Mindful Hybrid Presence: Explorations, Trade-Offs and Enabling Technology Designs

Dissertation

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Abstract

This PhD thesis introduces and discusses the concept of *mindful hybrid presence* – an intentional and balanced way of maintaining presence across the physical and digital realms in today's Western society. Whereas the term presence in Human-Computer-Interaction is rather bound to Virtual Reality research, this thesis focuses on the ways current digital mobile technology devices, such as notebooks, smartwatches and most prominently, smartphones, affect our experience of presence and engagement with our inner and outer world(s). As the listed devices, and their services, become increasingly intertwined with our everyday lives, so does the concern increasingly grow that our reliance on them can negatively impact our presence and well-being. I propose the concept of mindful hybrid presence as a potential solution to mitigate the negative effects, while harvesting the benefits, of the addition of digital presence.

As the title suggests, the thesis comprises three parts: explorations, trade-offs and enabling technology designs. These three parts are investigated through four research questions, with the first question grounding work for the remaining three.

The grounding research question, RQ0, guides the explorations of the continuum of hybrid presence. I consider hybrid presence to encompass a feeling and experience of stretched consciousness along the being-here in the physical environment and the being-there in the digital environment. In hybrid presence, these environments are to blend so as to ultimately diminish the border between them to offer new ways of connecting, learning and experiencing our environment and ourselves. However, many people report having problems with such blended environments, in particular being dissatisfied by the amount of time and the quality of the digital interaction. To address these problems, this thesis proposes the concept of consciously instrumentalizing mindfulness cues into technology to encourage a mindful hybrid presence – a state of heightened intention and awareness to manage and navigate presence between the realms in the hybrid presence continuum.

Following, RQ1 investigates users' perception and experience of presence to examine the trade-offs of hybrid presence. By following a user-centred approach, we employ qualitative and quantitative data collection methods such as user surveys and interviews, love/breakup letters, experience sampling, as well as automated data tracking with corresponding machine learning analysis. The results of these investigations yield several users' needs within hybrid presence, reflecting a rather complex influence of hybrid presence on people's overall feeling of well-being. The emerging users' needs call for a balanced approach to the subject of interacting with the digital environment, opposed to common restrictive approaches – at the same time highlighting a crucial need to (self-)control primarily digital presence.

RQ2 and RQ3 lead investigations into the design and evaluation of enabling technology designs for mindful hybrid presence. Within this scope, we investigate mindfulness in HCI to develop self-control strategies that are to be consciously instrumentalized within technology. This led us to set our focus on either: 1) raising awareness on intentional digital interaction or the physical environment the digital interaction is taking place in, or 2) encouraging activity

redirection to the physical environment after prolonged digital presence. These strategies oppose current works that focus on restricting the digital environment only, in that they take a holistic approach towards the whole context in which digital interaction and digital influence is taking place. We implement these strategies within a series of high-fi prototypes and evaluate the capability of the prototypes in fostering mindful hybrid presence through field and lab studies. The studies' findings suggest mindfulness-based designs to promote a more intentional and balanced interaction with the digital environment with further investigations needed on a canonized way of evaluation metrics.

The thesis discusses the complex interplay between technology, presence, and mindfulness for current and emerging ubiquitous technologies, from a user-centred point of view. It offers insights into the role of technology in our lives and suggests further topics on the design of technology to support more intentional and balanced engagement with the world accessible from our digital devices.

Zusammenfassung

In dieser Dissertation wird das Konzept der *mindful hybrid presence* vorgestellt und diskutiert. *Mindful hybrid presence* versteht sich als eine bewusste und ausgewogene Art und Weise der Aufrechterhaltung der Präsenz in den physischen und digitalen Bereichen der heutigen westlichen Gesellschaft. Während der Begriff Präsenz im Bereich der Mensch-Maschine-Interaktion eher an die Virtual Reality-Forschung gebunden ist, konzentriert sich diese Dissertation auf die Art und Weise, wie aktuelle digitale mobile Technologiegeräte wie Notebooks, Smartwatches und vor allem Smartphones unsere Erfahrung von Präsenz und die Auseinandersetzung mit unserer inneren und äußeren Welt beeinflussen. In dem Maße, in dem die genannten Geräte und ihre Dienste zunehmend mit unserem Alltag verwoben werden, wächst auch die Sorge, dass unsere Abhängigkeit von ihnen unsere Präsenz und unser Wohlbefinden negativ beeinflussen kann. Ich schlage das Konzept der *mindful hybrid presence* als potenzielle Lösung vor, um die negativen Auswirkungen der zusätzlichen digitalen Präsenz abzuschwächen und gleichzeitig die Vorteile zu nutzen.

Wie der Titel schon andeutet, besteht die Arbeit aus drei Teilen: Erkundungen, Abwägungen und Entwürfe von Technologien, die eine achtsame, hybride Präsenz unterstützen. Diese drei Teile werden anhand von vier Forschungsfragen untersucht, wobei die erste Frage die Grundlage für die Arbeit an den übrigen drei darstellt.

Die grundlegende Forschungsfrage (RQ0) leitet die Erforschung des Kontinuums der hybriden Präsenz. Unter hybrider Präsenz verstehe ich das Gefühl und die Erfahrung eines gespannten Bewusstseins entlang des Hier-Seins in der physischen Umgebung und des Dort-Seins in der digitalen Umgebung. In der hybriden Präsenz sollen diese Umgebungen miteinander verschmelzen, so dass die Grenzen zwischen ihnen letztlich verschwinden und neue Möglichkeiten der Verbindung, des Lernens und der Erfahrung unserer Umwelt und unserer selbst entstehen. Viele Menschen berichten jedoch, dass sie Probleme mit solchen gemischten Umgebungen haben, insbesondere sind sie unzufrieden mit dem Zeitaufwand und der Qualität der digitalen Interaktion. Um diese Probleme anzugehen, schlägt diese Arbeit das Konzept der bewussten Instrumentalisierung von Achtsamkeitshinweisen in der Technologie vor, um eine achtsame hybride Präsenz zu fördern - einen Zustand erhöhter Absicht und Bewusstheit, um die Präsenz zwischen den Bereichen im Kontinuum der hybriden Präsenz zu steuern und zu navigieren.

Im Folgenden untersucht RQ1 die Wahrnehmung und das Erleben von Präsenz durch die Nutzer, um die Kompromisse der hybriden Präsenz zu untersuchen. Indem wir einen nutzerzentrierten Ansatz verfolgen, verwenden wir qualitative und quantitative Datenerhebungsmethoden wie Nutzerumfragen und -interviews, Liebes- und Trennungsbriefe, Erfahrungsstichproben sowie automatisierte Datenverfolgung mit entsprechender maschineller Lernanalyse. Die Ergebnisse dieser Untersuchungen zeigen verschiedene Nutzerbedürfnisse innerhalb der hybriden Präsenz, die einen ziemlich komplexen Einfluss der hybriden Präsenz auf das allgemeine Wohlbefinden der Menschen widerspiegeln. Die sich abzeichnenden Nut-

zerbedürfnisse erfordern einen ausgewogenen Ansatz für die Interaktion mit der digitalen Umgebung, der sich von den üblichen restriktiven Ansätzen abhebt - und gleichzeitig ein entscheidendes Bedürfnis nach (Selbst-)Kontrolle der primär digitalen Präsenz hervorhebt.

RQ2 und RQ3 leiten Untersuchungen zur Gestaltung und Evaluierung von Technologie-Designs für achtsame hybride Präsenz. In diesem Rahmen untersuchen wir Achtsamkeit in HCI, um Strategien zur Selbstkontrolle zu entwickeln, die bewusst in der Technologie instrumentalisiert werden sollen. Dies hat uns dazu veranlasst, unseren Fokus auf Folgendes zu legen: 1) Bewusstmachung der absichtlichen digitalen Interaktion oder der physischen Umgebung, in der die digitale Interaktion stattfindet, oder 2) Förderung der Umlenkung von Aktivitäten in die physische Umgebung nach längerer digitaler Präsenz. Diese Strategien stehen im Gegensatz zu aktuellen Arbeiten, die sich nur auf die Einschränkung des digitalen Umfelds konzentrieren, da sie einen ganzheitlichen Ansatz für den gesamten Kontext verfolgen, in dem digitale Interaktion und digitaler Einfluss stattfinden. Wir setzen diese Strategien in einer Reihe von High-Fi-Prototypen um und bewerten die Fähigkeit der Prototypen, eine achtsame hybride Präsenz durch Feld- und Laborstudien zu fördern. Die Ergebnisse der Studien legen achtsamkeitsbasierte Designs nahe, um eine bewusstere und ausgewogenere Interaktion mit der digitalen Umgebung zu fördern, wobei weitere Untersuchungen zu einer kanonisierten Art von Bewertungsmetriken erforderlich sind.

Die Arbeit diskutiert das komplexe Zusammenspiel zwischen Technologie, Präsenz und Achtsamkeit bei aktuellen und neu entstehenden allgegenwärtigen Technologien aus einer nutzerzentrierten Sicht. Sie bietet Einblicke in die Rolle der Technologie in unserem Leben und schlägt weitere Themen für die Gestaltung von Technologie vor, um eine bewusstere und ausgewogenere Auseinandersetzung mit der Welt zu unterstützen, die über unsere digitalen Geräte zugänglich ist.

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1
INTRODUCTION

Whether we wear computers on our body, or have them embedded in our environment, the ability of computers to alter our perception of the physical world, to support constant connectivity to distant people and places, to provide information at our fingertips, and to continuously partner with us in our thoughts and actions offers much more than a new "killer app" – it offers the possibility of a killer existence.

– Abowd and Mynatt [3]

1.1 Motivation and Context

Humans naturally want to improve themselves and grow as individuals [82, 101]. In this pursuit, they will utilize any available means *"want[ing] it all, and want[ing] it now"*[1]. Sometimes, when presented with tools that can make their performance *"harder, better, faster, stronger"*[2], they may embrace the tools without realizing that something valuable might get lost along the process. In the contemporary digital era, the tools are digital technologies. In particular smartphones, with their widespread availability and high interactivity, have led to technology heavily intersecting with human's everyday activities [70, 92]. I argue that this technological ubiquity leads humans to concurrently reason and engage with stimuli from the digital and physical realms in a *hybrid presence*. As such, this thesis aims to explore the interconnectedness of the physical and digital realms, and the potential advantages and disadvantages that arise from this interdependence. To conceptualize and manage presence that benefits human well-being, I introduce the concept of *mindful hybrid presence*. Mindful hybrid presence involves purposefully and consciously blending the physical and digital stimuli to cultivate awareness, enjoyment, and relatedness to the realms, encouraging individuals to be fully present and balanced in their experiences across both realms. With the goal of cultivating mindful hybrid presence in everyday scenarios, the thesis presents several mobile digital technology designs that were implemented and evaluated in-the-wild. The subsequent sections elucidate the historical and conceptual motivations for embracing mindful hybrid presence.

Over 30 years ago, Marc Weiser envisioned a world in which *everything* becomes a computer [130]. This concept, often referred to as ubiquitous computing or pervasive computing,

[1] https://www.youtube.com/watch?v=hFDcoX7s6rE&ab_channel=QueenOfficial

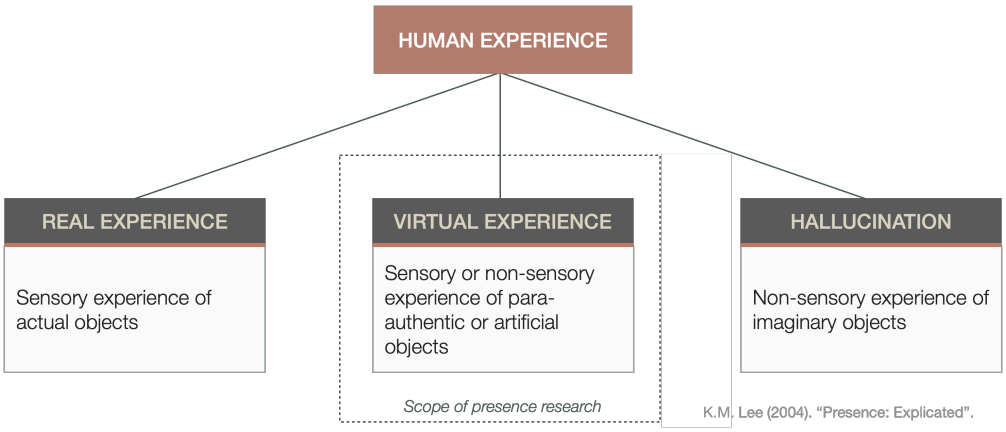
[2] https://www.youtube.com/watch?v=gAjR4_CbPpQ&ab_channel=DaftPunk

envisions a world where computing power is embedded in various objects and spaces, making them smart and interactive. As such, technology is to seamlessly integrate into our environment, fade into the background and become almost invisible, as to no longer interfere with our daily activities, but rather support them. Weiser called it *calm technology*, as technology that enables us to engage with it when needed, however allowing us to maintain our focus on the task at hand [131].

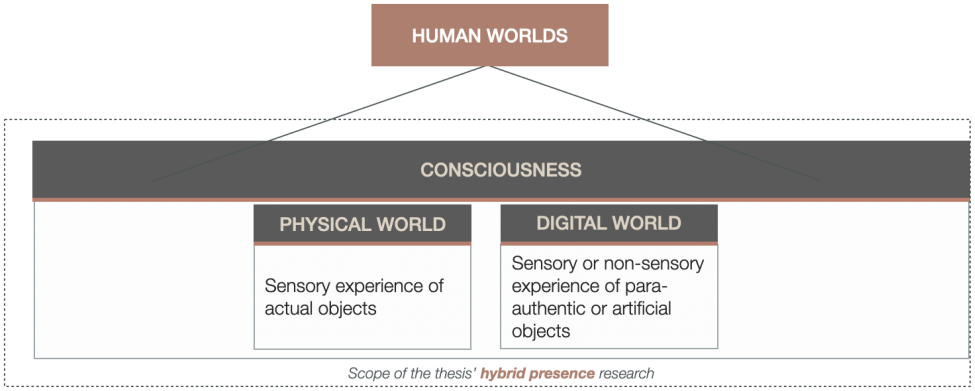
While the realization of ubiquitous computing is still evolving – not everything has become a computer yet – certain devices have come close(r) to fulfilling the vision of being always available everywhere. Notebooks, tablets, smartwatches, or smartphones, have become ubiquitous in our lives. With the introduction of the iPhone in 2007, human interaction with technology took a transformable turn [105]. Human pockets acquired a powerful computer, coupled with widespread access to mobile internet. As consequence, smartphones have emerged as the most prominent and ever-present companions [16]. 80% of users keep their smartphone not further than within the same room, all the time [25]. In extreme cases, users consider smartphones to be part of their own selves [43, 47]. Although all digital technologies, and the eco-system they together belong to, are relevant for ubiquitous computing [90], it is smartphones that lead the way due to its high interactivity and easy portability in both public and private settings [70, 92], often as *"subtle background objects"* [2]. The smartphone ownership share was 85% in Germany in 2022 [114] and up to 100% in many Western countries already in 2014 [89].

This dominant ownership rate, coupled with context-independent interaction possibilities, have facilitated a seamless integration of additional *digital realms*, calling for human engagement in diverse social, work or personal contexts (e.g., sleep, relaxation). Consequently, our experience of *presence* is not only bound to real, sensory experiences in the immediate physical environment or inner, non-sensory experiences within our thoughts and emotions (as per [69], see Figure 1.1a). These modes of experiences encounter each other to intertwine and *"shape the decisions behind where we go, what we see, where we eat, or what we do"* [55], resisting the division often assumed between the digital and physical realm [55], as previous researchers also have discussed (e.g., [18, 30, 130]). In the context of presence coupled with ubiquitous computing devices, Waterworth and Riva [127] phrase it as: *"Ambient displays, tangible interaction objects, environmentally embedded sensors and a variety of location and state-sensitive mobile devices have made it possible for the physical and the virtual to be combined as never before, in a way that allows our natural sense of presence in the physical world to be preserved (potentially, at least) while we also deal with virtual entities, distant people, and other digitized sources of information"* [127, p. 1].

Thinking back only a few years, the COVID-19 pandemic is a great example of the speed with which we moved from the office to remote work, from school attendance to online classes or from cafes to virtual gatherings. The pandemic showed the importance and capabilities of the digital world in enabling society to adapt and humans to continue having an *actual life*, while respecting physical restrictions and social distancing measures [22] in the physical environment.



(a) Notion of the three human experiences according to Lee [69], showing the scope of presence research being bound exclusively to the virtual experience.



(b) My concept adopted from [69], extending the presence research to span the consciousness division between the physical and digital realm embodied as *hybrid presence*.

Figure 1.1: Comparison of the three human experiences by Lee [69] and hybrid presence within this thesis, with emphasis on extending the presence research.

In the light of the previously listed findings, this thesis adapts Lee's [69] notion of the threefold experiences by blending the three realms under the umbrella of consciousness and stretching our presence along these into a *hybrid presence* (see Figure 1.1b). In that sense, *hybrid presence* encompasses the unbreakable entanglement of physical, digital and mental stimuli in shaping everyday experiences, perceptions and feelings. Whether listening to music (digital) while running the park (physical), or dreaming of the sea (mental) while writing a publication on a computer (digital) – the quality of experiences across the whole presence spectrum ultimately form our overall sense of satisfaction and fulfillment. A more elaborate discussion on hybrid presence is presented in section 2.1.

On the surface, the digital realm seems as an excellent enabler of multi-tasking, making people as efficient, informed or entertained than ever before. This requires frequent interac-

tions and dependence on digital devices and services. Indeed, humans interact with their smartphones 96 times throughout the day on average [1], regardless of context, with almost 90% of these pick-ups being innerly driven [51]. This reflects an urge to check for updates, fueled by the innate fear of missing out (FOMO) [44]. Failure rates to resist the temptation of media use via digital technology is much higher than the failure rates for, e.g., shopping or smoking [24]. This is by no coincidence so: the digital realm presents a multitude of interactive content and services that constantly compete for our engagement. The digital services are by design set to be immersive and interactive, often utilizing persuasive techniques to keep users engaged for extended periods [93, 94]. Social media platforms, video games, and streaming services are engineered to capture and hold our attention, employing features such as infinite scrolling, autoplay, and personalized recommendations [74, 94]. These design patterns make it difficult to resist the digital realm, leading to prolonged periods of shared or interrupted presence that can distract from our experiences and relationships in the physical realm. Consequently, many individuals experience an internal conflict concerning their patterns of digital technology use [70], particularly when it involves passive, unconscious engagement with technology [123].

Each one of us has probably at least once lost track of their immediate physical, temporal or social surroundings while interacting with a piece of digital technology. For example, we may have briefly interrupted a conversation when a smartphone notification popped up. Or we may have been so focused on getting that one perfect shot for social media that we lost the moment of awe when visiting a new place. On the other hand, we might have video-called family and friends from around the world, experiencing the feeling of togetherness even though we were physically in distributed locations. In such and similar cases, we could to some extent disengage from the *physical* realm and immerse into a *digital* one. However, people report fearing disengagement from the real world when interacting with technology [41]. Some individuals state that it causes stress and negative emotions [83]. Various public and academic sources, including (ironically) social media, raise concerns about the negative impact of smartphones on our lives (e.g., [48, 66]).

Finding an appropriate and satisfying balance of purposeful and efficient presence across the realms, now that the digital world is an integral part of it, thus becomes essential for effective functioning and overall well-being [128]. Given that this thesis is anchored in the research area of human computer interaction (HCI), with emphasis on *computers*, my goal in the following chapters is to present computing solutions that aim to support the described balance.

1.2 Scoping the Role of Technology

The emerging field of *digital well-being (DW)* addresses the need to navigate and mitigate the negative influence of the digital realm on presence, aligning with the identified challenges of increased *human-technology symbiosis* and promoting *health, well-being, and eudaimonia* in the context of future HCI challenges [117]. Although the research field of DW does not explicitly refer to the concept of presence, it acknowledges the importance of managing individuals' experiences and interactions with digital technology for the purpose of, e.g., meaning [75], or self-improvement [134].

If believing the press and media, today's digital technology is all but calm – Abowd and Mynatt [3] used the term *killer existence* already in the early 2000s to highlight the potentially negative impact of technology's pervasive presence. The urgency and novelty of this topic have prompted both academia and industry to develop a wide range of digital self-control tools to manage presence in the digital realm. These tools mostly incorporate monitoring smartphone use behaviors and blocking notifications or certain apps (e.g., [54, 64]), with their aim to reduce the overall time spent within the digital realm and the number of interactions (see [4, 78, 92, 100] for reviews). However, as not all screen time is equally meaningful or productive [27], their effectiveness is debatable and they may even trigger negative feelings in the user [92, 100].

While physically separating from digital technology devices might seem as the most straightforward solution, with so called *digital detox* retreats on the rise [98], it is often impractical given technology's integral role in our personal and professional lives [48]. On the contrary, many individuals express a fear of missing out on digital content [44], further complicating a decision to disconnect from the digital realm. In fact, there is ongoing debate about the influence of media and research on, predominantly, the negative smartphone addiction narrative with varying opinions on the significance of these factors [10, 65].

Therefore, current technological solutions to manage our presence utilize information exclusively from *within the digital world* (such as screen time, number of pickups or used apps), ignoring the holistic perspective of presence, i.e., the physical context in which interaction with the digital realm happens. The impact and perception of these contexts can vary among individuals, and what may be unwanted for one person could be desired or acceptable for another [61]. Thus, understanding the nuances of digital technology use and their effects on our presence in the first place becomes imperative in developing effective technology strategies for managing presence and promoting well-being.

Goal This thesis aims to understand the nuances of digital technology (use) and their effects on our presence in order to develop technology systems effective in managing presence and promoting well-being according to individual's values and goals.

1.3 Background

In the realm of HCI research, presence has primarily been discussed and studied within the context of virtual reality (VR). In VR, presence serves as a fundamental evaluation measure for assessing the quality and effectiveness of virtual environments. However, the concept of presence has evolved over time, leading to various notions, definitions, and related concepts. The following section lists the common notions and definitions of presence, focusing on the central aspects of *being there* and *being here*. In addition to presence, related terms such as immersion, absorption, and absence are often intertwined in discussions within the HCI field. To picture their importance and difference to presence, these terms are discussed in the subsequent sections.

1.3.1 Presence

Many notable concepts of *presence* have been defined and evolved over time in the field of HCI [110]. This section elaborates the *being there* (and *being here*) concept of presence, as ubiquitous computing devices and services offer content or experiences that can shape and immerse users in various ways, transporting individual's consciousness to another place and benefiting from side effects of increased immersion [13].

The *being there* notion of presence evolves around the subjective experience of presence, highlighting the feeling of being (physically) present in a particular place or environment. Marvin Minsky [88] coined the term telepresence in 1980, which was further expanded upon by Witmer and Singer [133] to entail *"the subjective experience of being in one place or environment, even when one is physically situated in another"* [133, pg. 1]. Presence can be, and is normally, felt first in the real environment before extending to digital environments. The real world serves as the foundation for people's understanding and perception of presence, whereas telepresence is considered a special case within this broader context [11, 34, 79, 110, 135]. In the context of understanding presence within HCI research, presence has become a synonym for telepresence and the environment is commonly considered a virtual environment. However, the environment can be *"real, virtual, symbolic, or some combination thereof"* [132, pg. 1].

Further scholars looked into the consciousness associated with presence. Loomis [72] refers to presence as a basic state of consciousness, consisting of attribution of sensation to some distal stimuli, or more broadly to some environment. Sas and O'Hare [106] share this view, adding that presence involves a *shift in focus of consciousness*, wherein individual's consciousness, i.e., the cognitive processes and awareness are oriented towards stimuli located either towards an imaginary world within themselves or a technology-mediated world outside of themselves [33]. Along the lines of multiple worlds, Kim and Biocca [62] added *not being here* to the concept of *being there*, illustrating the transition between physical and virtual environments as integral to the experience of presence. Waterworth et al. [128] embrace the concept of presence from a spatial perspective, considering both the physical and virtual realms as part of the present

moment. In other words, presence encompasses the here and now in equally the physical and virtual worlds.

Another set of notions discusses the necessity of user's active involvement to experience presence. On the one hand, Biocca [11] describes presence as a phenomenal state where individuals feel located and *active* within an environment – in case of telepresence, the environment is mediated through technology. On the other hand, according to Slater [112], presence can occur involuntarily when the necessary technology-related stimuli, including immersion and individual perceptual and motor characteristics, are provided.

This thesis extends examining presence outside of VR environments and lays emphasis in comprehending presence within the tangible, physical world, particularly considering the pervasive presence of ubiquitous computing devices. The objective is not only to explore the sensation of *being there* in the digital realm, but also to investigate the impact of technology on the aspect of *being here*.

1.3.2 Immersion

While immersion is sometimes used interchangeably with presence in certain contexts [110], the prevailing perspective in the VR literature views immersion as a contributing factor to presence rather than a direct synonym [110]. There are two contrasting viewpoints regarding immersion [71], often referred to as *perceptual* [12] and *psychological* immersion [71]. The first regards immersion as an objective quality of a VR system [113], focusing on factors such as the VR system's characteristics and technical aspects. On the contrary, the second perceives immersion as a subjective psychological state characterized by the individual's perception of being *"enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences"* [133, pg. 227]. This thesis follows the latter notion of immersion when referring to individuals being immersed in the digital realm.

1.3.3 Other Related Terms

Attention is a fundamental aspect underlying the concept of presence. Directing one's attention towards meaningful stimuli supports a stronger sense of presence [133] and immersion, regardless of the nature of the spaces, i.e., whether physical, mediated, or imagined [62]. An allocation of focused attention to stimuli is necessary for *involvement* and *engagement* [133]. However, involvement does not guarantee presence and vice versa [110, 112].

Flow represents an optimal state of focus and engagement in an activity, achieved when the level of challenge in a task matches an individual's skill level [21]. Flow goes beyond mere engagement as individuals lose self-consciousness and experience a distorted sense of time [21]. Some researchers argue that presence contributes to the flow experience [96, 118], whereas others consider it a more profound state of engagement than presence [14] with absorption surpassing both flow and presence in terms of the level of engagement with

media [14]. *Absorption* involves getting completely immersed in a task, whether it's watching a movie, reading a book, or experiencing virtual reality [6]. It represents the inclination to be completely engaged in a sensory, imaginative, or conceptual experience [119].

This thesis emphasizes the significance of not just user involvement but also the impact of the mere presence and availability of devices and services on the user's sense of presence and overall well-being. By exploring presence, I aim to encompass the broader scope of factors that contribute to the user's experience and the effects of technology.

1.3.4 Absent Presence

In the realms of presence research, Waterworth and Riva [127, p. 6] point out that there is *"not only a conflict between presence here and presence there, but often also a conflict between self and other, presence and absence"*. While presence in HCI has primarily focused on VR research, psychology researchers discussed the concept of presence in relation to everyday technology as early as two decades ago. Gergen [42] discusses the ability of virtually all communication technologies that enable remote interactions, with particularly cell phones, to contribute to *absent presence*: someone who is *"physically present but is absorbed by a technologically mediated world of elsewhere"* [42, pg. 227]. Gergen envisions absent presence to lead to various outcomes, primarily influencing the self, one's relationship to others and the society in general. Firstly, it can result in an increase in the number of social connections, although these connections tend to be shallow in terms of depth. Secondly, individuals may exhibit different ethical and moral behaviors, which may or may not align with their personal or the society's existing values. Thirdly, there is a possibility of a shift in or even a loss of self-identity. Finally, everyday activities may be devalued in favor of engaging with entertaining digital content.

A recent qualitative study [2] explored absent presence w.r.t smartphone use in social contexts, identifying drivers of absent presence. Smartphones' small screen size and personalized content consumption contribute to absent presence, and their availability blurs the boundaries between different contexts of use, leading to *handheld individuality*. Consequently, absent presence can cause *unintentional misattunement* [2], giving the impression of social indifference, a behavior sometimes referred to as phubbing [103]. Phubbing differs from daydreaming as it is easily accessible through smartphones, often a habitual behavior beyond complete control, and societal interventions are uncertain [2].

Whereas absent presence focuses on the rather negative impact of smartphones on presence, this thesis takes a broader perspective by examining the entire range of presence influenced by everyday ubiquitous technology. I refer to this spectrum as *hybrid presence*, which will be discussed in the upcoming section.

1.4 Thesis Overview

The thesis is structured as follows:

Chapter 2 examines *hybrid presence*, a continuum of consciousness between being completely anchored in the physical world without technological influence – being *completely offline*, and a state of being fully unconscious of the physical environment while engaging with technology – being *fully immersed digitally*. The chapter addresses the implications of mindfully navigating this spectrum to provide a definition of *mindful hybrid presence.*

Chapter 3 first sets up a research space as basis for positioning the overall research goal of the thesis, as well as the research publications within a structured framework. The chapter then lists a set of four research questions serving as guiding principles through the overarching structure of my research. After addressing each question, I present the employed methodology and the single contributions from the included publications. The chapter concludes by listing the core contributions of the thesis.

Chapters 4 & 5 present a detailed description of each publication from the included publication corpus. Chapter 4 is centered around understanding *hybrid presence* from a user-centred point of view, both qualitatively and quantitatively, so to understand the challenges, opportunities and trade-offs associated with navigating between the physical and digital realms. Chapter 5 lists the design, implementation and evaluation of potential technological solutions aimed at supporting individuals in navigating their *hybrid presence* in a more *mindful* way.

Chapter 6 concludes the thesis with a discussion of the obtained findings along the research questions posed at the beginning of the thesis. The discussion validates and reinforces the research contributions while also identifying potential gaps or areas for future work.

2
MINDFUL HYBRID PRESENCE

The mobile phone has not merely met requirements or fulfilled needs. It has not just extended our capabilities or opened up the possibilities for new social practices. It has made us different people. Humanity has re-defined itself through the digital tools it has devised or even more radically: our tools are us.

– Frauenberger [36]

2.1 Hybrid Presence – Between *Completely Offline* and *Fully Immersed Digitally*

*"**Hybrid** (adj.): having or produced by a combination of two or more distinct elements : marked by heterogeneity in origin, composition, or appearance"* [1]

The term *hybrid* refers to the combination of different elements or aspects from two or more distinct categories or domains. In the context of presence and this thesis, *hybrid presence (HP)* refers to the interweaving of the digital and physical worlds as both significant parts of our presence nowadays. Thus, HP covers the entire middle ground in a continuum-like space, as in Figure 2.1, between two extremes of our consciousness being *completely offline* (i.e., presence anchored in the physical world only) and being *fully immersed* (i.e., presence immersed in the digital realm) – with arguably neither of the extremes reachable in today's Western cultures. Throughout this thesis, I will refer to this continuum as the *HP continuum*.

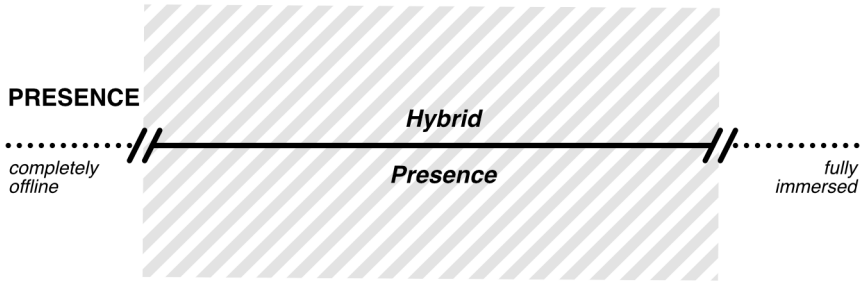


Figure 2.1: In hybrid presence, humans can neither achieve the state of being fully immersed digitally, as per [111], nor can they completely shut off the influence of the digital realm to be completely offline.

[1] https://www.merriam-webster.com/dictionary/hybrid

The HP continuum is similar to Milgram and Koshino's reality-virtuality (RV) continuum [86], as it represents a blend of the digital and real realms. The RV continuum provides a framework for categorizing and comprehending various types of experiences in between the range from completely real environments with only physical elements to purely virtual environments with virtual elements, concerning explicitly visual displays. The term *mixed reality (MR)* describes the middle ground between the two extremes on the continuum.

The HP continuum does not target the realism of the experience or the environment, but rather revolves around the sense and experience of human consciousness that is stretched and shaped between the *here* in the physical environment and the *there* in the digital environment, that is, in a mixed, hybrid space. Our natural presence is attuned to the real, sensory environment, which contains tangible objects with which we can interact and which gives us sensory feedback as sights, sounds, tactile sensations or social interactions, among others. In HP, however, there is a digital presence that coexists with (or on top of) the natural, physical presence. The digital environments offer a range of digital channels for information, communication or entertainment, to name a few. People become immersed in these digital channels while simultaneously being located in the physical environment, so our experiences are in most cases shaped by both environments. In the field of ubiquitous computing, previous researchers ([18, 49, 107]) have emphasized that digital parts of the world are also real and even physical. Harrison and Dourish [49] calls these *hybrid spaces* because effectively both worlds merge to focus on the overall experience and the task at hand. As Weiser [129] framed it, the distinction between the physical and digital is *"literally visible, [but] effectively [in action] invisible."*

Skarbez et al. [111] recently revisited the RV continuum and introduced a discontinuity on the virtual side of the spectrum, suggesting that reaching the endpoint of pure virtual reality is unattainable. As the authors discuss, any form of reality mediated by technology should be considered as mixed reality[2] given that external virtual environments cannot control or manipulate the interoceptive senses (e.g., proprioception).

Reflecting the discontinuity on the virtual side, I propose a discontinuity on the other, physical side within the HP continuum. In current everyday settings, I argue that being completely offline[3] is no longer attainable, as the digital and physical realms are highly intertwined in shaping our experiences and sensations[4].

Some researchers [52] argue that the only way to disconnect from the digital world (and thus completely escape its influence) is physical distance from the devices. However, even

[2]The authors discuss an exception to this being a fully simulated environment, such as in the Matrix movie

[3]The term offline can bear a dual meaning within this context. It might refer to the act of disconnecting from the internet, while still engaging in digital devices' use that requires no internet connection, such as taking notes on the smartphone or reading books with an e-reader. A stricter definition refers to complete abstinence or even physical dislocation from any form of digital device, such as going for a hike or engaging in a one-on-one conversation without digital distractions.

[4]This applies to Western, industrially developed cultures. It might not hold in cultures or regions with absent or underdeveloped technological infrastructure, such as, e.g., in the rainforests of Amazonia.

when not actively using a digital device, we can still come into contact with digital media and information through various ubiquitous and persuasive channels, such as screens in public spaces, the ambient sounds of notifications from other devices, or the phantom sound of our own devices [31].

Even in instances when digital devices are not physically present in the immediate moment, it is highly probable that the digital domain has affected an experience beforehand (such as selecting a hiking route through online browsing and pictures) or has engaged in digital processing of the experience afterward (such as sending images to friends via messaging services).

In light of the addressed coexistence, the term *hybrid* in hybrid presence notes the interplay of physical and digital elements within the same space, that is, engaging in digital activities that affect the physical environment or engaging in physical activities that are affected by experiences and elements from the digital realm. For example, we may have witnessed or even participated in a live-event and recorded the event on a smartphone or visited a scenic spot and focused on getting the perfect picture for social media - rather than immersed ourselves in the actual situation in both cases. Likewise, when engaged in a video game or answering text-messages, there is no exclusion of, e.g., family members to answer some of their questions. Consequently, our sense of presence is no longer exclusively bound to either realm, but is constantly shaped by and connected to both, with varying degrees of influence from each. Sometimes, hybrid presence moves closer to the offline endpoint – at other times, it is closer to digital immersion.

Hybrid presence can, on the one hand, enable a seamless transition between different modes of engagement in activities, such as socially communicating in person and online. On the other hand, it can render an absent presence (as elaborated in subsection 1.3.4) and result in feelings of, e.g., neglect and disappointment within the person opposed to the absentee. This ambiguous nature of hybrid presence raises questions about the nature of our experiences and the impact of the digital realm on our sense of presence in the physical world. How does our engagement with the digital affect our perception of the present moment? How much of our presence is in the physical world when a significant portion of our attention and cognitive processes are directed towards the digital? How to manage navigating our presence in a way to enhance our well-being, enjoyment and integrity?

Many users report that they are unable to take advantage of the hybrid presence so to balance the realms as they see fit [32]. Most often, they simply want to reduce the time spent interacting with digital platforms or reduce the number of distractions caused by the devices [54, 61], as these factors diminish their overall sense of agency over presence [76]. Some users describe unintentionally becoming immersed in the digital world (i.e., falling down the *rabbit hole*), neglecting their immediate physical environment and becoming disconnected from their surroundings and the passage of time [32]. The most obvious solution lies in eliminating the digital devices and thus the digital realms. Yet, this is hardly a sustainable option due to the numerous ways that the digital does provide support in various everyday contexts, such as

companionship and entertainment [48, 52]. Moreover, the design of many digital devices and services is often on purpose made to capture human's attention [94].

To manage presence in a way that enhances well-being and decreases negative effects, I instrumentalize mindfulness to develop strategies of heightened awareness and balance of the digital and physical realms, to promote *mindful hybrid presence*.

2.2 Defining *Mindful Hybrid Presence*

The perceived difficulties in navigating between the physical and digital realms can lead to extended and inattentive presence. Addressing this challenge calls for a strategy that mitigates negative outcomes while retaining the benefits of the digital realm, all while implementing the strategy from within the digital realm. We identified this as a context where mindfulness could prove beneficial.

Mindfulness has witnessed an increased attention in research and media outlets, with its practice being praised in particular for improving mental health and overall well-being [87]. This thesis applies the notion of mindfulness which defines it as a *state*[5] of heightened in-the-moment awareness and presence, intentionally paying attention to one's thoughts, feelings, and experiences as they arise, and accepting them without reactive and judgmental labeling as good or bad [56, 57].

Definition [a]

Mindful Hybrid Presence (MHP) refers to the intentional and conscious integration of both physical and digital environments in a manner that promotes awareness, enjoyment, and connection. This concept encourages individuals to be fully present in the moment, while also actively engaging with and navigating between the two realms. It emphasizes the importance of maintaining a balanced and authentic experience in both spaces, recognizing their interconnected nature, and leveraging their unique affordances to foster meaningful interactions and personal growth.

[a] I have used ChatGPT to iteratively `https://chat.openai.com/` rephrase and extend the wording of the definition.

The quality of mindfulness, cultivating awareness and attention to the present moment, could thus help individuals to better navigate the realms around them and within themselves, both in the present moment and in the long term. However, the idea of employing mindfulness

[5] There is debate on whether mindfulness is a temporary state or long-term trait or a practice itself, e.g., does frequent mindfulness practice lead to a person becoming more mindful in general or does mindfulness practice improve only in-the-moment awareness, see e.g., [23]

from within a digital technology system to manage the use of that same system may initially appear contradictory since in this case, the digital systems are considered both the cause of the problem and the medium through which a potential solution is delivered [108]. The aspect of holistic awareness in mindfulness serves to live *with* technology, not *next to* or *despite* it as two separate entities. As part of the research that we conducted, we designed, developed and evaluated mobile apps and tangible user interface (UI) that incorporate mindfulness as follows, namely to:

1. cultivate in-the-moment awareness to promote *intentional technology use*.
2. cultivate *awareness of the physical and mental context of technology use* within the digital realm, and
3. *redirect activity* to the physical realm to encourage re-balancing presence after prolonged time spent in the digital realm.

3

RESEARCH QUESTIONS, METHODOLOGY AND CONTRIBUTION

In a world where technology is omnipresent, the question arises of how its role towards enhancing well-being and human eudaimonia can be optimized, especially addressing interaction issues and ensuring a human-centered approach.

– Stephanidis et al. [117, pg. 1232]

3.1 Research Space

To situate the increasing interaction between humans and technology with the goal of promoting health and well-being in the face of future HCI issues [117], I establish a research space (see Figure 3.1) that puts hybrid presence (see Figure 2.1) in relation to human's overall well-being. The macro goal of the research space is to illustrate the general research domain of this thesis, namely the influence of digital technology on overall well-being. On a micro level, the research space is a framework to place the contributions of each publication included within the thesis.

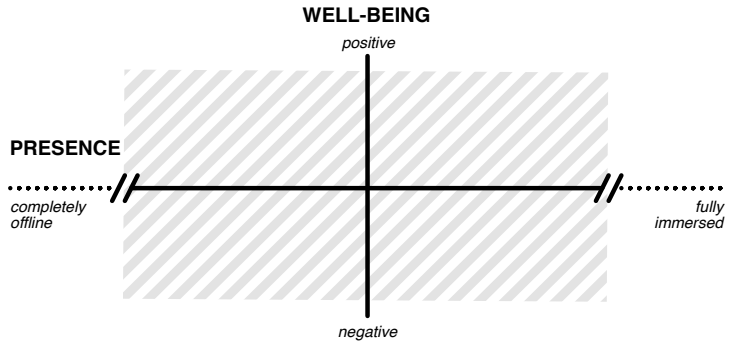


Figure 3.1: The research space that puts hybrid presence in relation to well-being. I use this space to position my publications.

The elaborated HP continuum (see section 2.1) is positioned on the X-axis of the space. Rather than a single point in the continuum, hybrid presence is a sliding quality, inclining in favor of one or the other realm depending on several in-the-moment characteristics.

To put the continuum in relation to well-being, the additional Y-axis of the space represents general well-being, ranging from positive at the top to negative below. Accordingly, the

research space is divided into four quadrants. In the top two quadrants, there is a hybrid presence that evokes feelings of positive well-being, assuming that digital and offline activities are in balance [121]. Balance in this context does not necessarily promote an equal split of e.g., time spent in activities or the mere count of activities in one realm or another. Rather, it denotes either an intentional, context- and individually-appropriate incline towards one realm or the other, or a conscious entanglement of both realms.

In contrast, the bottom two quadrants present a hybrid presence that induces negative well-being, i.e., when the perception of presence is out of balance. The resulting effects can be social isolation [53], digital overload and information overwhelm [115] or disturbed sleep [28], among others. This thesis focuses primarily on the loss of agency over hybrid presence [76] as a result of negative experiences.

Consequently, *mindful hybrid presence*, as strategy proposed in section 2.2, encourages intentional actions across the hybrid presence continuum that foster an increased sense of agency for the presence to remain in a balanced state, i.e., in the top two quadrants of the space.

3.2 Research Questions & Contribution

The following three research questions provide a framework for exploring and technologically navigating the introduced research space.

3.2.1 Background Exploration

The previous section highlighted the need to investigate the specifics and management of the entanglement of the digital and physical realms. This exploration is guided through the following preliminary research question:

Exploration

RQ0 How does the increasing entanglement of humans and ubiquitous digital technology impact the concept of presence?

Contribution This research question is addressed through a review of presence definitions from the field of VR, together with the notion of absent presence by Gergen [42]. The contemplation is collected in section 1.3 of the thesis. I then speculate that humans act within a hybrid presence continuum in section 2.1 between being completely offline and fully immersed digitally as the spectrum's unattainable endpoints. The concept of hybrid presence prompts an investigation into the advantages, disadvantages, and user requirements associated with

this blending of environments, as examined in RQ1. To navigate the continuum of hybrid presence according to the discovered user's requirements, I propose mindfulness as a strategy that guides both RQ2 and RQ3.

3.2.2 Trade-Offs

This part lays a user-centered understanding of hybrid presence and conducts an exploration of its trade-offs. It presents an exploration of the whole research space with emphasis of how the right, digital part of the space, influences the left part, that is, presence within the physical realm. Current research is more focused towards the negative consequences of digital technology, in particular the technology use patterns that people employ. This point of view is however strongly debatable in research circles [10, 65]. Recent research efforts found that the negative narrative is driven by media [65] and include setting up a love dictionary for technology [39]. However, we identified a lack of research works that compare user's perspective on the positive and negative influence on the holistic presence, that is, the influence on feelings, experiences and activities within the physical and digital realm combined. Thus, we uncover the intricacies of both positive and negative consequences that are associated with hybrid presence, as well as the trade-offs in relation to people's overall well-being. We discuss the favorable and less favorable ways in which mobile digital environments shape our presence in its sense of self, our relationships with others, and our perception of time and space. This exploration is guided by the following research question:

Trade-Offs

RQ1 What are the positive and negative consequences of a hybrid presence on human well-being and what are the resulting human's needs?

Methodology To address RQ1, we utilized methods that involved collecting and analyzing empirical data. In the qualitative phase, we employed techniques such as user surveys, focus groups and interviews, followed by a rather unconventional approach known as love/breakup letters [80]. We analyzed the data thematically in [P1]. In [P2], we employed a twofold analysis: first, we analyzed the letters' sentiment using Google's natural language processing API. In the second phase, we constructed an analysis framework that establishes connections between distinct smartphone features and individuals' emotions, as well as real-world implications based on the statements extracted from the letters. These methods allowed us to gain insights into users' perspectives and experiences of presence in hybrid spaces. To complement our qualitative findings, we performed a data collection field study that incorporated automated data tracking and experience sampling in [P3]. We quantitatively analyze users' behaviors within so-called mobile phone rabbit hole (MPRH)s. As the existing understanding of MPRH

from related work [19] was insufficient to explain our quantitative findings, we supplemented the study with an expert focus group to deduce a mixed-method definition of MPRHs.

Contribution This part of thesis contributes three research publications [P1, P2, P3].

In [P1], we took a user-centered approach to explore both experts' and non-experts' understanding of presence and the influence of digital technology on it. The study revealed the delicate balance required to prevent negative influences in and of the digital realm, with self-control playing a central role. Positive influences included escapism and feelings of competence and social connectedness, while a loss of control led to negative consequences, such as the loss of time, competence, awareness, autonomy, and self.

Building on this preliminary exploration, we conducted a detailed investigation of smartphones' impact on users' emotions and experiences in the physical realm in [P2]. Through love or breakup letters, users were found to have a complex emotional relationship with their smartphones leaning more towards the positive – albeit it worsened during COVID-19. Again, self-control was considered most important in managing smartphone influence. We identified eight common patterns of smartphone features and their emotional and real-world consequences, ranging from positive roles such as assistant and companion to negative roles such as hinderer and obsession.

In the third paper [P3], we employed a quantitative-centric method to analyze smartphone usage patterns in sessions where presence was more digitally inclined, referred to as MPRH sessions. We found these sessions to often involve absent presence behaviors associated with social media, gaming, and entertainment apps. Interestingly, almost 55% of MPRH sessions did not induce feelings of regret, challenging the notion that all MPRH sessions are inherently negative. To complement these quantitative findings, we collected input of six HCI experts within a focus group to define a MPRH. The deduced definition emphasizes the loss of awareness as a key attribute of MPRH, only considered negative if it leads to passive interaction and regret.

RQ1: Main Findings

The Need for Balance A wide range of digital experiences is rarely strictly positive or negative, but rather subject to numerous contextual, individual or digital factors, such as the appropriateness of situation, the meaningfulness of consumed content or user's inner emotions. This stands for both the digital device (e.g., smartphone) and the services the device provides (e.g., social media keeping a user up-to-date versus social media providing meaningless content). This emphasizes the importance of striking a balance in presence tailored to context and the individual.

The Need for (Self-)Control Humans state the necessity to regulate their digital presence in order to achieve a relationship with digital technology as they see fit. They primarily assume themselves responsible for this regulation.

The Role of Escapism In certain situations, people welcome an unawareness of their surroundings, namely when they want to escape the present physical world.

The Non-Intentional Use Humans often have no clear intention to use their digital technology devices (i.e., habitual use). Steady situations, such as experiencing boredom, are good predictors of non-intentional use interactions. In turn, such situations present good opportunities for presence redirection to the physical realm.

3.2.3 Technology Designs & Evaluation

Within this part of the thesis, the focus shifts towards the exploration and development of digital technology designs that facilitate and promote mindful hybrid presence. This involves implementing and evaluating mindfulness-based digital technology designs that support individuals in making *conscious* choices about their engagement or disengagement with technology, encouraging them to allocate their attention and time in a manner that aligns with their values and goals. Two research questions guide this part of the thesis.

RQ2 explores mindfulness-based strategies that hold promise for cultivating mindful hybrid presence in conjunction with digital technology. Subsequently, it examines the creation of targeted interventions or features within digital systems that embody these strategies.

Designs

RQ2 How can mindfulness cues be consciously instrumentalized in digital technology designs to support mindful hybrid presence?

RQ3 examines the evaluation of the developed technology designs in promoting mindful engagement or disengagement with technology in a hybrid presence context.

Evaluation

RQ3 In what ways do the instrumentalized digital technology designs promote mindful hybrid presence?

As RQ2 and RQ3 are linked closely together, with five out of seven publications in this corpus addressing both questions, I will provide a joint explanation of the methodology and contributions for both questions.

Methodology This part explores the potential technological solution space based on mindfulness. We first conducted a systematic literature review on mindfulness in HCI [P4], analyzing the adopted notions, application areas and developed technology for cultivating mindfulness. This inspired developing cues that *raise awareness of the physical realm* within digital interventions and systems, next to cues that *redirect activity* (back) to the physical realm. For the latter, we conducted an online survey to examine which activities users wish to be redirected to in [P5]. Following the discovered gap that there is a lack of tools that employ contextualization and the physical realm as awareness cue [P6], we designed and developed a series of prototypes that leverage these cues. The prototypes encompass various known HCI tools and approaches, including self-reflection tools (as reviewed in [8]), behavior change interventions (such as those discussed in [63, 126]), and material speculations as in [125].

To evaluate the efficacy and user experience of the developed mindfulness-based prototypes, we conducted empirical, in-the-wild studies in [P6, P7, P9, P8] lasting between one and four weeks, next to a series of exploratory lab studies in [P10]. These studies involved collecting and analyzing objective usage data and gathering feedback from participants regarding their experiences with the developed artifacts in fostering mindful hybrid presence. The studies evaluated the hedonic and pragmatic qualities of the prototypes, after which we developed a set of seven Likert-scale questions to examine the role of technology in supporting life-technology balance.

Contribution The systematic literature review on mindfulness in [P4] gave us insights into the various meanings and applications of mindfulness within the context of HCI. This resulted in establishing a framework for researchers interested in this area of study and guiding us towards the mindfulness notion that fits our research. We thus decided to follow Kabat Zinn's definitions of heightened and non-judgmental awareness [56, 57] and Ellen Langer's perspective on the opposite of absentmindedness [67]. Guided by the adopted notion of mindfulness combined with users' need for self-control that emerged in [P1], we proceeded to investigate the market for digital self-control tools available on Google's Play Store and their underlying mechanisms in [P6]. Through this examination, we identified an absence of holistic digital self-control tools, i.e., existing tools focus only on digital, smartphone use metrics and rarely consider the broad physical and inner context in which smartphone use takes place. This prompted us to develop and evaluate the following five systems and concepts:

Life-Relaunched [P6] is a mobile application emerged from the design space in which we originally discovered the gap. The app offers the user different types of smartphone adaptations to the context in which they use it. The aim is to create awareness of the context in which the smartphone use takes place. For example, based on the Wi-Fi network, the app notices that

the user is at home, so it puts apps that are relevant for that context on the home screen or block notifications of apps that are not on the home screen. Although 10 participants recognized the potential of the system within a four-week in-the-wild study, they rarely changed their working methods after the initial installation, indicating their unwillingness to invest time and effort in such technological solutions.

MindPhone [P7], is a mobile application that prompts users to consider their next activity after unlocking their smartphone, aiming to prevent absentminded smartphone use. In a two-week field study with 28 participants, we compared the effectiveness of two prompts at unlock. The first focused, per usual, on the digital world *"Why do you want to use your phone right now?"*. The second shifted focus to the real-world context *"What activity do you want to do after you finish using your smartphone?"*. The study revealed the real-world prompt to be more effective in promoting mindful hybrid presence, leading to reduced smartphone usage compared to the purely digital prompt. Users had the option to respond to the prompt either actively by writing or passively through an overlay screen, with personal preferences being evenly divided between the two options. The same prompt could, for instance, be employed proactively as an intervention to discourage users from prolonged smartphone use, as in [19].

MEMEories [P8] is a mobile application that leverages internet memes for self-reflection, promoting *asynchronous awareness* of the physical realm as an alternative to previous in-the-moment interventions. In this study, participants were asked to use internet memes to describe their day in the mobile app, and their experience was compared with using a traditional text journal. Both journaling formats demonstrated the advantage of heightened awareness, but the use of memes offered an additional benefit of humor, focus and emotion regulation. By incorporating memes, the system fulfilled the hedonistic human need for enjoyment and humor. Instead of restricting or shaming users to limit their consumption of memes, the negative connotation typically associated with them was transformed into a new purpose, encouraging a greater awareness of people's surroundings.

Real-World Wind [P9] is an interventional mobile application that proactively helps users break free from the digital tunnel after experiencing excessive smartphone use, i.e., overload. The app presents users with short challenges to engage in, designed to divert their attention away from the smartphone without needing to consciously decide what to do next. We developed over 80 short challenges that we called *winds* based on findings from a previous study [P5], aiming to restore balance in users' presence after prolonged digital engagement. After a one-week exploratory field study, participants expressed positive feedback towards the challenges, but further investigation is needed to identify the most effective timing for offering them. One possible approach is using the predictor of negative MPRH that we developed in [P3], which could help determine the opportune moments for presenting *winds*.

In [P10], we explored the concept of ***irreversibility*** in digital systems. This approach differs from previous systems in that it does not directly promote real-world awareness. Rather, the approach is inspired by the real-world pattern of (irreversible) causality. We implemented irreversibility in three tangible prototypes to represent the finality of interaction, the infea-

sibility of undoing actions, and the permanence of leaving private data within the digital realm, respectively. The findings revealed that incorporating irreversibility in digital interactions slowed down the speed of interaction and increased mindfulness. Irreversibility therefore discouraged automatic, absentminded interactions with technology by requiring more thoughtful and creative engagement.

RQ2 & RQ3: Main Findings

The Physical Realm as Intervention Prompt Utilizing information on the physical realm as intervention prompt to manage presence from within the digital realm has demonstrated promise. Yet, striking a balanced presence is a complex task and demands novel perspectives and approaches to develop accurate evaluation measurements of balanced presence.

Automation and Autonomy Although stating a desire to retain a sense of control over their digital presence, humans demonstrate low motivation efforts to actively customize technological interventions to their individual needs and contexts themselves.

Importance of Hedonia Humans place importance on solutions that are not overly restrictive and still offer enjoyable experiences.

3.3 Thesis Contribution

The thesis' contribution to the field of HCI is threefold, as follows:

Concept The thesis introduces the concept of *hybrid presence* as a continuum between the physical and digital realms. The relation of hybrid presence to well-being is depicted through the means of a research space. To harvest the benefits of hybrid presence, the thesis proposes *mindfulness* as strategy and coins *mindful hybrid presence* as intentionally navigating the continuum to foster physical and mental well-being in the space.

System To encourage mindful hybrid presence from within the digital realm, the thesis presents five interaction or digital system designs and their respective implementations.

Empirical The empirical contribution is twofold. First, the thesis provides qualitative and quantitative empirical explorations on the influence of technology on people's presence along the hybrid presence continuum. Second, the thesis includes mixed-methods empirical evaluations of the implemented systems, assessing their value in fostering mindful hybrid presence in the field and proposing practical implications and future opportunities for research.

3.4 Publications

The following two chapters present the research publications, published throughout my PhD work, that contribute to this thesis. The chapters lay a more comprehensive overview of each individual paper, organized according to the research questions. Each publication is introduced with a brief summary, explaining the publication's contribution and relation to the research question. This is accompanied by a preview of the paper in its published state and a graphic of how the publication investigates the research space.

To get a quick understanding of these publications and their single main contributions, please refer to Table 3.1. For the original publications and a table that provides a clear explanation of the contributions made by all the authors, please consult Table 6.1.

	RQ	Title of Paper	Publication Venue	Research Method		Contribution Type
[P1]	RQ1	On Ubiquitous Technology, a Digital World and their Influence on People's Feeling and Control of Presence in Everyday Life	CHI EA '21	Expert Focus Group (N=6), User Survey (N=36)		Empirical
[P2]	RQ1	The Tale of a Complicated Relationship: Insights from Users' Love/Breakup Letters to Their Smartphones before and during the COVID-19 Pandemic	PACM IMWUT '23	Love/Breakup Letters (N=82)		Empirical
[P3]	RQ1	A Mixed-Method Exploration into the Mobile Phone Rabbit Hole	PACM MobileHCI '23	Data Tracking Study with Experience Sampling (N=21), Expert Focus Group (N=6)		System, Empirical, Labeled Dataset
[P4]	RQ2	A Review and Analysis of Mindfulness Research in HCI	CHI '19	Literature Survey (N=38)		Literature Survey
[P5]	RQ2	I Wish I Had: Desired Real-World Activities Instead of Regretful Smartphone Use	MUM '22	User Survey (N=67)		Empirical
					Measures	
[P6]	RQ2 + 3	Implicit Smartphone Use Interventions to Promote Life-Technology Balance	MuC '23	App Market Survey (N=152), Field Study (N=10)	Life-Smartphone Balance	System, Empirical
[P7]	RQ2 + 3	MindPhone: Mindful Reflection at Unlock Can Reduce Absentminded Smartphone Use	DIS '22	Field Study (N=28)	Absentminded Smartphone Use (SUQ-A), Screen Time, Number of Pickups	System, Empirical
[P8]	RQ2 + 3	MEMEories: Internet Memes as Means for Daily Journaling	DIS '21	Field Study (N=31), Interviews (N=7)	User Sentiment, Enjoyment, Motivation	System, Empirical
[P9]	RQ2 + 3	Real-World Winds: Micro Challenges to Promote Balance Post Smartphone Overload	CHI' 24	Field Study (N=25)	Life-Smartphone Balance	System, Empirical
[P10]	RQ2 + 3	Point of no Undo: Irreversible Interactions as a Design Strategy	CHI '23	Explorative Lab Studies	User Experience	Concept, System, Empirical Evaluation

Table 3.1: Overview of publications included in the thesis and their primary contributions

4

EXPLORING HYBRID PRESENCE

This chapter presents three publications that follow a user-centered approach in examining individuals' perception and interaction in a hybrid presence. It emphasizes findings on the benefits and drawbacks that hybrid presence has on human well-being, resulting in novel needs for technology.

RQ1: *What are the positive and negative consequences of a hybrid presence on human well-being and what are the resulting human's needs?*

Papers [P1, P2] in this publication collection focus on qualitatively exploring the vertical dimension of the research space. They specifically investigate the impact of the digital realm on (physical, real-world) presence and well-being. The third paper [P3] takes a quantitative-centric approach to analyze smartphone use patterns when presence inclines towards the digital realm, in sessions referred to as MPRHs.

[P1] On Ubiquitous Technology, a Digital World and their Influence on People's Feeling and Control of Presence in Everyday Life.

This study uncovers the perceived well-being of individuals in hybrid presence, encompassing the entire Y-axis of the research space, i.e., both positive and negative outcomes on each side of hybrid presence, see Figure 4.1. The study particularly emphasizes the impact of the digital realm (see the arrow in Figure 4.1) on the sense of presence in the physical environment.

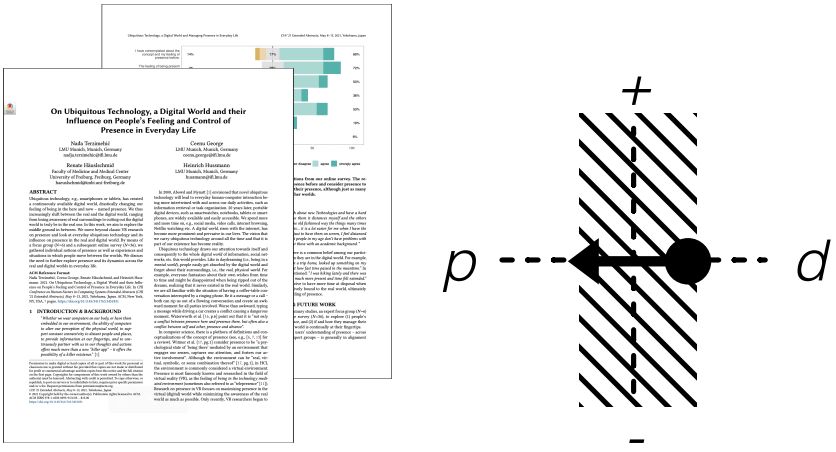


Figure 4.1: [P1] investigates the impact of the digital realm (arrow in the right-hand-side graphic) on the sense of presence in the physical environment.

Summary We explore the concept of presence in the context of ubiquitous technology, considering its impact on individuals' perceived feeling of presence in everyday life. We conducted a focus group with N=6 presence experts to gain insights into their conceptualizations of presence in both the real and digital worlds. Subsequently, we carried out an online survey with N=36 non-experts to further explore their understandings of presence and investigate how one world may impact the other. We examined individual experiences and situations related to transitioning between the physical and digital worlds, as well as the motivations and effects associated with such transitions. Findings discovered that the digital world has both positive and negative influences on the conceptualization of presence, particularly in terms of spatial and self-existential understandings of being-here or being-there. This influence is similar to walking along a delicate line, where (self-)control dictates whether the walk will tilt to the positive or negative side of influence, as in Figure 4.2.

Figure 4.2: In [P1], participants described the experience of managing presence to be likened to a see-saw, requiring a delicate equilibrium in order to ensure that the impact of the digital realm is either beneficial or detrimental.

Reference Nađa Terzimehić, Ceenu George, Renate Häuslschmid, and Heinrich Hussmann. 2021. On Ubiquitous Technology, a Digital World and their Influence on People's Feeling and Control of Presence in Everyday Life. In Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA '21). Association for Computing Machinery, New York, NY, USA, Article 266, 1–7. https://doi.org/10.1145/3411763.3451831

[P2] The Tale of a Complicated Relationship: Insights from Users' Love/Breakup Letters to Their Smartphones before and during the COVID-19 Pandemic

Similar to the previous publication [P1], this publication explores the perceived well-being of individuals in hybrid presence, encompassing the entire Y-axis of the research space, as per the shaded area in Figure 4.3. We employ the method of love-breakup letters to particularly emphasize both positive and negative outcomes of hybrid presence.

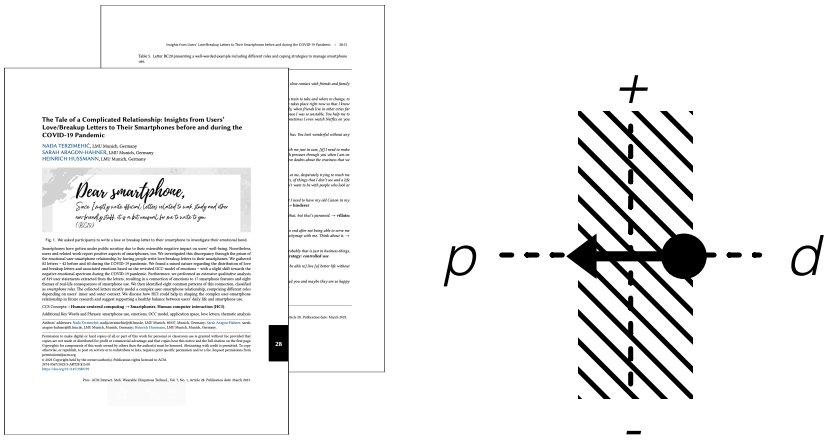


Figure 4.3: [P2] also investigates the impact of the digital realm (arrow in the right-hand-side graphic) on the sense of presence in the physical environment, using the method of love-breakup letters to particularly emphasize both positive and negative outcomes of hybrid presence.

Summary Within this work, we examine the emotional relationship between smartphones and users' everyday lives. This includes both the overall smartphone (use) experience and specific smartphone features or functionalities. We employ the method of *"love or breakup letters"* that N=82 participants wrote to their smartphones, both before and during the COVID-19 pandemic. We conduct an analysis of users' emotions towards their smartphones, the features or functionalities that triggered those emotions, and their potential real-life consequences. A combined manual qualitative analysis and an automated sentiment analysis of the letters and statements resulted in eight distinct patterns – *smartphone roles* – to describe the user-smartphone relationship. The roles *assistant, companion, entertainer* are perceived as predominantly positive, whereas *hinderer, nuisance, object, obsession*, and *villain*, resulted as negative roles. Each role is associated with a different, non-exclusive set of emotions and consequences. An increased smartphone use during the COVID-19 pandemic resulted in decreased positive feelings towards the smartphone, compared to pre-pandemic findings. Overall, the study's findings show a highly complex, rarely black-and-white relationship of humans with their smartphones, and suggest further investigations to support a healthy and personalized balance.

Reference Nađa Terzimehić, Sarah Aragon-Hahner, Heinrich Hussmann. 2023. The Tale of a Complicated Relationship: Insights from Users' Love/Breakup Letters to Their Smartphones before and during the COVID-19 Pandemic. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 7*, 1, Article 28 (March 2023), 34 pages. `https://doi.org/10.1145/3580792`.

[P3] A Mixed-Method Exploration into the Mobile Phone Rabbit Hole

This publication explores the digital part of the research space (see Figure 4.4), as within MPRH sessions, presence is assumed to be predominantly leaned towards the digital realm. We approached the exploration with a focus on quantitative analysis.

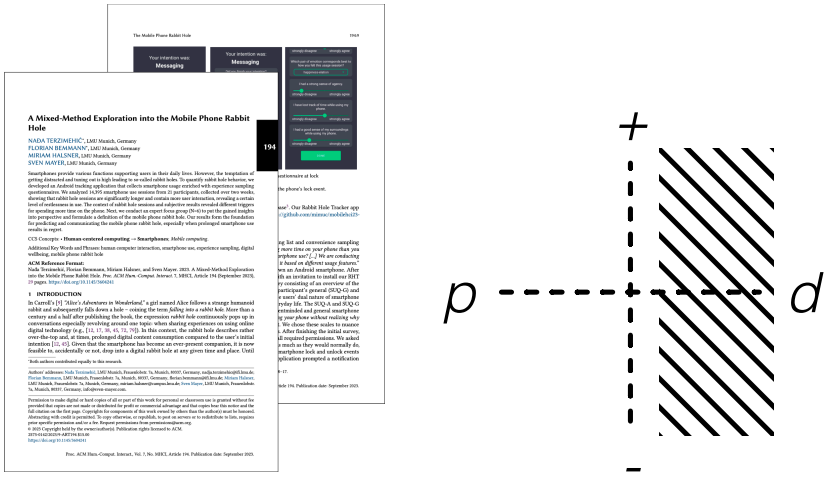


Figure 4.4: [P3] quantitatively investigates individual's perceptions when presence is leaned towards the digital part of the research space, referred to as MPRH, supplemented with a qualitative definition of MPRH.

Summary We conducted a mixed-method analysis of smartphone use behaviors, specifically focusing on MPRH sessions. To do so, we developed an Android app, *Rabbit Hole Tracker*, to track quantitative data related to users' smartphone use, such as screen time and activity recognition. We furthermore employed experience sampling [9] to gather users' perspectives on MPRH sessions, including their intended smartphone use goals and their subsequent smartphone activities. We collected and analyzed 14,395 labeled smartphone use sessions from 21 participants over a two-week period of *Rabbit Hole Tracker* field deployment. Next to the quantitative field study, we conducted a focus group with six HCI experts to expand the understanding and communication of MPRH sessions in potential prevention and intervention scenarios. Findings revealed that MPRH sessions tend to be longer than regular smartphone use sessions and involve increased usage of apps related to gaming and visual entertainment. Users also visited the home screen more frequently during MPRH sessions. MPRH sessions were more likely to occur in the evening and when users were in stable situations, such as being connected to Wi-Fi and having the phone set to vibrate. The study contributes to a deeper understanding of behaviors within MPRH sessions, enabling future research to develop prediction and mitigation strategies.

Reference Nađa Terzimehić, Florian Bemmann, Miriam Halsner, and Sven Mayer. 2023. A Mixed-Method Exploration into the Mobile Phone Rabbit Hole. *Proc. ACM Hum.-Comput. Interact. 7,* MHCI, Article 194 (September 2023), 29 pages. `https://doi.org/10.1145/3604241`

5

ENABLING MINDFUL HYBRID PRESENCE

This section of the thesis introduces a set of digital concepts and working prototypes to promote and facilitate *mindful hybrid presence* in our daily lives. RQ2 embodies the exploration of strategies and designs:

RQ2: *How can mindfulness cues be consciously instrumentalized in digital technology designs to support mindful hybrid presence?*

Whereas related research has stayed within the limits of the digital realm as the intervention method, the following sections present systems and tools that leverage the physical realm as an intervention prompt. These systems have different objectives, but they all share the commonality of perceiving technology use within a real-world context and aiming to increase user awareness of that context or the interaction itself through *mindful reflection* or desired *activity redirection* in the physical world. The concepts behind these two strategies were explored in papers [P4] and [P5], respectively.

Papers [P10, P6, P7, P9, P8] showcase functional prototypes that embody the strategies mentioned within the systems. For each presented prototype, I offer a concise overview of its relevance to the research space, its implementation of the identified strategy, and the approach taken for evaluation, specifically addressing research question RQ3:

RQ3: *In what ways do the instrumentalized digital technology designs promote mindful hybrid presence?*

5.1 Strategies to Promote Mindful Hybrid Presence

[P4] A Review of Mindfulness Research in HCI: Current Lines of Research and Future Opportunities

This publication investigates the treatment of mindfulness in HCI. In terms of exploring the research space, mindfulness embodies the roles of either keeping (awareness of) hybrid presence in the positive, upper section of the space (see the shaded area in Figure 5.1) or move presence from the lower right part (negative digital presence) to the upper, positive quadrants of hybrid presence (see the curved arrow in Figure 5.1).

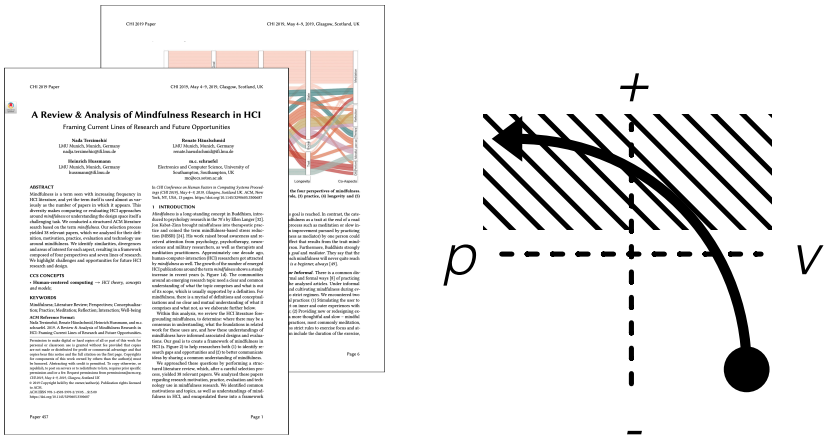


Figure 5.1: [P4] explores the concept of mindfulness in HCI. The goal of mindfulness as strategy is to either maintain hybrid presence within the area of positive influence on well-being (the shaded area in the upper quadrants), or to move presence from the area with negative digital influence to areas with positive influence (the curved arrow).

Summary In order to promote a balanced approach between the physical and digital realms, we explored the concept of mindfulness. One understanding of mindfulness regards it as being fully present in the moment, experiencing and accepting the present moment in its entirety [57]. We thus found mindfulness to be a highly suitable concept to raise awareness within hybrid presence. However, we encountered a lack of clarity regarding defining and applying mindfulness in HCI. To address this gap and gain insights for future research [68], we conducted a systematic literature survey focused on the term *mindfulness* within HCI. Through this systematic survey, we synthesized existing work on mindfulness in HCI until the year 2018, which, after a careful selection process, yielded 38 relevant papers to be reviewed. We identified common motivations and topics, as well as understandings of mindfulness in HCI, and encapsulated these into a framework consisting of current *lines of research*, as well as *perspectives* on mindfulness. The outcome of this study was a comprehensive map of mindfulness research in HCI, which revealed various opportunities for future exploration. Some of these open research avenues include *studying technology (dis)engagement* and examining the relationship between *control and acceptance* in the context of human-technology symbiosis, which we identified as highly relevant for research to be subsequently conducted.

Reference Nađa Terzimehić, Renate Häuslschmid, Heinrich Hussmann, and m.c. schraefel. 2019. A Review & Analysis of Mindfulness Research in HCI: Framing Current Lines of Research and Future Opportunities. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*. Association for Computing Machinery, New York, NY, USA, Paper 457, 1–13. https://doi.org/10.1145/3290605.3300687

[P5] I Wish I Had: Desired Real-World Activities Instead of Regretful Smartphone Use.

This publication qualitatively explores offline activities for the strategy of *activity redirection*, i.e., the transition of presence from the bottom right corner of the research space (negative digital presence) to the upper left corner (positive presence in the physical realm), as in Figure 5.2.

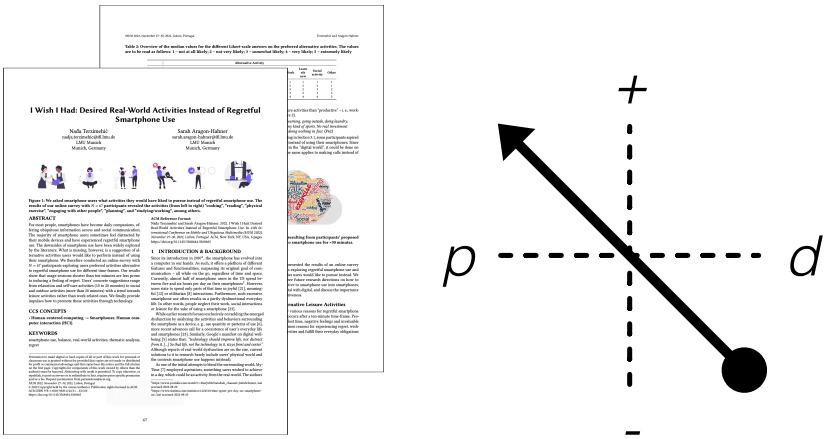


Figure 5.2: [P5] qualitatively explores *activities* beneficial for redirecting presence from the negative digital influence, to positive influence in the physical realm.

Summary Within this qualitative exploration, we follow the perspective of regret [58], i.e., an inference that the "*past might have unfolded differently, particularly if a different decision had been made*" [102], to explore why people feel they should not have used their smartphone and what everyday life activities they would have liked to be redirected to instead of regretful smartphone use. We report insights from a questionnaire executed with $N = 67$ participants, hypothesizing that different smartphone interaction session lengths yield different reasons for feeling regret and diverse desired alternative real-life activities. Our results show that participants stated usually not to feel regret for sessions shorter than ten minutes, unless the user is distracted or the interaction leaves participants in a distressed state, for, e.g., reading bad news or comparing themselves to unrealistic ideals. Users prefer to swap longer smartphone interaction sessions with relaxing, self-care, physical, organizational or social activities – that is, with a trend towards leisure activities rather than work-related ones, challenging the established opinion that smartphones use is detrimental only because of procrastination and decreased productivity.

Reference Nađa Terzimehić and Sarah Aragon-Hahner. 2022. I Wish I Had: Desired Real-World Activities Instead of Regretful Smartphone Use. In *Proceedings of the 21st International Conference on Mobile and Ubiquitous Multimedia (MUM '22)*. Association for Computing Machinery, New York, NY, USA, 47–52. https://doi.org/10.1145/3568444.3568465

5.2 Working Prototypes and Evaluations

All five publications within this corpus present at least one working prototype that has either been evaluated in the field or within lab settings with organic participants. These publications explore the research space as follows:

- [P10, P6, P7] investigate the potential of *preventive* designs or interventions centered around heightened awareness. Their goal is to sustain a mindful hybrid presence in the upper regions of the research space, depicted with the two-sided arrow as in Figures 5.3, 5.4 and 5.7 for papers [P6], [P7] and [P10], respectively.
- [P8] strives to promote an attentive state by transforming potentially unfavorable presence into favorable engagement with technology (depicted with the arrow in Figure 5.5), using the physical realm as inspirational input.
- [P9] suggests an *intervention* to transfer presence from the negative digital to the positive physical space (depicted with the arrow in Figure 5.6), thereby encouraging balance restoration following prolonged digital engagement.

[P6] Implicit Smartphone Use Interventions to Promote Life-Technology Balance: An App-Market Survey, Design Space and the Case of *Life-Relaunched*

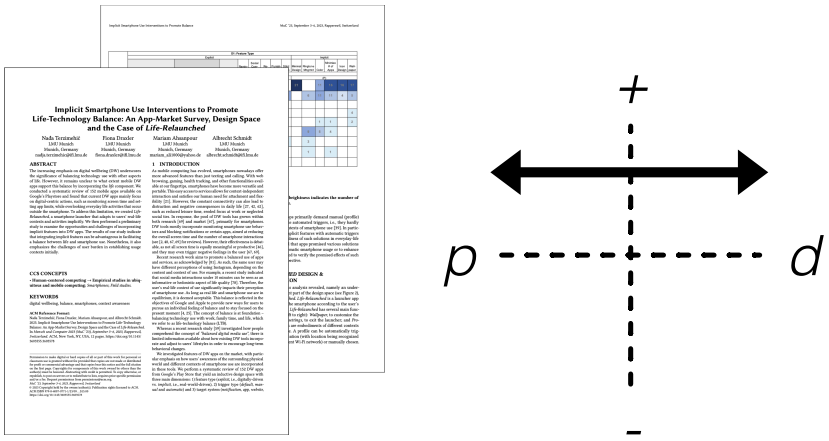


Figure 5.3: [P6] presents *Life-Relaunched*, a mobile app which adapts the smartphone's home screen to its context of use in order to prevent presence tilt towards the negative space, i.e., to sustain a mindful hybrid presence in the upper regions of the research space.

Summary Our previously presented work emphasizes the importance of promoting a balanced use of smartphone apps and services, with users' perceptions of smartphone use being influenced by content and context. Within this work, we refer to the concept of balance as life-technology balance (LTB), evolving around balancing technology use with other activities of everyday life. While some DW apps aim to support this balance, there is limited information on how they incorporate users' lifestyles and everyday contexts. We conducted a systematic review of 152 DW apps on the market that revealed a saturation of digital-related features (such as time monitoring or blocking apps), but a lack of emphasis on everyday real-world contexts and behaviors. Based on these findings, we introduced Life-Relaunched. Life-Relaunched is an Android launcher that automatically adjusts the smartphone's environment based on users' real-life context, *implicitly* reminding users of their current context. In a field study with *N=10* participants, the most commonly used features of Life-Relaunched were home screen adjustment and notification blocking. Participants rarely made changes to the app configurations after the initial setup, indicating a need for more technological support in maintaining LTB.

Reference Nađa Terzimehić, Fiona Draxler, Mariam Ahsanpour, and Albrecht Schmidt. 2023. Implicit Smartphone Use Interventions to Promote Life-Technology Balance: An App-Market Survey, Design Space and the Case of *Life-Relaunched*. In *Mensch und Computer 2023 (MuC '23), September 3–6, 2023, Rapperswil, Switzerland*. ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3603555.3603578.

[P7] MindPhone: Mindful Reflection at Unlock Can Reduce Absentminded Smartphone Use.

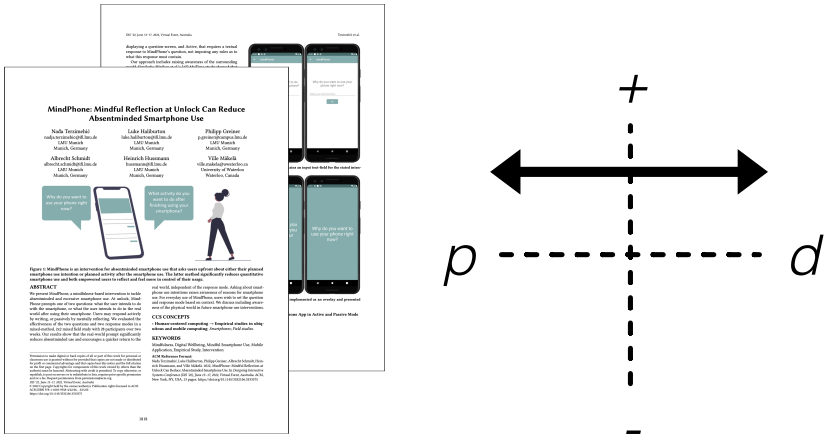


Figure 5.4: [P7] presents MindPhone, an intervention to again prevent tilting presence to the negative space of the digital realm. MindPhone encourages in-the-moment reflection and awareness at smartphone unlock, by either raising awareness of smartphone use intention or activities to be made after smartphone use.

Summary We designed *MindPhone* – a smartphone app-based tool to tame holistic absentminded smartphone use. MindPhone encourages in-the-moment reflection and awareness of people's smartphone use intention ((**I**)ntention question) or their surrounding physical world (Real-World (**A**)ctivity question) at smartphone unlock. We conducted a mixed-method study collecting data over four weeks, including a two-week field deployment of MindPhone with 28 participants assigned in two groups, based on receiving either the (I) or (A) question. Each week, we tracked screen time and unlocks, and gathered absentminded smartphone use questionnaire scores (SUQ-A) [81] and qualitative feedback.

We found that the (A) question significantly reduces smartphone use, while encouraging users to return to the real world. The (I) question raises awareness of reasons for smartphone use. Although quantitative measures of smartphone use increased after stopping the use of MindPhone, participants point to a shift in thinking towards smartphone use. We discuss the implications of setting the focus on the real world in smartphone interventions, as well as personalization to incorporate a periodic use of MindPhone in everyday life.

Reference Nađa Terzimehić, Luke Haliburton, Philipp Greiner, Albrecht Schmidt, Heinrich Hussmann, and Ville Mäkelä. 2022. MindPhone: Mindful Reflection at Unlock Can Reduce Absentminded Smartphone Use. In *Designing Interactive Systems Conference (DIS '22)*. Association for Computing Machinery, New York, NY, USA, 1818–1830. https://doi.org/10.1145/3532106.3533575

[P8] MEMEories: Internet Memes as Means for Daily Journaling.

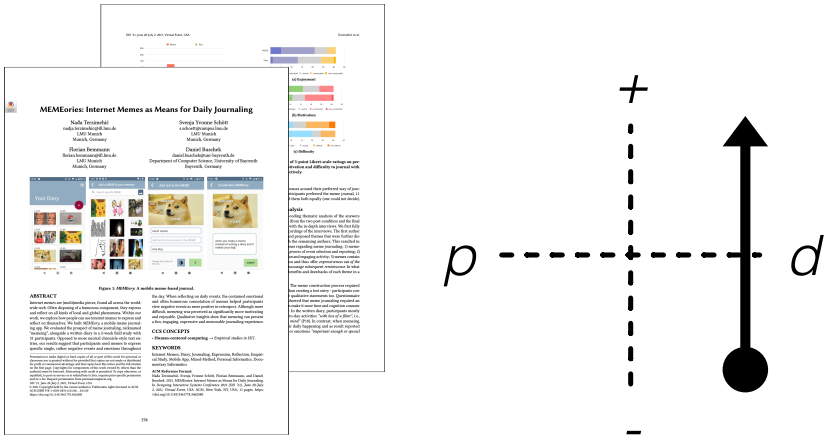


Figure 5.5: [P8] presents *MEMEory*, a daily journaling app that utilizes internet memes as journaling input. As internet memes bear potential to capture presence negatively in the digital realm, we re-purpose memes to raise awareness of individual's daily life to move presence to the upper, positive quadrant (arrow on the right).

Summary Internet memes are highly enjoyable texts, images or videos that spread rapidly on the internet, encompassing humorous and creative content [109] that captures the attention and engagement of users within the digital realm. In this study, we assign internet memes a reflective purpose by utilizing them as a means of daily journaling. We create a mobile journaling application called *MEMEory*, which supports users in their self-reflection by condensing their daily experiences into an internet meme. We tested *MEMEory*, and consequently the concept of using internet memes as journaling input, in a mixed-method field study with N=31 participants over the course of a week, using written diaries as point of comparison for another week. Furthermore, N=7 participants from the field-study participant pool gave in-depth interviews at the end of the study. We provide an empirically rich data set of analyses, consisting of app usage, meme content (i.e., reported topics, sentiment and event granularity in the diary entries), questionnaires (i.e., at the beginning, the middle and the end of the study), and concluding in-depth interviews with a subset of participants from the field study. Conceptually, we contribute the novel idea and first exploration of using internet memes as an alternative visual and humorous expression form to promote self-reflection and engagement in daily journaling. Our results indicate that memes offer out-of-the box emotional processing of specific, rather negative events, with a humorous note. As such, they can facilitate a fun, engaging, expressive and memorable journaling experience.

Reference Nađa Terzimehić, Svenja Yvonne Schött, Florian Bemmann, and Daniel Buschek. 2021. MEMEories: Internet Memes as Means for Daily Journaling. In *Designing Interactive Systems Conference 2021 (DIS '21)*. Association for Computing Machinery, New York, NY, USA, 538–548. https://doi.org/10.1145/3461778.3462080

[P9] Real-World Winds: Micro Challenges to Promote Balance Post Smartphone Overload.

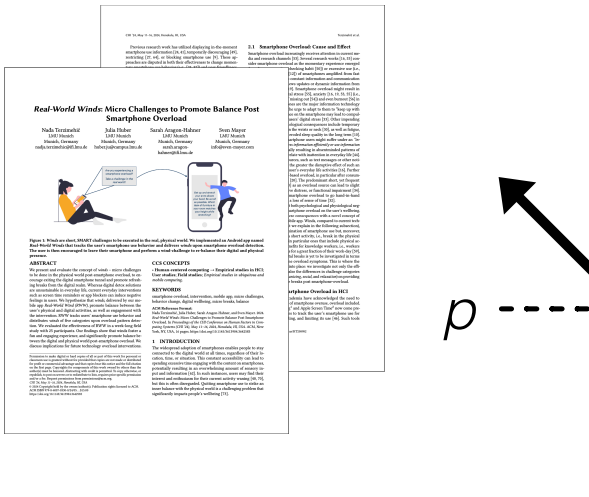


Figure 5.6: [P9] builds on top of [P5] and implements RWW. RWW is a mobile app that encourages exiting the negative space of the digital realm by encouraging executing a small challenge in the physical realm, to re-balance presence (arrow in the right).

Summary Drawing from research on LTB and daily challenges, we develop the concept of *winds*, that is, micro challenges to encourage users to exit the digital smartphone tunnel and engage in real-world activities. The challenges provide specific, achievable goals to promote balance and enjoyment. We implement an Android mobile application called RWW to track users' smartphone use behavior and deliver short two-minute challenge post smartphone overload. We evaluate the app through a one-week, in-the-wild study with $N = 25$ participants. These participants completed 449 challenges across five different challenge categories: *physical exercise*, *mental exercise*, *relaxation*, *organizing task* and *social activity*. The social activity category promotes the highest balance and enjoyment. RWW received high system usability scores and significantly improved participants' perceived life-smartphone balance. Our contribution includes the conceptual development of *winds*, the implementation of RWW, and empirical evidence supporting the effectiveness of discouraging smartphone use in favor of real-world activities for improving life-smartphone balance.

Reference Nađa Terzimehić, Julia Huber, Sarah Aragon-Hahner, and Sven Mayer. 2024. Real-World Winds: Micro Challenges to Promote Balance Post Smartphone Overload. In Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24). Association for Computing Machinery, New York, NY, USA, Article 246, 1–16. https://doi.org/10.1145/3613904.3642583

[P10] Point of no Undo: Irreversible Interactions as a Design Strategy.

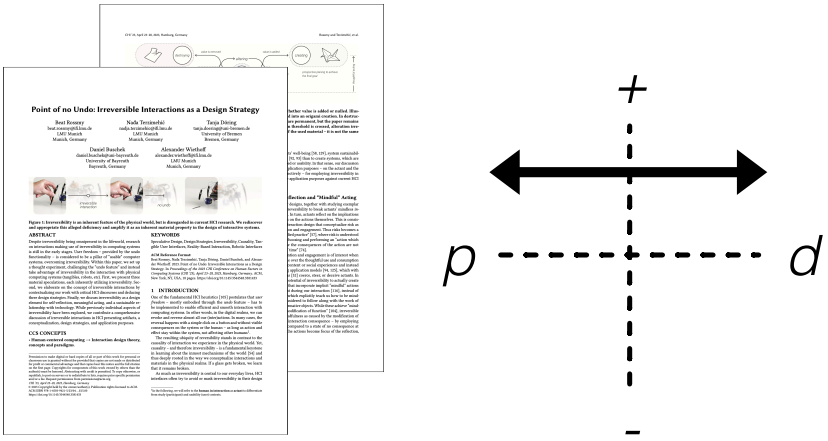


Figure 5.7: [P10] internalizes the real-world pattern of *irreversibility* within a series of technology designs. Their evaluations show the potential of irreversibility to retain presence in the upper quadrants of the space by sparking mindful and reflective acting within the digital realm.

Summary Within this paper, we explore the *undesign* [97] of reversibility within interface design, sharing our observations, insights, and learnings, while not questioning the usability of either reversible or irreversible interactions. As such, we line up with speculative [5] and critical design [7] practices for a critical reflection on the societal and technological status quo, rather than focusing on the *"utility-oriented, featureladen, and productivity-enhancing development of digital technologies"* [50]. In order to inform the design of irreversible interactions, we contribute a comprehensive conceptualization and discussion of irreversible interactions as a topic in HCI. We provide insights from our material speculations [125] and compare our observations with exemplar projects, which fit our understanding of irreversible interactions. The material speculations and their evaluations show irreversibility to spark mindful and reflective acting within the digital realm. From the insights, we derive an initial conceptualization of the properties and factors that shape the qualities of irreversible interactions. We then contextualize related work with our speculations and our conceptualization, and deduce *altering*, *creating*, and *destructing* as design strategies for irreversible interactions. We conclude with application purposes, focusing on reflection and mindful acting, meaningful thresholds, and embedded narrative. We end our discussion with the influence of irreversibility on power and empowerment in HCI.

Reference Beat Rossmy, Nađa Terzimehić, Tanja Doering, Daniel Buschek, Alexander Wiethoff. 2023. Point of no Undo: Irreversible Interactions as a Design Strategy. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23), April 23-28, 2023, Hamburg, Germany*. ACM, New York, NY, USA, 18 pages. https://doi.org/10.1145/3544548.3581433.

6
DISCUSSION AND FUTURE WORK

To regain our full humanity, we have to regain our connectedness with the entire web of life.

– Capra [15]

Within the previous chapters, I reflected on the concept of hybrid presence and proposed mindfulness as one potential strategy for navigating the physical and digital realms within hybrid presence, i.e., mindful hybrid presence. Mindful hybrid presence implies a raised awareness of our actions and thoughts in the realms and suggests the inclusion of the context of the physical realm in the digital. Therefore, section 2.2 wraps up addressing RQ0.

The upcoming sections present the main outcomes of the thesis along the research conducted for RQ1 throughout RQ3. I contextualize these outcomes in relation to related work and offer suggestions for future investigations. After addressing the limitations of the thesis, I conclude the thesis by listing potential intriguing topics that arose during my research and writing process, but that were not extensively covered in my published works.

6.1 RQ1: Affordances and Trade-offs of Hybrid Presence

Through the presented user-centered explorations addressing RQ1, we have gained insights into the complex connection of individuals with the digital realm, as the latter intertwines with the physical realm. All three papers in the exploration corpus of the thesis (see chapter 4) show users often feeling torn and in need of balance between benefits and drawbacks of the digital realm across device levels (e.g., smartphones), application levels (e.g., social media apps), and even within applications themselves (e.g., messaging on Facebook vs. scrolling through news feed). Cho et al. [19] show that the same application can be perceived differently on feature level, whereas we found an ambiguity in affordance perception based on time spent within the application [P5, P3], violated intention of smartphone use [P3] or loss of sense of agency [P1].

One key aspect of affordances is the duality of digital technology through the *assistant* role [P2]. Within this role, technology affords itself to achieve a certain task within the physical realm, ultimately resulting in a perception of gaining competence [P1]. This comes closest to Weiser's vision of the role of ubiquitous computing becoming *"effectively invisible"* [129] and to humans becoming more efficient [48]. However, some people expressed experiencing a decline in competence over time, either through forgetting a skill (e.g., having difficulties with handwriting or remembering numbers) or through the disability of keeping up with technological advancements. However, the emergence of new technologies and their impact on the loss of

existing human skills has been a historical debate going back to the ancient Greeks. They considered writing down knowledge to be harmful to human memory, yet writing has been one of the pillars of knowledge preservation throughout history. With the current ongoing debate on the progression of generative artificial intelligence (AI) tools, the issue of skill loss has the potential to become an even more heated topic.

Another perhaps unexpected affordance we found is user's desire to *escape* the physical realm, in particular when faced with discomfort. This aligns with the role we identified as the *companion* in [P2] (although the companion role encompasses more than just escapism, such as easy portability). Similarly, previous research [26, 75] also observed the significance of escapism in users' interaction with digital technologies. However, our research in [P9] revealed that the most uncomfortable task of social activity brought participants' the highest level of enjoyment and balance. Embracing discomfort as such would align better with the acceptance principle of mindfulness, too. This finding raises a question regarding the design of future technologies in relation to human agency and mindfulness: should we prioritize designing for escape or resilience, control or acceptance (among others)?

The *entertainer* role embodies the significance of hedonic values that the digital realm provides. This finding aligns with previously conducted research on meaningful interactions [84, 85]. In our work, we found a positive framing for the *entertainer* role, however only if enjoyed in an intentional, balanced and non-distracting manner (i.e., not harming other, more important activities, dominantly in the physical realm). In [P3], namely, we found in particular visual entertainment apps to lead to MPRHs, that is, a sense of being absorbed or immersed in the digital realm to the detriment of other aspects of life. Furthermore, MPRH were often experienced with a certain level of restlessness, in quest for the next dopamine shot. A recent study found boredom as strong predictor of users turning to entertainment apps' use [99].

On the opposite side of the see-saw in Figure 4.2 lay the feelings of loss and social pressure. The first can either be momentary, present-oriented losses of the sense of surroundings, of oneself, or time. On the long run, they are coupled with a loss of competence. We encapsulate these negative roles of the digital realm within the *nuisance* and *hinderer* roles in [P2].

People thus seek support and empowerment in technology, while also recognizing the need for detachment and downtime when feeling overwhelmed by it. Opposite to many media and research headlines, our results show a tendency for users to rather cherish and love their devices and services. Consequently, a restrictive, potentially shame-inducing approach could be swapped by rather adopting a balanced approach [P1]. Such balanced approach considers both intentional digital engagement and disengagement, with particularly disengagement becoming crucial to pursue activities in the physical realm or, conversely, to accept moments of boredom and void without constant digital stimuli. However, more research is needed on what constitutes *"balance"* in technology use. There is currently no consensus on what the optimal ratio of technology engagement and disengagement is, as it can vary based on individual short- and long-term preferences and needs, as well as contextual or social circumstances.

6.2 RQ2: Designing Technology for Mindful Hybrid Presence

Technology for mindful hybrid presence requires designs that promote intentional and balanced engagement and disengagement with and from technology, respectively. We introduced two strategies rooted in mindfulness principles – *raising awareness of the context of technology use* and *activity redirection*. These approaches aim to promote self-control and foster deliberate and balanced interactions within the digital and physical realms.

6.2.1 Internalize Design for Intentional and Balanced Use

Our user-centred explorations in [P1, P2] show the dominant need for designing for self-control, a finding also noted by previous research work [78]. Whereas related research and market tools focus on digital behaviors and prompts [4, 78, 92, 100], I take a unique approach by leveraging real-world contextualization as a prompt and inspiration. Our work in [P6] has highlighted the lack of tools in the market that employ real-world contextualization as a strategy for promoting mindful hybrid presence. Consequently, we have developed interventions that embody frictions in [P7], a smartphone alteration in [P6] and activity redirection in [P9]. All approaches showed their potential to foster intentional and balanced use of technology. Specifically, in *MindPhone* [P7], we observed real-world cues to be more effective than digital-only cues in direct comparison.

The presented approaches place the biggest portion of responsibility and burden on the user. In [P2], our users perceived that this should indeed be so. However, recent related work (e.g., [27, 76]) proposes internalizing managing mechanisms within technology itself, sharing the responsibility between users, designers and tech companies, and governance proposal.

To address the designer efforts, we introduced the concept of *irreversibility*. Irreversibility suggests introducing friction or constraints [20] that make it more difficult to reverse certain actions or engage in absentminded digital behaviors. Each step of an irreversible interaction is to be reflected upon, ultimately slowing down the speed of interaction. This internalizes the friction within the UI design itself, offering an alternative to simply adding another layer of control, such as an additional intervention, on top of existing technology.

Our *MEMEories* project [P8] re-purposes addictive internet memes as a tool for positive daily self-reflection and expression. As such, we as designers enable users to still indulge in internet memes, yet assigning internet memes a meaningful purpose to mitigate the sense of loss of time. In the recently developed *SwitchTube* [73], users can toggle between explore mode and focus mode. The first enables exploring the digital realm and thus diverging from their initial intention. The latter helps users stay focused on their intentions by removing features unrelated to the intention. These designs could be perceived as so called *bright patterns* [104], which aim to highlight and promote, among others, healthy and balanced digital behaviors. Their nemesis are attention-capture dark patterns [93, 94], that is, patterns often employed

to keep users engaged and to maximize online activity. Whereas detecting and counteracting on dark patterns has received increased attention recently, there is currently a research gap on exploring the potential of bright patterns to guide users towards more intentional and balanced interaction.

The listed principles are embedded within the software of technology. More recently, Stepanovic et al. [116] explored tangible, physical prototypes to foster intentional and balanced interactions with the smartphone. Similarly, Haliburton et al. [46] explored the principle of a tangible box to physically separate from a smartphone and thus to encourage intentional periods of disconnection, which I touch upon in the next section.

6.2.2 Turn to Offline

In a recent thought experiment on the future of HCI research, Fuchsberger et al. [38] explored the emerging topics and potential future research foci named as *"turns"*. With the shift of a significant portion of our lives into the digital realm caused by the pandemic, they speculated on a potential *turn (back) to nature* and a *turn to offline*. This idea may initially appear contradictory to the hybrid presence argumentation of no true disconnection from the digital world – nonetheless, it sparks the need to (re-)discuss and perhaps redefine the concept of being offline. Current offline practices usually involve the complete exclusion of technology in certain contexts or altogether from everyday life, also known in research circles as *"digital detox"*. The time span of current digital detox practices ranges between 24 hours to four weeks, as a recent review reports [98]. The name of digital detox itself already implies a certain cleanse from the digital influence. However, the idea of hybrid presence questions the necessity of such a long time span, as in [P7] we witnessed a return to old digital behaviors once an intervention is removed. Rather, we envision smaller bursts of intentional and intuitive time reservations throughout the day for experiences and activities in the physical realm.

We contribute to the turn-to-offline movement with our work on *winds* [P9]. In that work, we focused on promoting short tasks to be done in the physical realm, i.e., offline, to encourage exiting the digital tunnel and to regain balance in presence after spending prolonged time in the digital realm. Yet, we only charter the path to new ways of creating more physical, tangible moments in lives marked by hybrid presence. For instance, if digital assistants (or a twin [60]) will be able to achieve most tedious tasks without human interference, will this make up for more opportunities to indulge in other, possibly offline activities? How to design the process to keep the human in-the-loop to mitigate over-reliance on the digital? Further research works will require exploring both the problem and solution space, with possibly doing it ahead of the technology deployment as, e.g., speculations [125] or future workshops [122].

6.3 RQ3: Evaluating Technology for Mindful Hybrid Presence

In order to evaluate the developed prototypes in promoting mindful hybrid presence, we placed emphasis on capturing users' perceptions and gathering feedback to better understand their perceived well-being. Throughout our research works, the measurement approaches have evolved. We initially focused on emotional response and enjoyment in [P8]. Midway, we adopted screen time and the number of smartphone pickups in [P7] as a measure of smartphone use intervention effectiveness. However, we decided to move away from this approach, as recent calls in the field advocate moving beyond mere screen time as the sole metric of success [27], stressing that mere screen time reduction may not always align with what users truly desire [76]. In conjunction with the emerged need for balance in RQ1, we employed evaluating subjective LTB in the most recently published research works [P6, P9].

We investigated user's perceived life-technology balance with a set of the following seven 7-point Likert-scale questions:

Q1 *I spend too much time using my smartphone.*
Q2 *I use my smartphone for the right reasons.*
Q3 *I feel in control of my smartphone usage.*
Q4 *I successfully perform my activities in the real world, regardless of the presence of my smartphone.*
Q5 *I find it difficult to stay in the moment when my smartphone is nearby.*
Q6 *I am satisfied with my life-smartphone balance.*
Q7 *I successfully balance my real-world and digital activities.*

This set reflects several factors we found in related work and our explorations. Whereas user's satisfaction with perceived time spent is reflected in Q1, interference with activities in the physical realm as part of balance [95] are contained in Q4 and Q7. Q2 displays user's perceived meaningfulness of interaction [17]. User's sense of agency over technology use [76] is depicted with Q3. Q5 embodies in-the-moment presence and mindfulness, as per our conducted research. As a future research opportunity, we propose conducting more systematic tests to assess the validity and reliability of the life-technology balance scale.

6.4 Limitations

User-Centered Approach The presented research within this thesis followed a user-centred approach to understand mindful hybrid presence according to the users' beliefs, feelings and opinions on what is right for them. As consequence, we designed and evaluated technologies that correspond to this understanding of (mindful) hybrid presence. Nonetheless, there are several shortcomings with this approach. First, the user-centred design in itself needs re-thinking given that we as humans are no isolated entities on this planet [124]. Although the concept of mindful hybrid presence briefly touches upon this by emphasizing the importance of the environment, be it digital, physical or social, as presented within the thesis is still very individualist-centric. I touch upon this topic further below. Second, we do not claim exclusiveness nor exhaustiveness of the emerged trade-offs or needs within hybrid presence and welcome further investigations and discussions within the research community. Finally, individuals may lack the necessary knowledge to inform their individual notion of the „right fit" within hybrid presence. Future work could benefit from including non-HCI experts, such as physicians, psychologists or philosophers, among others, into discussions around the affordances and challenges surrounding hybrid presence to evaluate the rightness of user's *"right fit"*.

Evaluation Measures and Study Participants In the studies conducted to address RQ3, we used a variety of methods and corresponding measures to evaluate the effect of the implemented technology designs and prototypes on facilitating mindful hybrid presence. While this approach allowed us to explore many facets of the phenomena, it was unable to compare the different approaches with each other. Future work could continue our efforts on the standardization of the developed seven item evaluation scale in [P9] or the development of new, standardized measures. In addition, our studies were rather limited in their duration, participants' diversity and age range. More recently, we published [45] the results of a longitudinal, large-scale study on the use of design frictions to control smartphone-use behaviors, but more research is needed, especially with a more diverse participant pool covering not only the Western culture.

Downsides of Mindfulness By adding the attribute of mindful to hybrid presence, and assigning the concept to the upper, positive quadrants of the research space in section 3.1, we considered mindfulness to be a principle of causing no harm. However, the act of staying in the present within mindful hybrid presence, with heightened attention and acceptance of things as they are might not be the best solution for certain individuals due to, e.g., the trauma they have experienced [35]. More explorations of alternatives to mindfulness might be necessary in this case.

Current Snapshot of Technology Finally, the thesis captures and investigates a snapshot of the current technology landscape. Given the rapidly evolving nature of technology – as I write this thesis, generative AI, available to the masses, is enabling entirely new experiences – user and societal expectations are about to change as new innovations develop. Thus, the findings presented in this thesis might not fully be applicable for future technological advancements and their potential impact on mindful hybrid presence.

6.5 Further Remarks

6.5.1 Ethical and Societal Considerations

The research work presented develops around understanding and promoting mindful hybrid presence through technology for *individuals*. However, the impact of the increasing entanglement of people, *"things"* [124], and technology in hybrid presence extends to society at large. Given the interventive approach of most of the technologies addressing RQ2 & RQ3, future work could extend this idea with a focus on the development and evaluation of group interventions. Again, these are only feasible on a micro-level. On a larger scale, however, there are issues of teaching and learning [91], or setting policy [29] for a wide range of digital behaviors. This work has explored digital well-being, which is also in its infancy - but there is digital etiquette [59], policy [29], digital equality [77], or privacy, to name a few. I do not claim to be exhaustive on these behaviors - these are rather my observations and conclusions that occurred during the synthesis of the work presented within the thesis.

Often, people may not fully comprehend the negative consequences associated with digital presence, especially when it involves sensitive matters such as believing and sharing fake news or sharing content including society members who cannot give active consent, e.g., children or persons with disability. This is where the matter of educating society members becomes important. Our work on irreversibility [P10], in particular the *SocialShredder* material speculation, works towards the goal of implicitly educating digital privacy and security. It aims to raise awareness of the finality of donating private data, such as *likes*, within the online space. Recently, [91] design and evaluate the development of a university course on digital well-being for students, to *"foster the emergence of a new generation of designers and practitioners that considers digital wellbeing and social good"*. Further considerations include developing a set of guidelines, i.e., digital etiquette [59], across multiple research disciplines to tackle online harassment and encourage respectful online communication and digital empathy [37]. Yet, such solutions still require a great amount of effort on the user side to learn and implement these guidelines on top of everyday life obligations. Adding the disinterest of computing companies to safeguard user's digital behaviors – after all, their business model is to exploit and profit from user's increased digital behavior – there emerges a need for governance and policy encouraging responsible use on a larger, legislative level, similar to the European

General Data Protection Regulation (GDPR) policy [1] focusing on general data privacy and protection or the European Union's AI regulation act[2].

Continuing the discourse on data privacy, our presented implemented systems in the second part of the thesis require almost continual tracking, monitoring and analysis of user data to determine patterns, contexts and behaviors of interest for interventions [100]. Although we only briefly mention privacy in [P2], as user's concerns related to privacy issues, it remains a challenge for HCI. In our most recent publication [45], we cooperated with developers of the mobile app *oneSec*[3], a digital intervention app similar to our *MindPhone* [P7]. *OneSec* also relies on user's data to deliver an intervention. Contrary to the majority of current interventions, it employs opt-in instead of the common opt-out method, storing all user data locally with user's sharing their data for analysis only if explicitly volunteering to do so.

Finally, we presented work that reflects experiences and attitudes of citizens within the global West. Yet, optimal hybrid presence envisions a future of technology that is accessible and inclusive, regardless of the user's cultural, socioeconomic status or background. Currently, there is a divide in access to technology and the online-to-offline benefit of using technology (also referred to as *third-level digital divide* [120]). This hinders social equality [120], with further concerns evolving around the confirmation of existing biases that are associated with the rise of AI [77].

6.5.2 Hybrid Presence Beyond Current Ubiquitous Computing

It is difficult to imagine the concept of hybrid presence not expanding beyond the notions presented within this thesis and current ubiquitous computing paradigms. Presence research already centers around VR computing devices, but now augmented and mixed reality are increasingly being added to the mix and evaluated in lab and the field. In particular augmented and mixed reality bear great potential of providing novel experiences with permanent audio, video and even tactile digital signals added to the physical environment. Keichi Matsuda's video on HYPER-REALITY[4] depicts a dystopian insight into a potential development of these technologies and life as such. Additionally, humanoid robots and amplified humans are envisioned to participate space and perform a range of tasks only humans were able to do, which might raise interesting existential questions for humans. In light of these rapid advancements, recent research efforts (e.g., [40]) propose reconsidering the notion of presence to trespass its borders currently bound to VR.

In light of these developments, I conclude my dissertation with an eagerness to follow and participate in further discourse on the concept and influence of hybrid presence as the boundary between the physical and the digital continues to irreversibly close.

[1] https://gdpr-info.eu/

[2] https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai

[3] https://apps.apple.com/tt/app/one-sec-delay-apps-focus/id1532875441

[4] https://www.youtube.com/watch?v=YJg02ivYzSs&ab_channel=KeiichiMatsuda

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List of Acronyms

AI artificial intelligence.

DW digital well-being.

FOMO fear of missing out.

HCI human computer interaction.

HP hybrid presence.

LTB life-technology balance.

MPRH mobile phone rabbit hole.

MR mixed reality.

RV reality-virtuality.

RWW *Real-World Wind*.

UI user interface.

VR virtual reality.

My Publications

[P1] Terzimehić, N., George, C., Häuslschmid, R., and Hussmann, H. "On Ubiquitous Technology, a Digital World and Their Influence on People's Feeling and Control of Presence In Everyday Life." In: *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*. CHI EA '21. Association for Computing Machinery, 2021. DOI: 10.1145/3411763.3451831.

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Original Contributing Publications

The research presented in this thesis is a result of continued support and collaboration with my thesis' advisers, professors, colleagues as well as supervised students from the MIMUC group and beyond. The following Table 6.1 presents the contributing share within the publication corpus included in this thesis.

	My Contribution	Contribution of Other Authors
[P1]	I came up with the idea and developed the concept of this work together with C. George and R. Haeuslschmid. I developed and conducted the focus group with C. George. The online survey was conducted and analyzed by me and R. Haeuslschmid. I wrote the paper in a leading role.	C. George and R. Haeuslschmid contributed to the original concept and draft. H. Hussmann contributed to the framing of the paper and provided feedback on the draft.
[P2]	The ideation and concept development were mine. I conducted the study and data analysis together with S. Aragon-Hahner. I wrote the paper in a leading role.	S. Aragon-Hahner contributed to the analysis and co-wrote the paper. H. Hussmann contributed to the framing of the paper and provided feedback.
[P3]	The idea for the project was mine. I developed the concept with F. Bemmann. I developed the focus group guideline and analyzed its results with F. Bemmann. I wrote the original draft with F. Bemmann in equal contribution.	This work is based on M. Halsner's master's thesis. M. Halsner implemented the Android data logging app and conducted the data collection study. F. Bemmann and S. Mayer did the quantitative analysis. S. Mayer provided feedback and contributed to the paper's framing.
[P4]	The idea for the literature survey was mine. I performed the paper set analysis with R. Hauslschmid in equal contribution. I further developed the framework with R. Haeuslschmid and H. Hussmann providing close feedback. I wrote the original draft in a leading role.	R. Haueslschmid performed the paper analysis with me and co-wrote the paper. m.c. schraefel contributed to the discussion and to the framing of the paper, providing feedback on the draft, together with H. Hussmann.
[P5]	I came up with the initial idea and developed the questionnaire together with S. Aragon-Hahner. I was the leading author and project lead.	S. Aragon-Hahner helped in the thematic analysis and in writing the paper.

[P6]	I came up with the project idea and concept. I developed the design space together with M. Ahsanpour and the study design with F. Draxler. I led the paper writing process.	This project is based on M. Ahsanpour's master's thesis. M. Ahsanpour developed the Life-Relaunched app and conducted the field study. F. Draxler helped with the study design and co-wrote the paper. A. Schmidt helped with framing the paper and provided feedback.
[P7]	The idea and concept for the project are mine. I performed the qualitative data analysis. I wrote the paper in a leading role.	This work is based on P. Greiner's bachelor's thesis. P. Greiner implemented the Android app and conducted the field study under my guidance in a leading role. L. Haliburton and V. Maekelle helped in the study design. L. Haliburton conducted the quantitative data analysis and helped in writing the paper. V. Maekelle, H. Hussmann and A. Schmidt contributed to the framing of the paper and provided feedback.
[P8]	The idea and concept for this project are mine. I did the data curation, and performed the data coding with S. Schoett. I performed the qualitative data analysis and wrote the paper in a leading role.	This work is based on S. Schoett's bachelor's thesis. S. Schoett implemented the Android app and performed the field study under the guidance of me (in a leading role), F. Bemmann and D. Buschek. F. Bemmann and D. Buschek contributed to the framing of the paper and provided feedback on the draft.
[P9]	I was responsible for the idea, concept and data analysis. I wrote the paper in a leading role.	This work is based on J. Huber's master's thesis. J. Huber upgraded the Android app from a previous bachelor's study and conducted the field user study, based on my and S. Aragon-Hahner's guidance and concept ideas. S. Mayer and I performed the quantitative data analysis. S. Mayer helped in writing the paper, partly based on J. Huber's thesis.
[P10]	I was included in developing the concept of irreversibility and the design strategies. I helped in framing and writing the paper.	B. Rossmy developed the main idea and the individual project concepts, co-designed and co-implemented the three artifacts together with the students (T. Fütterer, S. Bouzir, P. Kim). T. Döring supported the paper writing. D. Buschek, and A. Wiethoff offered conceptual help and support. The students executed the individual experiments.

Table 6.1: Overview of the contributions on the publications included in this thesis.

Writing Aids

This thesis fully reflects my and my co-authors' thoughts and concepts. I employed ChatGPT[5] to either concise, expand or to rephrase text in order to clearer communicate the developed concepts and research ideas. Additionally, I employed DeepL for rephrasing[6] the text and for automated language translations[7].

[5] https://chat.openai.com/

[6] https://www.deepl.com/write

[7] https://www.deepl.com/translator

Eidesstattliche Versicherung

(Siehe Promotionsordnung vom 12.07.11, § 8, Abs. 2 Pkt. 5)

Hiermit erkläre ich an Eidesstatt, dass die Dissertation von mir selbstständig und ohne unerlaubte Beihilfe angefertigt wurde.

München, den 08. September 2023

Nađa Terzimehić