there are like interchangeable. movable, so it's not, it doesn't have to be 123. It can be 312231.[. . .] And just gives them that flexibility within a very rigid scenario*" (**D7**). This concept was seen as changing how (**D7**) considered ways in which research or teaching can take place, which

do not fit rigid ideas but rather incorporate flexibility to support moments of uncertainty. "*I think almost as like the leaning into the uncertainty, okay. Yeah. Because I think of it as, like a researcher trying to run, an experiment. You want everything to be certain and planned and really fixed. But I think this really helps to think how, how you can have a sort of rigorous experiment that said, like, you know, yeah, scientifically rigorous, but also embrace some of that uncertainty*" (**D7**). Overall, work plans that changed and were flexible were seen as a potential benefit to educators and researchers working within education environments where uncertainty might be prominent within rigid scenarios.

6.6.4 The limitation of the speculative Temporal Uncertainty Toolkit

Despite the potential of the speculative toolkit to encourage designers to confront uncertainty and shift their perspective, it ultimately failed to achieve its objective of exploring Temporal Uncertainty within the context of design and HCI. Upon careful consideration, it appears that the toolkit is most effective when a user is addressing a specific Temporal Uncertainty they have encountered or are currently facing. Although the temporal prompt cards were included in Study 4, the most notable divergence from Study 3 was in the utilization of the toolkit. Study 4 involved speculation, whereas Study 3 focused on reflection. This difference may explain the discrepancies in the toolkit's performance.

Auger (2013) emphasizes that speculative design often involves envisioning technologies of the distant future. This is evident from the research findings that introduced concepts such as robot dogs (D5) and used virtual reality to evoke empathy (D1). However, the failure lies not with the designers, but with the toolkit's inability to provide a clear understanding of the expected boundaries of speculation. Auger (2013) suggests that speculation should be grounded in the realism of present-day science and constrained to avoid drifting into the realm of the far future. This approach allows speculation to lead to logical iterations of prototypes intended for specific user groups.

Several key observations can be made about the obstacles encountered by this version of the toolkit, as highlighted by Auger's viewpoint. There were no constraints on speculative activities, and designers lacked guidance on how imaginative or practical they needed to be. Unlike the second study involving Haze, designers in Study 4 did not start with a pre-established concept or prototype, relying solely on imagination for speculation. Additionally, there was a lack of clarity regarding the intended user group. The toolkit failed to address many of the key points presented by Auger, and there are further concerns

related to speculation and Temporal Uncertainty.

To address these issues, additional modifications to the toolkit's design are necessary. First, to ensure that designers are exploring Temporal Uncertainty rather than a more familiar concept like general uncertainty, the theory of Temporal Uncertainty needs to be more prominently integrated into the toolkit. This raises the following questions: How can the toolkit be redesigned to help designers understand Temporal Uncertainty? Will familiarity with the theory enable designers to explore various aspects of Temporal Uncertainty, particularly in relation to their design practice? Designers should first engage with a target user group to discuss Temporal Uncertainty. Consequently, the toolkit should remain reflective, allowing designers to explore Temporal Uncertainty with target user groups. The tools developed through this version, as demonstrated in Study 3, should then be used speculatively, similar to Study 2 and Haze. This would mean abandoning the current speculative version and replacing it with one that teaches the theory of Temporal Uncertainty, enabling designers to become facilitators using the toolkit from Study 3.

The current iteration of the toolkit inadvertently focused on general uncertainty, diverging from its original intent. It did, however, encourage designers to embrace the unknown and shift their perspectives on uncertainty, which could support HCI research in broadening the understanding of uncertainty. Future research could investigate which elements of this toolkit are effective in supporting work related to uncertainty in HCI. Nonetheless, as the goal was to explore Temporal Uncertainty, it is crucial to modify the approach based on previous recommendations. Further testing of these modifications will be essential to assess their impact on outcomes.

6.7 Discussion on the Speculative Version

Assembling speculative temporal uncertainty.

In the speculative version, designers had to assemble a speculative concept of Temporal Uncertainty from the use of the toolkit and workshop. This was different from the alternative versions when participants already knew and had lived their notion of Temporal Uncertainty. Designers had to imagine not only a Temporal uncertainty, but the contexts in which their chosen person might have experienced it. The lived context of Temporal Uncertainty is perhaps a key difference between this study and study 3. Nevertheless, the Temporal Uncertainty cards attempted to support the formation of these speculations to emerge. Interestingly in the instance of the reflective workshop, participants used the cards to delve deeper when reconstructing their Temporal Uncertainty,

whereas the designers used the cards and workshop to construct a speculative Temporal Uncertainty that was not as vivid as seen with participants' re-accounts during the reflective version. It meant that the stories for designers were a more fictitious level of detail yet, still complex and could appear as somewhat real situations that could happen, yet not as detailed as if actually living them. Furthermore, they tend to be more grounded around the notion of uncertainty, as opposed to Temporal Uncertainty, suggesting Temporal Uncertainty and the discussion of it, is perhaps better explored from a reflective perspective than speculative.

Within the creation of these speculative scenario problems, theories, and implications surrounding different concepts such as community, technology, and infrastructure became imbued. The card language supported designers to speak in depth about each of these issues and add speculative concerns for their demographic. The workshop and toolkit created speculative worlds that could be explored linguistically and thematically by designers.

Shifted Uncertainty Perspectives

A core understanding drawn from these findings was that designers' perspective of uncertainty had shifted, often from uncertainty being seen as "*Negative*" (**D2**) or needing to "*Reduce it*" (**D3**), to looking at uncertainty to be considered under the contexts of the user and instead asking "*How do I normalise it?*".

Noting this insight leads to considering how uncertainty is thought of within design thinking and practice. If the designer's previous relationship to uncertainty was to reduce it, though not the intention, the toolkit helped support the designers to hone in on a broader comprehension of the life events people encounter that create uncertainty. To reduce uncertainty in this sense could be considered as trying to reduce or eradicate a person's experience. Therefore, designers approaching uncertain thinking from a diverse perspective can "*add value*" (**D3**) and positive developments to the inclusion of people's uncertain events. These can generally identify more socially complex problems, such as with (**D2**) sourcing systemic issues around the uncertainty of their user.

In much of the HCI literature, the removal of uncertainty is seen as the only desired option. Our findings changed how this should be considered. Designers using the toolkit directly challenged the common notions of uncertainty by demonstrating that uncertainty is not something that can always be removed, as with (**D7**). Not treating uncertainty as an abstract concept that can or cannot be removed led designers to understand the complexity and changing nature of uncertainty. Beyond the notion of not being able to reduce uncertainty,

designers changed their understanding to one that is a source of inspiration that sparks creativity (**D6**). Meaning not only do designers gain novel perspectives of uncertainty but when considered through the lens of their user, it becomes a tool for creative thinking or a reason to change perspective and "*Lean into the uncertainty*"(**D7**).

6.7.1 Speculative Interventions

Designers produced interventions that they considered appropriate for the speculative situation in which their target user experienced uncertainty. This toolkit demonstrated how designers can create speculative stories with various dimensions that lead to the implications considered. These implications were what prompted the interventions that the designers considered. There were unexpected interventions in which tools or technology were not considered a factor in supporting uncertainty. For example, technology was defined by (**D3**) as the potential cause of uncertainty that instead required communal solutions to support the uncertainty the technology had produced.

Human intervention was a topic shared by (**D2**), who similarly believed that community and shared knowledge were the intervention needs in times of uncertainty. With suggestions that service design is the desired methodological approach. In this regard, the toolkit allowed the designer to take into account the user dimensions surrounding uncertainty, allowing a conscious choice of which intervention fits the needs and requirements of users. In addition, the toolkit allows suggestions on the type of design discipline required.

An interesting consideration in this research that had not been considered until now was the type of design approach needed along with the suggested intervention. Demonstrated in this study is the consideration that HCI approaching temporal uncertainty tools might be required to take an interdisciplinary approach to best serve the needs of the end users. A defining insight like this shows the toolkit's uniqueness in determining user needs and broadening the in-depth consideration of people's needs in their time of uncertainty.

The toolkit in this version is used as a speculative tool. However, the stages involved, the cards used, and the dimensions considered meant that the Temporal Uncertainty could be someone's reality. Although the interventions are produced from these speculative approaches, they changed the way designers considered uncertainty. Furthermore, they critiqued the place of tools in a time of uncertainty and generated ideas of the correct types of design fields that are best suited for the dimensions considered in the scenario. Situating these insights to a combined understanding, it should be noted that the toolkit gives designers a

novel starting point in thinking, approaching, and designing for uncertainty that could be taken and used with real participants to invoke uncertainty discussion and co-design interventions. Not the intended use case, as the aim was to achieve exploration of Temporal Uncertainty - nonetheless an important insight.

6.7.2 Key Takeaways for Speculating about Temporal Uncertainty.

Designers, though speculating, should still consider the guidelines in (Section 5.9.1). However, additional guidelines are added to this section that are specific to speculation.

Assemble instead of recreate.

- Define the user. This can be a current user of a project the designer is involved with or makes up.
- Ask why is the user in this time of uncertainty?
- Assemble the experience by first identifying the dimensions of this time, what people are involved? Are there any objects, technology, tools? Is there an infrastructure involved? As this is speculative, the more dimensions that can be considered is better.
- Discuss these dimensions, how is each one involved in this time of uncertainty? Use the cards to support discussion or alternative methods. Note that understanding any conflicts, frictions, problems, and strategies between these dimensions within this time can support a stronger assemblage of what this time of uncertainty might be.
- Understand at all stages that this is speculative and designer-centric. That the problems or strategies manifested are the creation of the designer and at this stage not factual.
- However, the ability to speculate offers creative story freedom that can insight new designer perspective either about uncertainty, their user or this potential temporal scenario the user could be in.

Personally reflect on uncertainty.

- When assembling a Temporal Uncertainty, a designer should consider what their views are on uncertainty and have these changed, either during or after the process?

- Note any biases or judgments about uncertainty that are still remaining or have changed.
- Consider how uncertainty might play a role in current or future projects?
- Understand Temporal Uncertainty to be subjective, contextual, and circumstantial if feelings of uncertainty have changed, say from negative to being positive that shift is due to this assembled Temporal Uncertainty and is contextual to this scenario. (See, 5.9.1).
- A multiple understanding of uncertainty is important, and when designing for Temporal Uncertainty, a diverse approach and output are required.
- Treat Temporal Uncertainty in a modular fashion, and the design approach for each uncertainty should be modular.

Speculate the intervention

- Note that interventions are speculative and must be treated in this way.
- However, it should be noted that aspects of these interventions could be relatable by many people. (See Section 6.8 for future work on this point)
- The interventions should be considered as the starting point for designers to explore people's times of uncertainty.
- Use the interventions as prompts to further discussion on Temporal Uncertainty and Temporal Uncertainty tools. This can be done within the designer's own work, in the current research project, or to begin a new Temporal Uncertainty design intervention - after speaking with potential end users.
- What design approach or method should be considered best to approach this Temporal Uncertainty.
- Understand that interventions may not come from tools but rather from service design, infrastructure design, or community participation, to name a few considerations.

6.8 Future work

- Designers may want to consider how accurate their speculative interventions are. Testing the end products with users or using the interventions as

prompts for further discussion could reveal novel insights about users and their times of uncertainty.

- Teaching scenarios that use design thinking might benefit from the toolkit to help designers learn multiple understandings of user uncertainty and awareness for different uncertainty perspectives.
- How more accessible does exploring users times of uncertainty become once the toolkit steps are pre-done by designers?
- How does designing for times of uncertainty from an interdisciplinary perspective better inform inclusive narratives?

6.9 Conclusion

In this work, a speculative version of the toolkit discussed in Chapter 5, study 4 was created. This version had multiple reasons for creation, such as when designers might not be able to access specific demographics, but have a need to explore Temporal Uncertainty or to build up an understanding of uncertainty from a diverse perspective to then work with participants who otherwise might not be able to engage with a one-to-one workshop for multiple reasons.

The findings demonstrated that speculating Temporal Uncertainty might be more challenging than reflecting on Temporal Uncertainty as seen in Chapter 5. It resulted in this toolkit working best at changing the perspective of designers towards uncertainty, yet did not achieve it's goal of exploring Temporal Uncertainty Tools. Instead, the unintended outcome of this study gathered insights into how to consider and think about uncertainty as a designer.

It is therefore the final contribution of this Ph.D., to instate that the reflective version of this toolkit worked as intended. Yet, the speculative version required the methodology and re-testing. Future work suggestions give a position for designers to alter this toolkit to better explore Temporal Uncertainty to better inform how designers in the HCI community can produce Temporal Uncertainty Tools to match the subjective and diverse experiences of end users.

Chapter 7

Discussion

7.0.1 Recap of Findings and Discussion

In the following section, I outline each chapter's contribution. This chapter will achieve this by revisiting the research questions in Chapter 1 and defining how the thesis contribution answers each of these questions. From here, future work and limitations will be discussed offering designers and researchers in HCI potential starting points for future work.

Chapter 3: Exploring the temporality of Chronic Fatigue Syndrome. An insight into living with uncertainty.

Shedding Light on the Lived Experience of Chronic Fatigue Syndrome: This research sheds light on the lived experience of chronic fatigue syndrome, revealing how uncertainty can be a pervasive aspect of daily life that challenges rigid notions of time. This research makes a significant contribution to the HCI community, highlighting how exclusion can arise from the tension between lived experience and inflexible systems. It identifies issues related to expectations of certainty in rigid social encounters and the need for agency in when and how certain activities occur that sync more closely to the temporality of health regulated by symptoms.

Enhancing the Field of Temporal Design: This research enhances the field of temporal design by utilising an interdisciplinary theoretical approach that merges Crip time theory with Temporal design. Through this approach, the thesis emphasises the significance of design intervention in shaping the temporal experiences of health. By examining and critiquing dominant concepts of time, it broadens our understanding of how time can be a factor of exclusion.

Generalised Uncertainty Guidelines for Designers: A set of generalised uncertainty guidelines has been created to assist designers in understanding the diverse temporal perspectives of individuals experiencing uncertainty, particularly those with health conditions. This list provides designers with a means of comprehending various aspects of someone's uncertainty, including the subject, cause, and social and communicative elements. Designers can use this list to extrapolate concepts of uncertainty to other social groups.

Subject of uncertainty

U1—ATTENDANCE: *How likely is it that I can attend this event, at all?*

U2—Need for DELAY: *In the case I can attend, will I be late? How much will I be late? When do I know that I will be late?*

Reasons for uncertainty

U3–LOCATION: *Do I have the energy to reach that location? Am I able to reach it in time?*

U4—PRIORITIES: *Given my current condition, is this event part of my priorities? Is it better to rest and recharge my energy?*

Social aspects

U5—ALTERNATIVES: *If I cannot attend, when would be an alternative time to repeat the event? Are there alternatives for me not attending?*

U6—COMMITMENT: *I am fine now, but how will my situation be when the event approaches? When will I know? When do I have to decide? When can I commit to something? How long should I commit? Can I even commit?*

General HCI Considerations for Designing Around Aspects of Uncertainty: Through a bottom-up approach involving people with CFS, the study resulted in a set of general HCI considerations for designing around aspects of uncertainty. These considerations are particularly relevant to critiquing tools that rely on rigid notions of time to promote social certainty. The considerations include understanding that there is a social expectation of being certain, recognising that this expectation can lead to exclusionary experiences, acknowledging that bodies and minds have their own health temporal experiences, recognising that this creates fluctuating uncertainty in personal and social encounters, encouraging HCI designers to develop tools and interventions that support communication around times of uncertainty and uncertainty about time, and aiming to expand inclusion by exploring and representing these Temporal Uncertainty experiences.

These considerations guided future work and prompted further research into whether this issue was isolated to people with CFS or if it was more widespread.

Chapter 4: Exploring Uncertainty in Digital Scheduling, and The Wider Implications of Unrepresented Temporalities in HCI

What insights are produced from a broader audience when given the ability to communicate Temporal Uncertainty? This work explores Temporal Uncertainty in HCI through the design and evaluation of Haze, a set of speculative prototypes that enable more nuanced communication of uncertainty around events and personal conditions. The study revealed several key insights from participants who used Haze. Participants felt that they could not openly express their Temporal Uncertainty, but they believed that Haze helped engender a form of temporal empathy, liberating them from the moral judgments associated with being uncertain in social planning. Those using Haze revealed personal physical and mental health issues, yet they felt that with Haze, they could potentially have more control over their health. Additionally, Haze highlighted problems around technologies formulating normative temporal discourses and the implications of supporting their maintenance.

Based on the insights from the study, the authors provide several clear recommendations for HCI designers to consider when designing for Temporal Uncertainty. These include recognising technology's responsibility in creating temporal norms, realising personal biases, designing novel yet simple Temporal Uncertainty features for scheduling, ensuring that Temporal Uncertainty communication needs group collaboration, and mitigating any negative consequences of Temporal Uncertainty in social scheduling.

This work critiques existing digital calendars and social event planning technologies that assume people are certain about event details. It highlights the importance of considering time as a factor of exclusion in HCI research and draws attention to the fact that exclusionary times of uncertainty affect not only people with permanent health conditions but also those with temporary conditions and even those without conditions.

The study also revealed a gap in its knowledge around the ability of others to contribute to the discourse on Temporal Uncertainty. This gap concerns how designers can broaden their scope around Temporal Uncertainty, the social challenges of living with Temporal Uncertainty, and the ability of tools to support Temporal Uncertainty when no current methods or tools exist to guide designers and researchers in fulfilling the call to action made within the findings of this study—leading as a key motivator for the following research studies.

7.0.2 Chapter 5: Temporal Uncertainty Toolkit a method for generating Temporal Uncertainty Tools

This work formulates a methodology and a toolkit for exploring Temporal Uncertainty in HCI. It builds on previous studies and provides a practical and reflective way for designers and participants to co-design Temporal Uncertainty tools. The study addresses several key questions: What is needed within a toolkit to support people and designers in exploring Temporal Uncertainty? What notions and scenarios of Temporal Uncertainty do people and designers want to design for? And what tools and solutions do people and designers develop when using the toolkit to address Temporal Uncertainty?

A method was developed to engage potential participants in reflecting on the times when they experienced uncertainty. This method serves as a reflective and generative tool that allows participants to re-engage with their times of uncertainty and reveal the individual, ontological, and subjective aspects of their experiences, as well as the problems, solutions, or strategies associated with them. Additionally, a slightly adapted version of the method enables designers to speculate on a user's potential Temporal Uncertainty. These two versions were designed to offer flexibility in how Temporal Uncertainty and its design outputs could be approached. Moreover, the method allows for identifying solution commonalities, which enables designers to group interventions by their common features and requirements without compromising the uniqueness and diversity of people's experiences of uncertainty.

The toolkit incorporates 117 expressions of Temporal Uncertainty, available on physical or digital cards. These cards represent different types of uncertainty, such as biological uncertainty, which participants and designers can use to communicate and reflect on their experiences of uncertainty. It was shown to reveal the conscious and subconscious aspects of uncertainty, supporting participants in reconstructing and dimensionalising their uncertainty, and unveiling details, subjectivity, context, and the evolution of their uncertainty experiences.

The toolkit emphasises a co-design process, which is integrated into the method, and enables the creation of tools and features that directly or indirectly reflect a participant's specific time of uncertainty. This approach provides designers with inspiration and practical design trajectories for developing Temporal Uncertainty tools.

A set of guidelines was developed for exploring Temporal Uncertainty and generating tools to support it. These guidelines include steps for identifying the source of uncertainty, reconstructing and dimensionalising the Temporal Uncertainty, understanding how the uncertainty branches into other uncertainties, and

considering thematically similar interventions to expand inclusion without compromising the subjectiveness of uncertainty. The guidelines also recognise the multidimensional and contextual nature of Temporal Uncertainty, advising designers to avoid generalising or assigning fixed concepts to uncertainty and instead consider how different dimensions and branches of uncertainty create varying frames and implications for design.

Finally, a set of guidelines was produced to support designers in speculating on Temporal Uncertainty. These guidelines aimed to offer strategies for adjusting their perception of uncertainty to reduce potential bias and encourage different design specialities to explore Temporal Uncertainty.

Overall, this research demonstrates the value of a reflective and the challenges of a speculative approach to designing for Temporal Uncertainty and provides practical tools and methods for achieving this in HCI design practice.

7.0.3 Defining Temporal Uncertainty

> The following definition of Temporal Uncertainty has been shaped in the context of this thesis. Temporal Uncertainty is the subjective experience of uncertainty in relation to diverse notions of time. It can affect people with and without health conditions who may not conform to social normative experiences. This phenomenon is complex and context-dependent, so it cannot be generalised or reduced to a single perspective. It requires a modular approach, considering the specific context and individual dimensions of a person's life. Tools, technology, and design approaches can support Temporal Uncertainty when designed with an approach that considers people's contextually subjective experiences.

7.0.4 Discussion

In this thesis, each research study influenced the next. It began as an investigation into time and people with CFS. Quickly, it expanded to an exploration into Temporal Uncertainty in regard to the living experiences of people with and without health conditions. Each finding contributed to the meaning of this thesis's definition of Temporal Uncertainty, (See subsection: Defining Temporal Uncertainty). Moreover, each research step produced definitive evidence of the importance of having tools in HCI that support people's temporal and subjective experiences of uncertainty. Therefore, while each research step has been detailed and discussed at length in previous chapters, this chapter combines each of these studies into a high-level discussion.

This thesis was motivated by an exploratory question: *How do people with*

Chronic Fatigue Syndrome experience time with regard to health and social interaction? The aim was to determine whether social usages or ideas of time resulted in any exclusion for individuals with CFS. Health conditions such as CFS impact many people worldwide, with CFS affecting 17 million people. As demonstrated by Vercoulen et al. (1994), there are dimensions to CFS that can support diagnosis and uncover disabling narratives. *Chapter 3: Exploring the temporality of Chronic Fatigue Syndrome. An insight into living with uncertainty*, does not consider social uses of time as a dimension of CFS diagnosis. Instead, it adds the dimension that social uses of time are an important factor in understanding the exacerbation of symptoms, such as the conflict between rigid times and health. Furthermore, it highlights the social inequalities faced by people with CFS from a social-temporal perspective. Research shows that bodies and minds cannot be standardised or quantified (Katzman et al. 2020). Chapter 3 expanded such insights by reporting on the findings that rigid social expectations around certainty can exacerbate the health of people with CFS. Moreover, it found that there was a need for agency in the timing of activities to align with health symptoms for people with CFS. The findings suggest that health uncertainty can lead to exclusion in social events and highlight the importance of considering diverse temporal needs in design thinking and HCI practice as a starting point for design intervention

Standard ways of thinking about time left participants with CFS in social frictions. The expectation to be certain and committed to rigid time structures created friction with the uncertainty of knowing how health would be at a given time. This was not isolated to people with CFS. Beyond CFS, *Chapter 4: Exploring Uncertainty in Digital Scheduling, and The Wider Implications of Unrepresented Temporalities in HCI*, demonstrated deeper social implications around being uncertain. Being uncertain was deemed a question of a person's morality that spurred social judgment if a person could not regulate to certainty. In other words, people encountered moral judgments. Which compiled a compelling case that people hide their uncertainty, and it is not a normalised time for people to be in.

Making uncertainty visible, through Haze, demonstrated key benefits to a wide range of people, including those with diverse or temporary health conditions, those without health conditions, employed individuals, and families. It provides support during times of uncertainty and allows for the communication and normalisation of complex notions of uncertainty around time, whether it's due to physical or mental health symptoms or other factors. (See Chapter 4: Findings). The speculation participants placed upon Haze stated people's times of uncertainty could become normalised. Moreover, they eluded that Haze allowed opportunities to foster

empathy if tools like Haze normalised uncertainty. Furthering the implication that currently, people's temporal experiences are hidden. Study 1 and Study 2 demonstrated that people are impacted socially and personally without tools, like HAZE, that support their temporal notions of uncertainty.

These studies presented in Chapter 3 and Chapter 4 are important for HCI, as they show how people experience uncertainty in relation to health or personal needs that are met with social exclusionary challenges. These findings expand upon existing work in the HCI community on inclusive design (Abascal & Nicolle 2005), (Dong et al. 2005), (Strohmayer et al. 2019), (Metaxa-Kakavouli et al. 2018), (McHugh et al. 2021). By exploring the temporal experience of uncertainty, our research reveals new opportunities to design tools that promote inclusion and challenge dominant expectations of certainty. While some HCI researchers have theoretically linked time as a potential factor of marginalisation, (Rapp et al. 2021), (Pschetz & Bastian 2018) this work demonstrated a practical approach, inspired by Crip time, to examine how social uses of time form exclusions for diverse people with and without health conditions. Highlighting how tools can be used to improve HCI inclusivity, both internally as designers and externally in the design outputs.

The research, presented in Chapter 3 and Chapter 4, wraps up two notable takeaways for HCI. The first is, expectations of certainty are an exclusionary notion of time for some people. The second is Tools that support notions of Temporal Uncertainty can not only perpetuate ideas of normality but enhance what might be deemed normative temporal discourses. In which the thesis places the following advisory, for the HCI community to recognise technology's responsibility in creating temporal norms. This revealing of dominant concepts of time aligns with (Pschetz et al. 2016) and expands design and HCI understanding of exclusionary time, namely around uncertainty. Time interlinked with health as exclusionary is not novel in the consideration of social science research that has considered social uses of time as a factor of ableist marginalisation for some time. (Kafer 2013*b*), (Kafer 2013*a*), (Sheppard 2020), (McRuer 2006), (Compton-Lilly 2016), (Freeman 2010*a*), (Nespor et al. 2009). These insights show the importance of revealing dominant notions of time to HCI designers. Revealing these notions can draw attention to potential exclusion through temporal discourse. Chapter 4, concludes that HCI has the potential to expand inclusion by establishing new norms through tools and technology.

In the broader context of uncertainty, HCI designers lack the tools or methods to explore people's experiences, particularly their temporal experiences associated with uncertainty. Chapter 4 found that people need tools to support them in times of uncertainty. Therefore, Chapter 5 and subsequent studies, aimed to create

tools and methods, as these are important in filling the research gaps. However, there are problems in the disparate understanding of uncertainty across HCI and design disciplines. (Dyer et al. 2021). These “attitudes” towards uncertainty in design fields are enclosed and require transdisciplinary intervention. ((Dyer et al. 2021, PP 3). This thesis demonstrates that interdisciplinary research between fields can yield new insights and inform the development of HCI guidelines for exploring people’s Temporal Uncertainty. It also shows that uncertainty should be treated as a multidimensional experience, rather than an either-or scenario.

In Chapter 5 it is demonstrated that this toolkit supported participants to identify the source of uncertainty. Namely, this signifies a conscious awareness of a time in which uncertainty was experienced. At this point, it is a generalisation of uncertainty, which the design of the toolkit allowed participants to go beyond generalising and draw out the specifics and implications of their time of uncertainty. This is an important part of the toolkit, as, generalising as per Chapter 5 (See: Discussion Section) could instead promote exclusion. This is because, as per our findings, people’s uncertainty is better understood as a contextually subjective uncertainty. These insights transform the argument that tends to dichotomise uncertainty as something to embrace (Soden et al. 2020),(Soden et al. 2022*a*), or reduce Hogg (2000*b*), (Christensen & Ball 2017), (Paletz et al. 2017). Instead, our research argues that uncertainty cannot be generalised in these terms. Branching uncertainty makes this evident. While people thematically can experience similar examples (Sources) of uncertainty, the individual dimensions that formulate their life change the context of the uncertainty, meaning it changes the required solution, as evidently demonstrated in (section 5.7). This defines the notion that uncertainty branches. Each dimension, context and so on, can create varying different types and experiences or “attitudes” of uncertainty, therefore a person’s uncertainty changes and adapts and creates new uncertainties based on their subjectivity. Overall, this means that, by generalising uncertainty or making it a dichotomy, leaves HCI researchers reduced to limited uncertainty approaches. contextually, subjective uncertainty changes this. It helps to position the designer without pre-defined notions of uncertainty and instead unpack the uncertainty meaning from the participant’s contexts. The Temporal Uncertainty toolkit allowed participants to create tools that supported their experiences of uncertainty.

For example, some participants created tools that used music to “time travel” and be present in spaces when physical presence was not possible. Another tool helped the partners of cancer patients gain knowledge about each moment and change in the cancer trajectory, such as getting chemotherapy and its after-effects. Another tool interconnected medical professionals with educational professionals to support students who felt uncertain about their health and its impact on their

future education. These tools were based on participants' reflections on their real-life experiences of Temporal Uncertainty. The toolkit's design promoted this reflective quality.

In Chapter 6, a second version of the Temporal Uncertainty toolkit is presented. This version is speculative, allowing designers to imagine and explore potential users' experiences of Temporal Uncertainty. The findings in Chapter 6 show that this approach helped designers shift their perspective on uncertainty. Instead of viewing it as something to be reduced, they began to see it in the context of the user's experience. This led to approaching the uncertainty in a context-by-context situation, leading to specific interventions from a designers' perspective. Sometimes these were not tools or designs but rather infrastructural suggestions, such as community building.

It moved the notion that uncertainty is something to be fixed or solved and instead a material in which to implement user needs or critique systemic issues that cause the temporal experience of uncertainty. To link back to Dyer et al. (2021) Chapter 5 and Chapter 6 finds that designers need an interdisciplinary approach when producing tools to support Temporal Uncertainty. This is because as designers demonstrated, specific design approaches or fields might be best suited for the context in which the uncertainty is being experienced.

The following recommendations drawn from Chapter 5 and Chapter 6 findings were as follows and aimed at HCI designers. It's important to understand people's individual experiences of uncertainty. Generalising uncertainty can lead to exclusion. Temporal Uncertainty in one area of life can branch out, leading to the emergence of new uncertainties in other areas. These new uncertainties can exist as their own pockets of Temporal Uncertainty, adding complexity to the overall situation. Designers, might need to think about how to design for flexibility and adaptability, so that the design can accommodate the emergence of new temporal uncertainties.

As HCI designers, it is our responsibility to promote inclusivity. While inclusive narratives have been present in HCI and Design for some time, this work introduces a new perspective in the form of Crip time and Temporal Uncertainty. Balancing inclusivity in narratives of Temporal Uncertainty can be challenging. For example, Chapter 3 found that expectations to orient bodies and minds towards certainty can be exclusionary. This was further expanded upon in Chapter 4.

However, when dichotomising uncertainty at such high levels, we risk losing contextually subjective uncertainty narratives, as shown in Chapter 5. This means that while we should advocate for designs that support times of uncertainty, we must do so with caution. Uncertainty tools require diversity and clear understanding. We must consider whether one uncertainty tool negates or

misrepresents someone else's preferred experience of uncertainty. When we create tools oriented towards uncertainty, do we support some while excluding others? These questions require further exploration, but highlight the challenges of dealing with people's broad experiences of time, particularly their encounters with times of uncertainty.

The Temporal Uncertainty toolkit addresses this issue by considering subjective and non-generalising uncertainty perspectives. It leads to commonalities between participant design outputs, providing manageable approaches for HCI designers to expand inclusion.

In summary, this thesis explores Temporal Uncertainty in relation to the experiences of people with and without health conditions. It reveals the importance of having tools in HCI that support people's temporal and subjective experiences of uncertainty. The research shows that dominant notions of time can be exclusionary, particularly for health conditions such as CFS. By revealing these dominant concepts, HCI designers can work towards expanding inclusion through the creation of new normatives. However, it is important to approach uncertainty as a branching concept and as contextually subjective. What may be uncertain for one person in a particular situation may not be uncertain for another person in the same situation due to their unique experiences and perspectives. This requires specific features and tools. However, as demonstrated by the findings in Chapter 5, the tools co-designed by participants do have commonalities that would aid others on a more general level.

This thesis demonstrates that an interdisciplinary approach is necessary when producing tools to support Temporal Uncertainty. By considering subjective and non-generalising uncertainty perspectives, designers can create manageable approaches for supporting people's temporal and branching experiences of uncertainty.

7.0.5 Reflecting on the potential implications of Temporal Uncertainty

A key focus of this research is to establish the normalisation of Temporal Uncertainty to support individuals. Although the studies within this thesis have demonstrated the importance of this argument, it is worth reflecting on the implications if Temporal Uncertainty were fully normalised. Temporal tools, such as clocks, synchronise people to perform tasks at set times. The challenge of these rigid forms of time is their impact on the orchestration of bodies and minds. Temporal Uncertainty challenges these established norms and creates a new standard that better served the needs of the participants in this thesis.

However, balancing between too much Temporal Uncertainty and too much Temporal Certainty may be a fine line to design with.

If we completely normalise Temporal Uncertainty, it could potentially harm functions of society that rely on notions of Temporal Certainty. Consider the Haze prototype once more. Haze worked well due to its finite scenario of a group of people making a social plan. What happens if we scale up Haze to include thousands of people? For instance, would a concert be delayed because of one person's Temporal Uncertainty? While it is an interesting prospect to consider a concert starting only when everyone is certain about the time, date, and place, it may not be realistic. If the band were in Temporal Uncertainty, the concert might be postponed. This raises an off-topic, but intriguing reflection on the hierarchical power positions potentially found within Temporal Uncertainty. Until future work is conducted, it seems that Temporal Uncertainty tools might be effective only on a small scale or in social dynamics where participants are equal.

Let us consider Temporal Uncertainty in a more critically time-driven context, such as hospitals. Hospitals rely heavily on time, with scheduled appointments, rapid response to emergencies, ambulances needing to arrive at specific times, staff rotas, cleaning schedules, patient monitoring, and more. While hospitals are certainly places where Temporal Uncertainty exists, the reliance on Temporal Certainty is crucial. For example, in the UK, news has highlighted instances where people experienced uncertainty about the time an ambulance would arrive, leading to severe consequences, including some fatalities. Although this Temporal Uncertainty is a result of an overstretched health service and not a design with intention, it nonetheless exists and has devastating consequences. Future research on Temporal Uncertainty in hospital settings could be an area of significant interest and exploration.

These reflections demonstrate that while Temporal Uncertainty can drive positive change, excessive Temporal Uncertainty in the wrong contexts or for certain people might have critically negative impacts. A balance between Temporal Uncertainty and certainty is required. Therefore, designing for Temporal Uncertainty necessitates careful consideration of who is affected and how. It is essential to reflect on the consequences of existing products, tools, designs, or theories, and similarly consider the implications of designing for Temporal Certainty.

This raises the question: What are the consequences, if any, of normalising Temporal Uncertainty? Who benefits, and who does not? The benefits may not be clear-cut; some may benefit at specific times, while others may be adversely impacted. While this thesis makes a strong case for normalising Temporal Uncertainty, it also acknowledges that some individuals, institutions, and areas of

society may be affected by it. This does not suggest eliminating the concept but rather understanding its place and determining when or if it should be designed for.

7.0.6 Guidelines for Expanding Inclusion in HCI through Temporal Uncertainty Tools

These guidelines are based on high-level insights produced within this thesis, considering Chapters 3, 4, 5, and 6. Encounters with Temporal Uncertainty are experienced by many diverse people, making living with uncertainty challenging but normative. Socially, certainty and the orientation of bodies and minds towards it are often more desired, yet this desire can cause exclusion. This rigidity can have social and health impacts, leading individuals to encounter moral judgments that reduce their ability to communicate their times of uncertainty. Tools in HCI and prevailing HCI mindsets tend to favour certainty. Critiquing these dominant notions of certainty and uncertainty can lead to positive interventions. Nurturing people's engagement with times of uncertainty produces actionable recommendations for HCI to expand inclusion, resulting in interventions, tools, and designs that address both individual and collective needs.

The framework is based on the three studies presented in this thesis and repurposes the knowledge gained from these studies into the following actionable guidelines for HCI researchers to explore Temporal Uncertainty.

To explore and address Temporal Uncertainty effectively, start by identifying notions of time that produce or create a conscious sense of uncertainty and investigate whether these narratives contribute to exclusion. Examine whether design or HCI practices exacerbate this exclusion due to pre-defined ideas of time and uncertainty, and critique how these practices may worsen the issues. Highlight how HCI can be adjusted to foster inclusion. Reflect on pre-defined personal or discipline-oriented attitudes towards uncertainty, and formulate attitudes based on the user's subjective and contextual experiences. Avoid generalising or reducing people's experiences of uncertainty to a simple dichotomy, and consider that thematically similar uncertainties may require different tools, interventions, or output requirements. Finally, create diverse tools, procedures, or outputs that normalise and represent the variety of times when uncertainty is present. Developing diverse tools with varied features will support users in the specific ways and times they require.

Overall, more diverse tools, with diverse features and addressing diverse problems means expanding to tools that support when and in ways they are required.

7.0.7 Future work

This thesis has established that uncertainty as a temporal experience can be linked with notions of social exclusion and has developed a set of guidelines for expanding inclusion through Temporal Uncertainty. However, several avenues for future work can build on these contributions. Firstly, evaluating the Temporal Uncertainty guidelines is essential. While these guidelines have been created, they have not yet been applied in real-world practice. Future research should use these guidelines to shape research questions that investigate people's needs during times of uncertainty and assess their effectiveness and applicability in various contexts and domains. For instance, what new research on uncertainty emerges from using these guidelines, and how does this research expand our understanding of uncertainty in HCI?

Secondly, conducting more uncertainty-focused design work in health-oriented settings is crucial. This thesis initially focused on individuals with Chronic Fatigue Syndrome and then expanded to understand other experiences of uncertainty. This trajectory aimed to include diverse perspectives and address challenges faced by individuals with health conditions, particularly in participatory design methods, which may be impractical for some. Additionally, the majority of this research was conducted during Covid-19, limiting in-person interactions. Future research could concentrate on specific orientations, such as health, to explore how various health conditions impact experiences of uncertainty, time, and society. The developed toolkit, which facilitates exploration and co-design of interventions in a single session, can significantly reduce the time and effort required. Researchers could use this toolkit to explore different aspects of temporal health uncertainty by adjusting the prompt cards and enhancing the support for health-related uncertainty, thereby expanding inclusion.

Moreover, there is a need to focus more on Crip time in HCI. Researchers should draw on Crip time theory to influence new notions of inclusion. The current lack of interdisciplinary crossover in this area presents an opportunity for HCI to benefit from pursuing such research. Investigating Crip time in relation to established Crip HCI could lead to technological and design innovations that support both individuals with health conditions and those without.

Lastly, testing the co-designed interventions is another important area for future work. While this thesis demonstrated that participants could create interventions to support their experiences of uncertainty, it would be valuable to understand how these interventions are perceived by others. Future research should investigate how interventions designed by participants are received and used by individuals with similar or different uncertainty experiences. Evaluating the impact and

effectiveness of these interventions in real-world settings could provide insights into their influence on inclusion and exclusion.

These directions offer potential for extending the contributions of this thesis and advancing the field of temporal design and HCI for uncertainty.

Chapter 8

Conclusion and Future Work

8.0.1 Conclusion

This thesis was motivated by an exploratory question: *How do people with Chronic Fatigue Syndrome experience time in relation to health and social interaction?* The aim was to uncover whether people with CFS experienced any forms of exclusion due to dominant concepts of time, inspired by Crip Time Theory and the work in Temporal Design. The research uncovered that expectations of certainty and rigidity resulted in exclusion for individuals with CFS, who have to cope with unpredictable and fluctuating health uncertainty. Furthering the research uncovered that this was not an isolated issue, but a common and diverse phenomenon that affected people both with and without health conditions. The research also demonstrated that communicating and supporting temporal uncertainty could increase empathy, inclusion, and control over one's health. However, there were no existing methods or tools in HCI that could help designers and participants explore and design for temporal uncertainty. Therefore, the research developed a toolkit and a workshop that could support designers and participants in uncovering, discussing, and intervening in their times of uncertainty. Our main contributions include:

- A novel conceptualisation of temporal uncertainty as a diverse and subjective experience that can create exclusion or inclusion depending on how it is represented and supported by technology.
- A prototype of a digital tool that supports the expression and sharing of uncertainty in social event scheduling in a more nuanced and flexible way, enhancing temporal empathy, inclusion, and collaboration.
- A toolkit and workshop that supports designers and participants in exploring and designing for temporal uncertainty in different contexts and domains,

uncovering the sources, dimensions, implications, and interventions of uncertainty, and producing diverse and subjective solutions that could expand inclusion.

We encourage designers in HCI to expand on temporal uncertainty and explore other alternative notions of time that may be marginalising. By doing so, we aim to expand inclusion, reduce exclusion, and enhance equality in society. We hope that this thesis will inspire additional exploration into the connection between temporal uncertainty and inclusion, particularly in relation to HCI tools and technologies. This research began with an endeavor to uncover diverse experiences of time. It demonstrates that by challenging the dominant narratives of time, such as certainty, HCI designers can enhance inclusivity for individuals with a variety of temporal experiences. This inclusivity is further fostered by the development of tools and technologies that are contextually relevant to these diverse experiences, as exemplified by the Temporal Uncertainty Tools that this thesis concludes its exploration with. This approach thereby fosters a heightened level of empathy and understanding for the diversity of people's temporal and subjective experiences.

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