Tampere University

Bakhtawar Aurangzeb Khan

EMERGENCE OF TECHNOSTRESS IN MULTI-USER VR ENVIRONMENTS FOR WORK-RELATED PURPOSES

Master of Science Thesis
Faculty of Management and Business
Examiner: Professor Henri Pirkkalainen
Examiner: Professor Jouni Kivistö-Rahnasto
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ABSTRACT

Author : Bakhtawar Aurangzeb Khan
Master of Science Thesis
Tampere University
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The virtual reality market is growing exponentially with forecasts indicating the global virtual reality market-scale to rise by almost eighty-three percent from 2022 by 2025. Social virtual reality is the virtual environment designed to function as a communication platform—comprising of multi-user characteristics such as shared spaces, avatar-based interactions, and tools facilitating remote collaboration. Despite the use of virtual reality and social virtual reality in organizations, the research highlighting the stress experienced by the users of multi-user virtual reality environments in organizations remain sparse. To address this gap in the research, this study applies the concept of technostress. While prior literature on technostress has highlighted several stress creating conditions with severe consequences (i.e., strains) for organizational use as well as use of virtual reality and social virtual reality, very little remains known about the stress creating conditions and the emergence of technostress in users using multi-user virtual reality in a work-related setting. A qualitative analysis using the critical incident technique was employed in this paper to highlight the stress creating factors and subsequent strains due to using social virtual reality in the organizational context. Semi-structured interviews were conducted with open-ended questions to glean the experiences of the users who are active in the multi-user VR environments for work-related purposes. The study identified four stressor categories which contained various stress creating conditions relevant to the context and therefore contributing to the existing literature of technostress. The study also identifies two strain categories that emerged. Furthermore, the study discusses the common patterns between the technostressors and the subsequent strains, opening new avenues of research on this topic.

Key words: Technostress, Technostressors, Strains, Virtual Reality, Organizational Context

PREFACE

I am very grateful to acknowledge the invaluable contributions of many important people in my life who have played pivotal roles in influencing my journey as I reach the finish line of my master's degree.

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Bakhtawar Aurangzeb Khan

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LIST OF ABBREVIATIONS

3D	Three-Dimensional
AEC	Architecture, Engineering, and Construction
AI	Artificial Intelligence
AR	Augmented Reality
CEO	Chief Executive Officer
DOF	Degrees of Freedom
HMD	Head Mounted Displays
ICT	Information and Communication Technology
IS	Information Systems
IT	Information Technology
MR	Mixed Reality
MUD	Multi-User Dungeons
SVR	Social Virtual Reality
TSST	Trier Social Stress Test
USA	United States of America
VE	Virtual Environment
VR	Virtual Reality
VRISE	Virtual Reality-Induced Symptoms and Effects
XR	Extended Reality

1. INTRODUCTION

Social Virtual Reality (SVR) is the virtual environment (VE) designed to function as a communication platform, encompassing multi-user attributes including avatar-based interactions, shared spaces, and tools facilitating remote collaboration (Torro, Jalo, & Pirkkalainen, 2021). Recent times have witnessed a substantial growth in SVR applications, owing to technological progress that has enabled Virtual Reality (VR) to host immersive multi-user experiences (Torro et. al, 2021; Jalo et al., 2020). As of now, the VR market is growing exponentially with forecasts indicating that the global VR market scale is anticipated to rise from under 12 billion U.S. dollars in 2022 and exceed to 22 billion U.S. dollars by the year 2025 (Statistica, 2023). Despite the growth trajectory of VR, there is very little research on its negative impacts on the organizational as well as social aspects. The active utilization of Information and Communication Technologies (ICT) is a necessity across various industries. As organizations seek new ways for innovation and performance improvement through ICT, it becomes essential for the organizations to become familiar with the potential adverse consequences associated with ICT usage. One of such negative consequences is the technostress (Pirkkalainen et. al, 2017; Tu et al., 2005). Brod (1984) described technostress as a modern disease which stems from an individual's incapacity to manage ICTs in a healthy way. There has been increasing recognition of technostress's impact on workplace performance and well-being, as understanding stress at the workplace is crucial. Technostress at the workplace represents a significant occupational health issue that impacts the physical and mental well-being of employees, while also influencing employee productivity and engagement overall (Tarafdar et al., 2007; Tarafdar et al., 2011; Wang et al., 2008).

Although technostress is a recognized phenomenon, its presence, and implications within the context of SVR for work-related purposes is yet to be thoroughly investigated. Therefore, to understand the stress creating factors triggered by multi-user VR environments in organizational-use context, and to fill the gap in prior research, this thesis aims to answer the following research question:

RQ: How does technostress emerge among individuals who use multi-user VR environments for work-related purposes?

To address the research question and gain insight of perceived stress nuances in VR, twenty semi-structured interviews with individuals who had used VR multi-user environments for work, were conducted. The questions for the semi-structured interviews were developed in accordance with the qualitative content analysis guidelines (Lune & Berg, 2017) and the critical incident technique (Gremler, 2004).

To address the research question, the structure of the paper is as follows: Chapter 2 through 4 delve into the foundation of the study, providing a foundational overview of the research, introducing the central themes of VR, SVR, and technostress. Chapter 2 gives an overview of VR, beginning with an introduction to the technology itself. It then delves into the advancements in VR technologies, including Head-Mounted Displays, tracking systems, and virtual environment interaction. The chapter also discusses the diverse applications of VR in various contexts.

In Chapter 3, the focus shifts to SVR. It explores the characteristics of SVR, such as immersion, presence, and interactivity. Additionally, the chapter introduces the role of avatars in SVR within virtual environments.

Chapter 4 discusses the transactional view of technostress and identifies its triggers, particularly within organizational settings. The overview of existing technostressors at the workplace is provided, along with the strains induced by information technology in the workplace.

Chapter 5 discusses the methodology employed in this study, outlining the approaches to data collection and analysis. The process of participant selection and the utilization of semi-structured interviews are detailed, providing a robust foundation for subsequent analysis.

Chapter 6 discusses the results of the study and is structured into categories of stressors related to hardware, software, social aspects, and coping with virtual-physical realities. It also explores the strains experienced by individuals in these categories, both physiological and behavioral.

Chapter 7 continues with the results of the study. In this chapter, common patterns within the stress-creating conditions and strains are identified and analysed. It also examines the associations between stressors and strains, particularly behavioral and physiological strains.

Chapter 8 engages in a comprehensive discussion of the research findings. It confirms and extends previous findings related to technostress and its implications in VR and SVR. The chapter also discusses the research's contributions, both in terms of academic knowledge and practical applications, while acknowledging its limitations. It concludes by proposing avenues for future research, paving the way for a holistic understanding of the convergence between technostress of multi-user VR environments in the organizational setting.

2. VIRTUAL REALITY

According to Pallavicini et al., (2019), VR is defined in several ways as it is characterized not only as a technology (Angelov et al., 2020) but also as an application or experience. According to Jason Jerald (2015), virtual reality is *“a computer-generated digital environment that can be experienced and interacted with as if it were real”* where the primary goal is to immerse an individual in the virtual environment in a way that they are fully engaged in VR and forget about the real world. Biocca & Delaney describe VR as *“the sum of the hardware and software systems that seek to perfect an all-inclusive, immersive, sensory illusion of being present in another environment”* (1995, p. 63).

In the context of extended reality (XR), VR is a component that falls under this umbrella term (Lee, 2021). XR encompasses VR, mixed reality (MR) and augmented reality (AR), (Lee, 2021), as illustrated by the Reality-Virtuality Continuum (Figure 1) by Milgram & Kishino (1994). The Reality-Virtuality Continuum depicts the extent to which these technologies supplement the real world (Angelov et al., 2020).

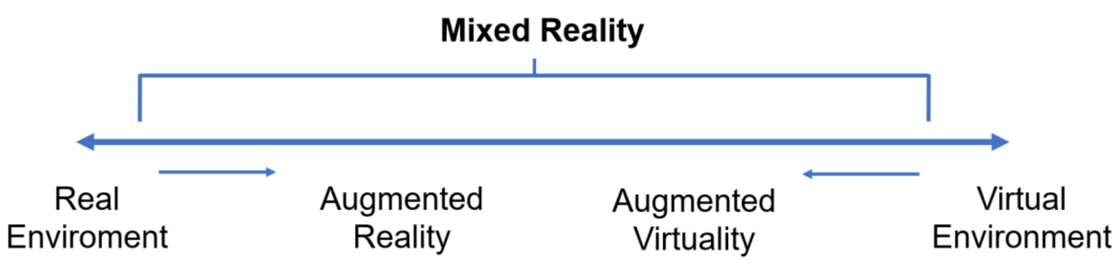

Figure 1 *Simple representation of Reality-Virtuality Continuum (as illustrated by Milgram & Kishino, 1994, p. 3)*

Through a head-mounted display (HMD), VR offers complete isolation from the physical environment. According to the Reality-Virtuality Continuum, this allows users to exclusively perceive the VE situated at the rightmost side (Lee, 2021). In contrast, AR enables users to view the physical environment while a wearable device overlays virtual objects onto it (Lee, 2021). MR devices, as a synthesis of both experiences, blend virtual and physical elements seamlessly (Angelov et al., 2020). VR attains the highest level of virtuality, making it the most immersive experience when compared to AR and MR, according to the continuum (Angelov et al., 2020).

2.1 Evolution and advancement of VR Technologies

The concept behind VR technology is not a recent development (Weech et al., 2019; Slater & Sanchez-Vives, 2016). Its origins trace back to the work of Sutherland when he introduced the initial concept i.e. "Sword of Damocles" in 1968 (Pausch et al., 1997; Slater & Sanchez-Vives, 2016), which was deemed the first known HMD. According to Weech et al., (2019) the "Sword of Damocles" display only depicted objects as wireframes. Over the past decade, the VR industry has experienced noteworthy advancements, owing to technological progress (Lee, 2021) and substantial reductions in production costs (Angelov et al., 2020). These advancements have led to greater accessibility and enhanced quality, resulting in a rapid surge of interest in VR among consumers, researchers, and business enterprises (Mütterlein & Hess, 2017; Angelov et al., 2020; Pallavicini et al., 2019). Due to its unparalleled capacity to deeply engage its users, VR technology holds significant potential in a variety of fields, as compared to conventional media (Pallavicini et al., 2019). The introduction and subsequent release of Oculus Rift (Oculus) in 2013, followed by the commercial VR sets availability led the public interest in VR to grow exponentially (Pallavicini et al., 2019).

Technological advancements have made it possible to develop expansive and immersive virtual environments featuring high-quality graphics. (Weech et al., 2019; Morie, 2006). Computers and head-mounted displays have witnessed significant improvements, resulting in more powerful devices with highly detailed displays (Angelov et al., 2020). Moreover, HMDs are more user-friendly, reliable, and comfortable (Morie, 2006). Additionally, since the prices have reduced, VR is now experiencing the widespread adoption that was initially envisioned in the late 1980s (Mütterlein & Hess, 2017; Martel & Muldner, 2017; Slater & Sanchez-Vives, 2016). The following sections discuss some of the VR technologies like VR HMDs, tracking and interaction.

2.1.1 Head-Mounted Displays

HMDs are wearable devices worn on the user's head and constitute a primary component of VR sets. When wearing an HMD, the user's visual perception from the physical environment is completely isolated, immersing them in the VE. (Cho et al., 2017; Lee, 2021). According to Angelov et al., (2020), modern VR HMDs can be classified into two main categories: standalone and tethered.

Standalone HMDs: Standalone HMDs incorporate a built-in computer responsible for generating the displayed VE and do not require external computing hardware. Additionally, embedded sensors track the HMD's position, adjusting the user's perspective as per the head movements. (Angelov et al., 2020). Standalone devices offer benefits like comfort and enhanced mobility due to their independence from external devices. However, they come with certain disadvantages due to their compact size and reliance on internal batteries—such as limited computing power and usage time (Angelov et al., 2020). Some examples of standalone HMDs include HTC Vive Pro 2, Meta Quest and Meta Quest 2 etc.

Tethered HMDs: Tethered HMDs require a connection to a computer since they lack built-in computing hardware. The computer they are connected to handles the necessary computations, resulting in superior performance and virtually limitless usage time. However, a drawback of tethered HMDs is the need for a cable connection to the computer, which can affect the comfort of the user (Angelov et al., 2020). Examples of tethered HMDs include Sony PlayStation VR, Oculus Rift and HTC Vive—all from 2016, to name a few. Apart from the two main categories, there are also other types of HMDs emerging, such as the hybrid HMDs and mobile HMDs.

Hybrid HMDs: Hybrid HMDs are specifically designed to accommodate both tethered and standalone operating modes (Angelov et. al, 2020). Hybrid HMDs offer users the flexibility to choose between two options: utilizing their internal hardware to operate as standalone HMDs or connecting to an external computer and functioning as tethered HMDs. This duality allows users to tailor their VR experience based on their specific needs and preferences. Examples of Hybrid HMDs include Valve Index, Meta Quest 2, Meta Quest Pro etc.

Mobile VR HMDs: The primary component of the Mobile VR HMDs, as the name suggests, is the user's smartphone. These devices operate similarly to standalone HMDs (Angelov et al., 2020). However, it is important to note that mobile VR devices lack the capability for direct interaction with the VE. One advantage of mobile VR devices is their relatively lower cost compared to other HMD classifications, as they leverage the user's own smartphone for operation (Angelov et al., 2020). Google's Cardboard (Google) is one such example of mobile VR HMD, which serves as an HMD made of cardboard. Users insert their mobile phones into the device, essentially using the phone's screen as the display for the VR experience (Google; Angelov et al., 2020).

2.1.2 Tracking

According to Bekele and Champion (2019), tracking is "*the process of determining users' viewpoint position and orientation.*" The extent of VR immersion primarily relies on the efficiency of the tracking system. In modern VR headsets, tracking is an important component (Angelov et al., 2020). Pal, Khan, and McMahan (2016) and Cummings and Bailenso (2016) have also emphasized the significance of tracking, particularly the tracking levels i.e., the degrees of freedom (DOF) provided, and its accuracy in positively influencing the sense of presence experienced during VR interactions.

Generally, there are three types of head-tracking (Pat et. el, 2016) which have been summarized in table below:

Table 1 Types of head tracking (Pat et. al, 2016)

Types of head tracking	Description
Positional Head Tracking (6-DOF)	Among the three types of tracking, positional tracking is the most prevalent in modern VR headsets and has been consistently recognized to offer the most optimal user experience (Cummings & Bailenson, 2016; Angelov et al., 2020;).
Rotational Head Tracking (3-DOF)	This involves the monitoring of rotation of the HMD, enabling the user's perspective to adjust as they turn their head. This functionality allows the user to freely explore the VE by looking around in any direction (360^0).
Translational Head Tracking (3-DOF)	This involves monitoring the user's head position which allows them to change their location within the virtual environment, consequently altering their viewpoint. It provides users with motion parallax cues, which are depth cues that are taken from observing objects from various angles

Types of head tracking	Description
	(Cummings & Bailenson, 2016; Narayan et al., 2005;)

Apart from the head-tracking, there are two categories for tracking which is used by modern VR headsets i.e., Inside-out and Outside-in (Angelov et al., 2020). These types, as described by Angelov et. al., (2020) have been summarized in table below:

Table 2 Types of tracking systems (Angelov et al., 2020)

Types of tracking systems	Description
Inside-out	The cameras are directly placed on the tracked device, and they depend on either cues from markers or the environment to oversee their tracking. The key benefit of the inside-out tracking approach is its convenience, as it removes the requirement for external tracking equipment.
Outside-in	Outside-in tracking entails the utilization of external cameras or sensors to observe the position and motion of the tracked devices. These external cameras are typically placed in the environment and track the movements of the devices, such as VR headsets or motion controllers, as they interact within the designated tracking area. This method allows for precise and accurate tracking but may require additional setup and calibration compared to inside-out tracking.

2.1.3 VE Interaction

Interaction with the virtual environment is an essential aspect of modern VR sets (Boletsis, 2017). This interaction generally comprises two modes: navigation and object interaction in VE.

Navigation: "VR locomotion" is commonly used to describe various methods and techniques for navigation in Ves in prior research (Slater et al., 1995). According to Boletsis

(2017), there are four distinct types of VR locomotion which have been categorized based on the interaction method, motion style, and the spatial context of the interaction. The categories have been summarized in the table below:

Table 3 Distinct types of VR Locomotion (Navigation) by Boletsis (2017) with illustrated examples

VR Locomotion (Navigation) type	Description	Examples
Motion-based	The locomotion techniques in this category rely on physical movements to facilitate interaction while maintaining continuous motion in open VR environments.	Swinging arms, walking-in-place, redirected walking, gesture-based locomotion, and reorientation
Room-scale based	Room-scale based locomotion leverages physical movement that enables interaction and allows for continuous motion. However, the key distinction is that the interaction occurs within VR environments limited by the size of the real physical space.	Real walking locomotion
Controller-based	In control-based locomotion, users employ controllers to achieve artificial movement within the VE. The VR interaction space is open and allows for a continuous and uninterrupted motion.	Joystick-based, human joystick chair-based and head-directed locomotion.
Teleportation-based	In teleportation-based locomotion, VR techniques involves non-continuous movement with artificial interactions in open VR. Instead of a continuous motion,	Point and teleport locomotion

VR Locomotion (Navigation) type	Description	Examples
	the user's viewpoint in VE is instantly teleported to predefined positions with the help of visual "jumps".	

Each VR locomotion (navigation) type has its advantages as well as disadvantages. For instance, controller-based techniques are less physically demanding compared to room-scale or motion-based navigation, as users can move in VE while remaining stationary in the real physical world. However, these techniques are more prone to causing VR sickness (discussed more in following sections).

On the other hand, room scale-based techniques enable continuous movement, but their effectiveness is constrained by the physical environment's size. Boletsis (2017) discovered that VR locomotion types allow for smooth and uninterrupted movement and were highly preferred. These preferred types include room scale-based, motion-based, and controller-based techniques.

Object interaction in VE: There are several ways to interact in VE via objects. This includes using input devices such as mice and keyboards (Martel & Muldner, 2017; Lum et. al, 2018) and also video game controllers (Weech et al., 2019). Other interaction methods include hand gestures and track controllers, (Han & Kim, 2017; Angelov et al., 2020; Lum et al., 2018; Lee et. al, 2017). In addition to their role as input devices, controllers can also offer tactile feedback to the user (Angelov et al., 2020). This tactile feedback is made possible through the use of haptic systems, enabling users to interact with objects in the VE and also sense and feel them (Kim et. al., 2017; Han & Kim, 2017).

2.2 VR Utility in Different Contexts

VR technologies have been demonstrating their applicability across various domains such as the military and psychotherapy, medicine and neurosurgery (Pallavicini et al., 2019; Slater & Sanchez-Vives, 2016; Mehrfard et al., 2019). In neuroscience, VR serves as a very powerful tool for body representation (Slater et. al, 2016). Immersive virtual reality has also been researched for visualizing astronomical phenomena, in educational as well as professional purposes (Schaaff et al., 2015). In education, the scope of VR is extensive. For instance, for learning geometry (Hwang & Hu, 2013), conducting virtual field trips (Çaliskan, 2011) and transforming social interaction (Bailenson et al., 2008). VR is being used for surgical trainings and has demonstrated its efficacy in multiple studies, supported by thorough analyses and assessments (Zendejas et al., 2013; Al-Kadi et al., 2012; Lorello et al., 2014). Other uses of VR include its application in physical training, cultural and social experiences, news and entertainment and virtual collaboration (Slater et. al, 2016). VR has also become an integral part of everyday home entertainment and a noteworthy example of this trend is the Meta Quest 2 headset, which achieved remarkable sales, surpassing those of Microsoft's Xbox Series S and X game consoles. (Hayton, 2022).

VR was first used in organizations in the 1990s, with the introduction of the first functional VR devices (Berg and Vance, 2017; Walsh and Pawlowski, 2002). The utilization of VR in the organizational context encompasses various applications. For instance, it has been utilized in behavioral therapy (Fox et al. ,2009) and remote collaboration (Du et al. ,2018). Furthermore, it has also been used in education (Dede, 2009; Dede et al., 2017). VR has been adopted for employee onboarding (Warnke, 2022), along with simulation and training scenarios. In recent times, advancements in technology have enabled VR to facilitate multi-user experiences, resulting in a significant growth in SVR applications (Jalo et al., 2020; Torro et. al., 2021). This has been discussed more in detail in the following chapter.

3. SOCIAL VIRTUAL REALITY

According to Torro et. al (2021), social virtual reality serves as a communication platform in a VR environment. It includes various multi-user attributes such as shared space, interaction through avatars, and tools that facilitate remote collaboration. A significant difference between the other multi-user VEs and SVR is the aspect of spatial interactivity and immersion—as it contributes to the user experience of co-presence. (Schultze, 2010; Torro et. al, 2021). SVR has the capacity to simulate face-to-face interaction which is seamless and intuitive. This is why SVR has gained recognition as an "ideal" platform for communication and collaboration (Slater and Sanchez-Vives, 2016, p. 27).

Previously, VR usage has been perceived as isolating due to its focus on single-user experiences (Kim et al., 2013). However, a new trend has emerged with the advent of SVR, where interactions are facilitated among multiple users within the same virtual space through avatars (Perry, 2015). According to Mütterlein and Hess (2017), among the promising applications of SVR, enhancing professional collaboration has been quite prominent. For instance, in the Architecture, Engineering, and Construction (AEC) industry, SVR can help in providing a shared spatial understanding of proposed designs of the buildings which would enhance collaboration between end-users and designers (Paes et al., 2017; Portman et al., 2015). Practitioners have identified various valuable use cases for SVR, as it fosters more comprehensive collaboration within virtual environments (Perry, 2015). Consequently, SVR has the potential to enhance organizational performance through its capacity to foster collaboration among diverse stakeholders across industry value chains. It also enables seamless teamwork, particularly in scenarios where in-person meetings are impractical (Jalo et al., 2020). However, when it comes to SVR utility in an organizational context, the literature remains sparse.

3.1 Characteristics of SVR

The three key defining characteristics that make SVR a unique experience and affect the human observations are the presence, immersion, and interactivity/interaction. (Mütterlein 2018; Bailenson et al. 2008; Walsh 2002). Schultze (2010) described presence as the feeling of "being there" in a VR environment, where simulated sensory data and user perception create a coherent place. It's about feeling present and acting in the virtual space as if it were real. Meanwhile, immersion is the extent of emotional engagement and involvement in the virtual environment, influenced by factors like sensory realism, panoramic displays, and contextual avatars (Schultze, 2010). Enhanced immersion can also lead to an effective sense of presence. The relationship is: immersion shaped by technological features (realism/sensory fidelity) influences the sense of presence. (Schultze, 2010). Interactivity is described as a psychological state of mind, specifically perceived interactivity, where the level of perceived interactivity varies based on individual perspectives and experiences with VR (Mütterlein, 2018). A significant difference between the other multi-user VEs and SVR is the aspect of spatial interactivity and immersion—as it contributes to the user experience of co-presence. (Schultze, 2010; Torro et. al, 2021). These key defining characteristics have been discussed more in detail in the following sub-sections.

3.1.1 Immersion

According to Agrawal et al., (2020), different fields researching immersion have provided varied definitions for the term 'immersion.' Various approaches have been put forward to assess or characterize immersion, depending on the particular situation. These approaches use different terminology and sometimes use similar terms with either converging or slightly varying explanations, as per the context. (Lee, 2021).

Despite variations in its definition, the general understanding of immersion suggests a state in which an individual feels surrounded by a particular experience or environment (McMahan, 2003; Ermi & Mäyrä, 2005; Nilsson et al., 2016 for example). Many researchers reference Murray's (1997) book, "Hamlet on the Holodeck," to explore the origins of the term and illuminate the ambiguity surrounding its usage (e.g., Brooks, 2003; Nilsson et al., 2016; Arsenault, 2005; Lee, 2021; Agrawal et al., 2020):

"*Immersion is a metaphorical term derived from the physical experience of being submerged in water. We seek the same feeling from a psychologically immersive experience that we do from a plunge in the ocean or swimming pool: the sensation of being surrounded by a completely other reality, as different as water is from air, that takes over all of our attention, our whole perceptual apparatus.*" (Murray, 1997, p. 98).

The different views of immersion can be summarized as the contrast between immersion as a subjective experience and immersion as a technology (Nilsson et al., 2016). According to Nilsson at al. (2016), there are four general perspectives of immersion that can be identified: immersion as a reaction to the unfolding narrative or world depicted; immersion as a characteristic of the system presenting the virtual world; immersion as the system's perceptual response; and immersion as a response to challenges that involve intellectual or sensorimotor abilities.

Table 4 Types of Immersion by Dede at. al, (2017) with examples

Type(s) of Immersion	Definition	Example(s)
Social immersion	Meaningful social interactions among participants within a common mixed or virtual reality setting enhance their level of immersion. In the physical world, people engage in collaborative decision-making and problem-solving processes, utilizing their surroundings to achieve objectives. When a virtual or partially virtual environment replicates such interactions, it fosters a stronger connection with the user, enabling them to feel deeply engaged and integrated within it.	• In a VR multiplayer game, players can interact, communicate, and strategize with each other, creating a strong sense of social immersion within the gaming community. • Attending a virtual conference in VR allows participants to network, exchange ideas, and engage in discussions, simulating a realistic social immersion experience. • Sharing a virtual workspace with colleagues in VR enables seamless collaboration, fostering a socially immersive environment for remote teams
Actional Immersion	Providing participants in an experience with the ability to initiate actions that lead to intriguing outcomes. The excitement of discovering new abilities to influence their surroundings serves as a	• In a VR game, players have the freedom to explore and influence the virtual world, creating actional immersion through interactive gameplay.

Type(s) of Immersion	Definition	Example(s)
	strong motivational factor, sharply honing their attention.	• Through physical interactions with virtual objects, users experience actional immersion, shaping the environment and driving the experience forward. • Empowering participants to make consequential decisions in a narrative-driven VR adventure fosters actional immersion, keeping them engaged and motivated.
Symbolic/Narrative Immersion	Creating strong semantic connections through the narrative of an experience. Narratives play a vital role in motivating and engaging learning across different domains. By invoking intellectual, emotional, and normative archetypes, the experience is enriched, adding an intricate layer of interconnected mental models.	• Solving symbol-based puzzles in a VR escape room makes users feel immersed in symbolic elements. • Exploring a VR art gallery with abstract artworks creates a sense of symbolic immersion. • Role-playing as a character in a VR story-driven game immerses users in a narrative-rich environment.
Sensory Immersion	Sensory immersion is when users utilize an immersive display, such as HMD, a cave automatic virtual environment, or a	• Using HMD in a VR roller coaster simulation, the user

Type(s) of Immersion	Definition	Example(s)
	digital dome, which provides a panoramic view of a virtual world, enabling them to imagine themselves as part of the experience.	experiences sensory immersion as they feel the thrilling motion and visual stimuli. • In a digital dome environment, participants are enveloped by a 360-degree projection, creating sensory immersion in an astronomical journey through space. • Through tactile feedback gloves in a VR surgical training simulation, medical students sense sensory immersion as they perform virtual surgical procedures with realistic touch sensations.

Improving the intensity of any of the aforementioned types of immersion elevates the overall level of immersion experienced in VR. Whether it involves any immersion or a combination of different immersion types, it has the potential to elicit psychological immersion, a mental state characterized by complete absorption and profound engagement with the virtual environment (Dede et al., 2017, p. 3). Immersion in SVR includes not only the sense of being in the virtual environment but also the sense of being in a shared space with others. Immersion here involves not only the environment but also the social interactions themselves.

3.1.2 Presence

Presence is defined as "*the subjective experience of being in one place or environment, even when one is physically situated in another*" (Witmer & Singer, 1998). Achieving presence is an important aspect in VR (Weech, 2019). Skarbez et al. (2017) noted that presence is a desirable result of engaging with VEs and a metric for evaluating their overall quality. The mind processes sensory input from the surrounding environment, leading to a formation of a hypothesis regarding its location. According to Slater (2003), presence emerges when the stimuli generated by technology outweigh those from the actual world, resulting in an illusion of presence, where the mind perceives itself to be situated in the VE, despite being aware of its virtual nature (Cairns et al., 2014; Slater, 2018). Due to this perceptual illusion, users respond to virtual stimuli in a manner similar to how they would react to real stimuli. when the perceptual system identifies a potential threat, the brain-body system instinctively responds, even though it may only recognize later that the threat was non-existent (Slater, 2018). In the context of VR, this significant aspect of presence makes it a highly valued tool (Weech et al., 2019).

In 1997, Lombard and Ditton identified six different forms that collectively constitute the sense of presence i.e., transportation, immersion, social richness, realism, medium as social actor and social actor within medium. Alternatively, Biocca (1997) proposed another widely cited typology of presence, which categorizes it into three types i.e., social presence, physical presence, and self-presence (Lee, 2021). A short summary of each type has been provided in Table 5 below:

Table 5 Categories of Presence by Biocca (1997) with examples

Type of presence	Description	Example(s) in VR setting
Social presence	This involves a feeling of being connected and engaged with other intelligences within the virtual environment. It encompasses both perceptual experiences, such as perceiving the presence of others, as well as cognitive experiences, which include the sense of interacting and communicating with them in the virtual space.	• Interacting with virtual characters and engaging in conversations, the user experiences social presence in a virtual social gathering. • Collaborating with remote team members through avatars in a virtual office, the user feels socially present in a collaborative VR environment. • Participating in a multiplayer VR game and communicating with other players, the user senses social

Type of presence	Description	Example(s) in VR setting
		presence in the virtual gaming community.
Physical presence	It is the experience of feeling present within the VE and is commonly associated with the sensory stimulation provided by the technology, which gives rise to the sense of being in the virtual space.	• Wearing a VR headset and navigating through a virtual museum, the user feels physically present among historical artifacts. • By using motion controllers to climb virtual mountains, the user experiences physical presence within a VR adventure game. • Engaging in a virtual firefight and feeling the impact of gunfire, the user senses physical presence in a combat simulation.
Self-presence	Self-presence pertains to the mental models, physiological responses, and emotional states of the user within the virtual environment—and the user's virtual self is experienced as if it were their actual self. This involves a deep sense of identification and embodiment with the virtual avatar.	• Through a realistic VR simulation, the user develops a profound self-presence, perceiving their virtual avatar as an extension of their true self. • Experiencing intense emotions in response to virtual events, the user's self-presence deepens, ultimately blurring the line between their virtual and real identities.

Type of presence	Description	Example(s) in VR setting
		• The user becomes fully immersed in the virtual environment, achieving a strong sense of self-presence and feeling as if they are genuinely present in the digital realm.

While presence is the primary goal of technology, achieving a fully immersive experience requires physical as well as mental involvement, in addition to presence. In other words, mere presence in the VR environment is not sufficient for an engaging VR experience. For true immersion, users need to actively engage their minds and bodies, becoming mentally absorbed and physically responsive to the virtual stimuli and interactions. This combined involvement of the physical and mental state creates a more profound sense of being present in the virtual world, enhancing the overall immersive experience. In Social VR, presence goes beyond individual immersion; as it also involves feeling present with other users.

3.1.3 Interactivity/Interaction

Steuer (1992) describes interactivity as the "*degree to which users of a medium can influence the form or content of the mediated environment*" (p. 80). Interactivity can be understood as a psychological state of mind, specifically perceived interactivity, where the level of perceived interactivity varies based on individual perspectives and experiences with VR (Mütterlein, 2018). Factors such as personal background and prior exposure to virtual reality may influence how individuals perceive and interpret the level of interactivity in each VR environment or its content. Research on the psychological aspects of how individuals perceive interactivity provides evidence that individuals' subjective interpretations of interactivity vary based on their psychological states and prior experiences (McMillan & Hwang, 2002), supporting the notion of perceived interactivity being influenced by personal factors in virtual reality contexts. In Social VR, interactivity extends to interactions with other users' avatars. Avatars in social virtual environments enable users to visually represent themselves, express their identity, and engage in non-verbal communication, enhancing social interaction and collaboration. They contribute to the immersive experience by fostering a sense of presence and personalization, making virtual spaces more accessible and engaging for users.

3.2 Avatars

An avatar is the visual depiction of a real user within a VE. Research has broadened the avatar concept to encompass the user's character or alter-ego, reflecting on how individuals may present themselves online, which could diverge from their true offline identity (Miller, 2011; Coleman, 2011). According to Peterson (2005), avatars can be described as digital representations of oneself within a VE, intended to facilitate interaction in that space (p. 30).

In virtual settings, the use of programmable avatars allows individuals to interact anonymously, leading to a heightened ability to communicate and express themselves compared to their real-life interactions. This can result in an increased sense of social connection and enhanced confidence (Falloon, 2010). Supporting this notion, Katz and Rice (2002) conducted research demonstrating that in virtual environments, the cyber-relationships formed tend to be resilient and long-lasting. According to Woolgar (2002), cyberspace has the potential to function as a medium for facilitating particular social activities and relationships, rather than merely replacing real-life experiences, as commonly believed.

Avatars can exist as graphic or visual avatars in a 2-D or a 3-D format. Example of a 2-d format are the icons in various online communities and forums whereas examples for 3-D avatars can be seen in digital games and virtual worlds. (Apperley & Clemens, 2017). Avatars can also take the form of textual descriptions, as seen in Multi-User Dungeons (MUDs) (Blascovich, 2001). In such environments, users create and interact with characters represented through written descriptions rather than graphical or visual representations.

3.2.1 Avatar design and their perception

In essence, avatars offer a wide array of emotional and behavioural expressions, allowing for diverse forms and styles that cater to individual preferences. Suler (2007) presents two avatar categorizations, comprising personality types and custom avatars.

While the personality types encompass personal traits that draw parallels to clinical diagnoses, suggesting a connection between avatars and users' personalities. (Narcissistic, manic, obsessive/compulsive, paranoid etc.)

Avatars, as digital representations of users, can vary significantly in their appearances, ranging from realistic human-like representations to fantastical or abstract forms. These avatars elicit different reactions from users, influencing their attitudes, behaviours, and social interactions. The multifaceted nature of avatar design and its impact on user perception and engagement has been highlighted in prior research. For instance, Slater and Steed (2001) discovered that avatars resembling realistic humans, but not meeting those expectations, were often labelled as "zombies." This labelling stemmed from initially high expectations that the avatars failed to fulfil. In contrast, Johnston and Thomas (1982) emphasized that for effective communication of sentience and emotional awareness, animated characters do not necessarily need realistic features. Smith (2001) argued that highly realistic game avatars could limit experimentation, while users reported greater individuality and self-expression with customized avatars. Westerman et al. (2015) identified the "halo effect," where physically attractive avatars were seen as more socially and task attractive, even cartoonish human avatars, boosting user confidence by mimicking their physical characteristics.

The characteristics of avatars have been discovered to significantly impact the behaviours and attitudes of avatar users, not only within the virtual environment but also in contexts beyond avatar use. This phenomenon has been termed the "Proteus effect." (O’Donnell, 2014). Avatars have the potential to influence users based on the version of the self they represent. Previous research provides evidence supporting this notion, indicating that using an avatar that embodies the ideal self (i.e., desired facets of the self) as opposed to the actual self (i.e., current traits possessed by the user) can result in improved psychological well-being (Bessière et. al, 2007), a stronger psychological connection to the avatar and VE (Jin, 2009) and more positive self-perceptions (Kim and Sundar, 2012).

4. TECHNOSTRESS

Even though the positive aspects of technology are widely known and researched, there has been an emergent interest in the different ways the technology does not have favorable affects in the organizational and social life. (Tarafdar et. al, 2013). In 1984, clinical psychologist Craig Brood introduced the term technostress (Gaudioso et al., 2017). Technostress affects individuals who struggle to manage information technology (IT) in a positive way (Tarafdar et al., 2007; Ayyagari et al., 2011). Simply put, technostress encompasses the negative impact on human behavior (including attitudes, thoughts, and psychology) caused by using technology (Tu et al., 2005).

Technostress has been explored in various domains, including the medical field (Arnetz and Wiholm, 1997), psychology (Brod, 1984), as well as from economic and organizational perspectives (Brillhart, 2004; Wang et al., 2008; Tarafdar et al., 2005). Within professional settings, technostress is linked to the utilization of workplace IT devices (like laptops and tablets etc.) and the IT applications extensively employed by organizational IT users as part of their routine work activities (Ayyagari et. al, 2011; Tarafdar et. al, 2019; Tarafdar et. al, 2007). Past research has indicated numerous technologies where technostress has emerged, for example technostress due to social networking sites (Maier et al., 2015; Whelan et al., 2020 and 2022) and use of artificial intelligence (Xia, 2023; Henkel et. al, 2020). Furthermore, since modern technology networks and mobile devices provide constant connectivity, it induces individuals to feel under constant supervision and invaded in their personal space, leading to elevated stress levels (Clark et. al, 1996). Additionally, many ICT applications, including enterprise resource planning systems, often fall short of fully aligning with business needs, necessitating significant modifications. Despite these modifications, technical issues like computer crashes and lag in applications persist, requiring time-consuming troubleshooting and support. Consequently, this situation fosters dissatisfaction and a sense of incapacity to manage challenges, often resulting in stress (Fisher at. al, 1999).

For over thirty years, the negative effects of using VR have been documented by various researchers (Grassini and Laumann 2021; Souchet 2020; Fuchs 2017, 2018; Melzer et al. 2009; Sharples et al. 2008; Nichols and Patel 2002; Cobb et al. 1999; Keller and Colucci 1998; Kennedy et al. 1993) but while technostress is a well-known phenomenon, its existence and implication in SVR under work-use context remains widely unexplored.

4.1 Transactional View on Technostress

Lazarus (1966, 1993) emphasizes that it is the individual's perception of the demand conditions, rather than the requirements themselves, which might make for a stressful situation. For instance, two individuals could have different perspectives on a similar situation. Similar empirical studies (Zhao et al., 2020; Wang & Yao, 2021) have confirmed that individuals evaluate various technostressors differently.

One of the predominant theoretical frameworks in order to understand technostress has been the ‘The transactional view of stress’. (Lazarus and Folkman, 1984; Lazarus, 1966;). The transactional model examines the relationship between stress creators (technostressors) and subsequent outcomes (strains) and in return, highlights the negative effects of IT, as illustrated in Figure 2. (Cooper et al., 2001; Lazarus, 1993)

Figure 2 *Transactional View of Stress*

Since the literature on technostress of VR/SVR in an organizational context is sparse, this section explores the existing studies on IT technostress and linked technostressors and subsequent strains in the work-use context in a way that is implicit to VR technostress.

4.2 Technostressors

Stress creators, or technostressors, are the IT-use related factors that cause technostress. (Li & Wang, 2021; Califf & Brooks, 2020; Tarafdar, 2007;). These factors are perceived as threatening or demanding by the individual and can also be the conditions in which the perceived demands of IT-use exceed the individual's available resources. (Ragu-Nathan et al., 2008; Ayyagari et al., 2011; Tarafdar et al., 2019).

Extensive research has highlighted different sources of technostress and its subsequent effects in both professional and personal (non-work-related) IT contexts. One example of technostress is the stress that arises from an excessive influx of notifications on personal devices (Galluch et al., 2015). Another example stems from the perceived demand of being readily availability through different online communication channels (Ayyagari et al., 2011). Prior technostress studies discuss technostress in context of compulsive use (Hsiao et al., 2017), security policy (D'arcy et al. 2014), SNS stressors and social overload (Maier et al. 2015), IT stressors (Ragu-Nathan, 2008), job demands and tasks, (Salanova et al. 2014), and increased IT use (Hudiburg 1989).

Technostress varies across organizational and personal contexts (Salo et al., 2019). The following section explores technostressors in an organizational setting.

4.3 Technostressors in an Organizational Setting

While technostress has been studied in both organizational and non-organizational information IT contexts, early research focused more on the organizational use of IT. Major information systems (IS) journals are increasingly discussing the significance of technostress in the workplaces across different industries and its documented detrimental effects on well-being and performance of the employees (Tarafdar et al. 2015a; Ayyagari et al. 2011; Pirkkalainen and Salo 2016). Technostress experienced by employees has been the subject of research in diverse industries, including studies conducted among sales professionals (Tarafdar et al., 2015), librarians (Ahmad, Amin, & Ismail, 2012), security personnel, business users of IT and employees in various other sectors (Shu, Tu, & Wang, 2011). Technostress at the workplace represents a significant occupational health issue that impacts the physical and mental well-being of employees, while also influencing employee productivity and engagement overall (Tarafdar et al., 2007; Wang et al., 2008).

As organizations seek new ways for innovation and performance improvement through ICT, it becomes essential for the organizations to become familiar with the potential adverse consequences like technostress associated with ICT usage. In an organizational context, technostress is the stress caused by the use of IT by individuals in a working environment. (Ragu-Nathan et al., 2008; Tarafdar et al., 2010). Ayyagari et al. (2011) and Tarafdar et al. (2007), among many researchers, provide theoretical and empirical evidence that the conditions which induce technostress, stem from technology use-related demands at the workplace. In 2008, Ragu-Nathan et al. identified sources of technostress experienced by employees who utilize ICTs in their work. These stressors include techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty. Hwang and Cha (2018) proposed similar technostressors for security-related employees, which included techno-overload, role conflict, role ambiguity, techno-uncertainty and even techno-complexity. Ayyagari et al. (2011) identified techno-stressors faced by business users of ICT, which included role ambiguity, workload, work–home conflict, privacy invasion, and job insecurity. In 2014, Lei and Ngai (2014) identified similar technostressors such as work–home conflict, invasion of privacy, and role ambiguity, however, they did not consider the specific occupations of the users.

Table 6 below outlines technostressors commonly found in a work-related context, as identified in prior literature, experienced by users utilizing ICTs in their work. It is important to note that the sources cited in Table 6 represent a subset of the numerous instances in prior literature that have explored technostressors due to IT within the workplace.

Table 6 Technostressors due to IT in the workplace

Work-related technostressors	Description	Sources
Techno-overload	Techno-overload arises when users must invest more time and effort to meet demands posed by IT usage. IT professionals often experience overload due to multitasking, productivity demands, and information load, leading to extended workdays and potential negative effects on well-being.	Tarafdar et al., 2007; Ragu-Nathan et al., 2008; Yun et al., 2012; Ayyagari et al., 2011; Tarafdar et al., 2011; Sellberg & Susi, 2014;
Techno-invasion	The rapid and unpredictable work environment can result in a feeling of techno-invasion, blurring work-personal boundaries due to constant availability pressure and integration of work-related IT into daily life. Balancing	Yun et al., 2012; Tarafdar et al., 2007; Harris et al., 2022; Ragu-Nathan et al., 2008; Tarafdar et al., 2011; Kim & Lee, 2021;

Work-related technostressors	Description	Sources
	work-family boundaries becomes challenging, increasing turnover intention and burnout.	
Techno-uncertainty	The constant evolution of IT presents challenges for employees, creating techno-uncertainty due to ongoing changes and the need to learn new systems. This uncertainty can lead to reluctance in adopting new IT tools. Moreover, frequent introductions of new IT can make existing skills outdated, causing frustration and anxiety among users	Tarafdar et al., 2011; Hwang & Cha, 2018; Tarafdar et al., 2007; Ragu-Nathan et al., 2008; Zhang, et. al, 2016
Techno-complexity	Gaining new IT skills can be time-consuming and challenging due to growing complexity. This difficulty is termed as techno-complexity	Sellberg et. al, 2014; Tarafdar, 2007; Ragu-Nathan et al., 2008; Tarafdar et al., 2011;
Techno-insecurity	Techno-insecurity is the fear of job loss to more skilled IT users. IT complexity can make employees feel inadequate, leading to frustration and helplessness. IT professionals also experience	Tarafdar et. al, 2011; Hwang & Cha, 2018; Zhao et al., 2020; Ragu Nathan et al., 2008; Tarafdar et al., 2007; Khlaif & Ayyoub, A., 2022

Work-related technostressors	Description	Sources
	technostress due to techno-insecurity.	
Work-home conflict	Balancing work and family have become harder, especially with remote work and widespread IT use. This intensifies pressure, leading to higher stress from work-home conflict.	Ayyagari, 2011; Ragu-Nathan et al., 2008; Tarafdar et al., 2007; Hwang & Cha, 2018; Yun et al., 2012; Kim et al., 2015;
Role ambiguity	Role ambiguity involves uncertainty about role expectations. IT factors like technology presenteeism and the changing technological speed affect role ambiguity experienced by employees.	Cooper et al., 2001; Ayyagari et al., 2011; Ragu-Nathan et al., 2008; Tarafdar et al., 2011; Hwang & Cha, 2018;

4.4 Strains due to IT in the workplace

According to Cooper et al. (2001) and Kahn and Byosiere (1992), the subsequent behavioral, and physiological and psychological effects of stress on people is the 'strain'. Some of the adverse consequences of technostress in IT, with their description and associated examples are summarized in Table 7 below:

Table 7 Categories of Strains due to IT in the workplace

Category	Description	Examples	Source(s)
Behavioral	Challenges or issues related to human behavior that can affect the use and implementation of IT systems.	Increased absenteeism, turnover, and a decline in the intention to continue using IT.	Tarafdar et.al., 2011; Ragu-Nathan et al., 2008; Tarafdar et.al., 2010; Maier et.al., 2015; Galluch

Category	Description	Examples	Source(s)
			et al., 2015; Califf & Brooks, 2020
Psycho-logical	The negative psycho-logical impact on an individual's mental and emotional well-being caused by stressors.	Burnout, decreased user and job satisfac-tion, exhaustion, con-centration problems and organizational as well as continuance commitment.	Gaudioso et. al., 2017; Reinecke et. al., 2017; Tarafdar et.al, 2010; Tarafdar et.al, 2011; Wang et. al., 2008; Salo et.al., 2019; Zhao et al., 2022
Physiolog-ical	The negative impact on an individual's physical well-being caused by stressors.	Increased stress hormone levels, nausea/headaches (VR sickness), and in-creased heart rate	Galluch et. al., 2015; Riedl et. al., 2012; Arnetz et.al., 1997; Riedl 2012,

Strains are subsequent consequences of stress that can arise from several factors including interruptions caused by IT (Tams et al., 2018), breakdown of IT systems (Riedl et al., 2012), and prolonged use of IT applications (Afifi et al., 2018). Various studies have highlighted strains in the workplace including loss of productivity (Tarafdar et al., 2007), declining work performance, lower job satisfaction (Ayyagari et al., 2011; Srivastava et al., 2015; Tarafdar et al., 2014; Aktan & Toraman, 2022), turnover intention (Galluch et al., 2015; Califf & Brooks, 2020), and burnout (Zhao et al., 2022).

4.5 Technostressors and Strains in VR and SVR

Even though there are not many studies on technostress in SVR under organizational setting, there have been separate discussions on technostress in the work-settings that use ICT. Relevant stressors and strains pertaining to technostress in the workplaces that use ICTs have been highlighted above. When it comes to VR, there have been studies on virtual reality-induced symptoms and effects (VRISE), introduced by Cobb et al. (1999). VRISE risks have already been identified in the EU-OSHA brochure on digitalization in 2019 as it represents genuine issues that result in a negative user experience.

(Souchet, 2023). Possible factors of VRISE in an organizational setting include cybersickness, visual fatigue, muscle fatigue and musculoskeletal discomfort, acute stress, and cognitive overload (Souchet, 2023). A short summary of these VRISE factors in organizational setting has been summarized in table below:

Table 8 Summary of VRISE factors in organizational setting

VRISE factors	Description	Examples of empirical studies on VRISE
VR sickness	VR sickness include visual fatigue, disorientation, headaches, paleness, perspiration, dry mouth, satiety, vertigo, lack of movement coordination (ataxia), queasiness, and fatigue.	Souchet et. al (2023); Coburn et al. (2020); Zielasko et. al. (2021); Boges et. al (2020); Caserman et. al (2021);
Visual fatigue	Physiological burden or stress caused by excessive strain on the visual system (Lambooij and IJsselsteijn, 2009).	Szpak et. al, (2020); Jacobs et al. (2019); Yoon et al. (2020); Chen and Hou (2021);
Muscle fatigue and musculoskeletal discomfort	The decline in muscle performance and strength due to prolonged or intense use. It also includes the sensations of pain, unease, or strain in the bones, muscles, ligaments, and tendons of the body.	Tulder et. al, (2007); Ahmed et. al (2017); Li et. al (2020b); Evangelista et. al (2021); Iqbal et. al (2021);
Acute stress	The state of uncertainty in an individual about what needs to be done to safeguard physical, social or even mental well-being (Peters, 2017)	La Torre et al. 2019; Brivio et al. 2018; Ragu-Nathan et al. 2008; Tarafdar et al. 2015; Tarafdar et al. 2019; Tarafdar et al. 2020;

VRISE factors	Description	Examples of empirical studies on VRISE
Cognitive overload	When the amount of information or tasks presented to an individual surpasses their cognitive capacity to process, leading to reduced comprehension and decision-making ability.	Zhang et. al (2017); Filho et. al, (2018); Speicher, Hell, et al (2018); Speicher, Feit, et al (2018);

It is important to note that the empirical studies mentioned in Table 8 above dealt with induced symptoms and effects of VR and do not explicitly discuss technostress.

Based on the discussion above, the existing literature implicitly recognizes the existence of technostress in VR/SVR in an organizational setting, despite the sparse theoretical or empirical analysis on the subject. Figure 3 below identifies the research gap and the focus of this study. While there has been separate research conducted in understanding stressors and subsequent strains in the workplace and in using VR, empirical research on the existence of technostress while using VR/SVR in an organizational context remains unexplored.

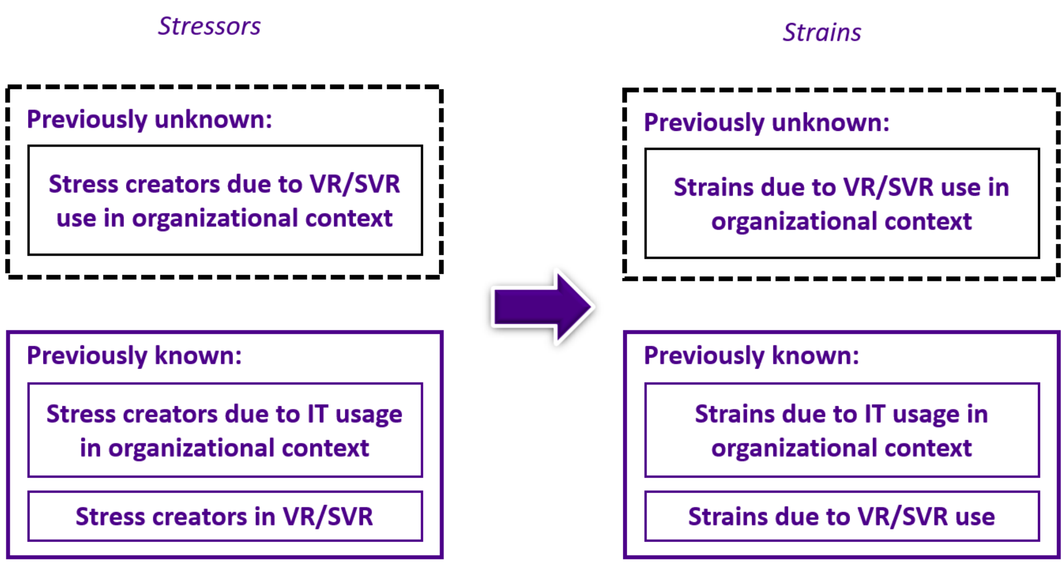

Figure 3 *Identifying the research gap and the focus of this study.*

5. RESEARCH METHODOLOGY & MATERIALS

Semi-structured interviews (Brinkman, 2014) were used to capture the user's viewpoint on VR-related stressors, and the subsequent strains. This approach was chosen as it helped in identifying the stressors of multi-user VR in an organizational context and the subsequent strains by encouraging the participants to discuss in context of stress. Using semi-structured interviews as the primary data collection tool allowed an insight on various aspects that have not been uncovered before, along with the context-specific explanations of VR use and subsequent consequences i.e., strains (Venkatesh et al., 2013). Data collection was carried out via semi-structured interviews to gain insight from the user's experiences on the existence of technostress in VR. By using this approach, speculations about hypothetical scenarios were actively avoided while focusing on the actual experiences of the users (van der Heijden, 2012).

5.1 Participant Selection

For this study, twenty semi-structured interviews were conducted from users who had used VR and SVR in an organizational context. Purposeful sampling (Patton, 1992) was utilized and the criteria for the chosen sample were that the individual was an active VR user in organizations who use multi-user VR environments for work purposes (e.g., attending networking events or running team meetings) and were willing to share their experience of using VR in a multi-user context. While the study aimed to have a diverse sample, it also recognized the need for data saturation. The interviews were monitored closely, and it was ensured that the new interviews continued to provide valuable insights and not simply repeat what had already been gathered.

To ensure diversity in the sample and gather comprehensive insights, the inclusion criteria for participants included individuals who were currently employed in various organizations where multi-user VR environments are utilized for work-related purposes; individuals representing different professional backgrounds and roles within their organizations; individuals from different professional backgrounds to capture a wide range of perspectives and individuals with varying levels of experience using VR technology. The selection efforts included contacting potential participants through professional networks, industry forums, and online platforms related to VR technology and organizational use context.

In addition to the primary participant selection, a **snowballing technique** was applied to broaden the pool (Babbie 2014; Lopes et al. 1996;). After conducting interviews with initial participants, they were requested to recommend other individuals who met the inclusion criteria and might be interested in participating. This approach facilitated access to potential participants who might not have been reachable through traditional selection methods and thus allowed for a more diverse and varied sample for this study.

While more than sixty individuals were contacted for the interviews, twenty participants were finalised based on the criteria mentioned above. The average duration of the interviews was between thirty-five to ninety minutes, and they were mainly carried out via video meeting tools (i.e., Microsoft Teams) as the participants were from different parts of the world. The interviews were recorded with the consent of the interviewees. These interviewees represented various roles across countries. The roles included Chief Executive Officer (CEO)s, founders, technology experts, managers, artists, developers, educators, and more, from countries such as the USA, Germany, Finland, France, and Turkey. A succinct summary of the interviewees has been provided in table 9 of chapter 6 below.

5.2 Semi-structured Interviews

The interviews were conducted in early 2023. For data contextualization (Klein and Myers, 1999), the participants were requested to provide insights into their background, the VR devices they use and their usage frequency. Additionally, participants were asked to share the purposes and applications of VR devices in their organizational settings, specifically focusing on multiuser experiences, along with the extent of their VR engagement.

During the interviews, participants were asked about negative or stressful situations they encountered while using VR in an organizational setting, the causes behind these feelings, and their reactions to such stressors. They were also inquired about interruptions while using VR and any security/privacy concerns in the multiuser setting. Participants reflected on how negative feelings affected their VR usage and if they took any measures to alleviate them. Additionally, the influence of external factors on their VR experience was explored, and participants were invited to share other stressful situations related to technology or VR. Each participant was asked detailed questions about their real-life examples, and perceptions. This led to narratives that described the subsequent strains of using VR/SVR in a work-related setting as well as the underlying stressors.

The interview approach adopted in this study was influenced by the guidelines proposed by Myers and Newman (2007). Techniques such as mirroring and empathetic reactions to participants' responses were employed to establish rapport and foster open communication. Additionally, flexibility was maintained during the interviews to explore emerging themes in-depth. Participants were encouraged to reflect on their past experiences, and in order to minimize recall bias, the questions were anchored in actual events. Data collection continued until data saturation was achieved, meaning that no substantially new information emerged, and the potential benefits of conducting further interviews were deemed marginal.

5.3 Data Analysis

This study focused on examining individual users' perceptions of technostress concerning their use of VR/SVR in an organizational setting. To analyse the qualitative data, the guidelines and procedures proposed by Berg (2004, 285-287) were followed. These procedures included identifying overarching categories derived from the literature, reading the data to establish data-driven categories, developing a coding scheme, sorting the data accordingly, searching for patterns, and relating the findings to prior research.

Following the recommendations of Berg (2004), two broad classifications from the technostress framework were extracted. The framework was adapted to the specific context of VR/SVR, resulting in the following general classifications[1]: SVR technostressors and Strains due to VR/SVR use.

Subsequently, the data was (re)examined, and relevant text portions (e.g., sentences or specific words) were identified and assigned to appropriate classifications. The analysis was conducted using NVivo software, where text portions were labelled with descriptive tags corresponding to their respective classifications. These descriptive tags represented the stress-creating conditions contributing to technostress, for example *'Platform variability,' 'VR reliability,' 'VR usefulness,'* etc. Next, similar descriptive labels were grouped together to form categories linked to the general classifications. For instance, stress-creating conditions like *'platform variability,' 'VR reliability,' and 'VR usefulness'*

[1] The technology characteristics were not included in the scope of the thesis.

were combined to form the *'Software-related'* stressor category. Similarly, '*visual fatigue'* and *'VR sickness'* were grouped together to form the *'Behavioral strain'* category. Based

Whenever applicable, concepts for the stressor and strain categories' names were derived from prior literature. Among the resulting labels, some contained new content which was not identified in previous technostress studies. Consequently, a coding scheme was created, comprising of the names, descriptions, and examples for the four stressor categories and their corresponding stress-creating conditions as well as the two strain categories. This systematic approach helped organize and structure the qualitative data for analysis effectively. To ensure the accuracy of the sorting process, the newly examined data was constantly compared to the previous coding. Multiple checks, sketches and iterations were utilized to validate the emerging categories. This iterative approach aimed to enhance the reliability and validity of the data analysis.

To ensure the appropriateness of the analysis, procedures outlined by Berg (2004) and the principles presented by Klein and Myers (1999) were followed and complied. Throughout the analysis process, the hermeneutic circle was employed. The discussion oscillated between the interviewees' specific descriptions of technostress experiences related to VR/SVR in an organizational setting and the Ayyagari et al. (2011) research framework, which defined the three concepts of technostress (minus the technology characteristics). This framework provided a comprehensive lens for generalizing, conceptualizing, and making sense of the gathered detailed insights.

In terms of the researcher-subject relationship, the participants were allowed to choose their stressful experiences to share and to express themselves in their own words without interruption. Due to the sensitive nature of the topic, the interviewer researcher remained empathetic and understanding of the interviewees' negative experiences. Before the interviews, each potential participant was provided with a detailed explanation of the study's purpose, the procedures involved, and their rights as participants. They were assured that their involvement was voluntary and that they could withdraw at any time without consequences. Participants were also informed about the measures taken to ensure their data's confidentiality and anonymity.

The interviewees openly reported their stressful experiences, candidly discussing personal experiences related to VR/SVR use and sometimes using strong language to describe the experience. Drawing on Lazarus's work on stress perception (1966; 1993), it is important to mention here that when it comes to multiple interpretations, stress can be subjective, and individuals may perceive similar situations differently.

6. RESULTS

This chapter discusses the empirical findings from the semi-structured interviews. Overall, the data indicates emerging patterns of stress-creating conditions leading to technostress and their subsequent strains among individuals using multi-user VR environments for work-related purposes. The names and specific identifying details of the participants have been anonymized throughout this section to protect their privacy and confidentiality, ensuring ethical research practices.

6.1 Background overview

Twenty semi-structured interviews were conducted with users who had experience using multi-user VR in an organizational context. The interviews were conducted in early 2023 and included participants from diverse professional backgrounds. The summary of the participants has been provided below in Table 9.

Table 9 Summary of the respondents

Country	Role in the organization	Experience in using VR (approx. years)	Current average usage of VR (approx.)	Length of Interview (minutes)
Finland	Technology Expert	14+ years	Once or twice a week, for 30 to 45 minutes	30 min
Türkiye	Managing Director	6+ years	2 to 6 hours daily	94 min
USA	CEO	2+ years	between 3 to 5 hours daily	52 min
Germany	CEO	8+ years	between 15 minutes to 1 hour daily	60 min

Country	Role in the organization	Experience in using VR (approx. years)	Current average usage of VR (approx.)	Length of Interview (minutes)
Germany	Product Manager	3+ years	2 to 3 hours daily	45 min
USA	Lead Technical 3D Artist	9+ years	approx. 6 hours daily	37 min
France	Content Creator	6+ years	1 hour daily	38 min
Netherlands	Event Host/ Organizer	7+ years	from 20 min to 2 hours	61 min
Lisbon	CEO	2+ years	Once or twice a week, for an hour	28 min
USA	Product Manager	7+ years	Between 2 to 2,5 hours daily	36 min
Germany	Senior Software Engineer	11+ years	Between one to eight hours daily	27 min
France	Web Developer	3+ years	4 hours daily	24 min
Finland	Partner/student	2+ years	1 to 3 hours daily	25 min
Finland	CEO (A)	6+ years	Once or twice a month for an hour	30 min
Finland	CEO (B)	6+ years	1,5 hours daily	33 min
France	Marketing Manager	5+ years	1 hour daily	34 min

Country	Role in the organization	Experience in using VR (approx. years)	Current average usage of VR (approx.)	Length of Interview (minutes)
USA	Educator in STEAM	2+ years	1 to 3 hours daily	28 min
Finland	Head of Sales	11+ years	1 to 2 hours daily	30 min
Romania	Educational Leadership	3+ years	twice a month, for a couple of hours	36 min
Finland	Coordinator of Technology Education	3+ years	twice a month, for over an hour	33 min

As seen from the table, the participants were from different parts of the world and had varying experience when it came to using VR. The participants, on average, used VR for approximately 2 to 3 hours a day, with some starting from 15 minutes a day and others going up to 6 hours. The use of VR varied based on the device, workload, and tolerance of the participant as a user. It is also pertinent to note that the calculation of the average VR usage was determined by considering each participant's current usage. Some participants mentioned that they had been more active in VR in past years compared to their current level of engagement.

Among the twenty participants, it was observed that many of them were using more than one VR device. The most commonly used VR device among the participants was the Meta Quest 2, followed by Meta Quest Pro and Meta Quest (One). To provide a clearer understanding, the VR devices used by the participants have been summarized in Figure 4 below:

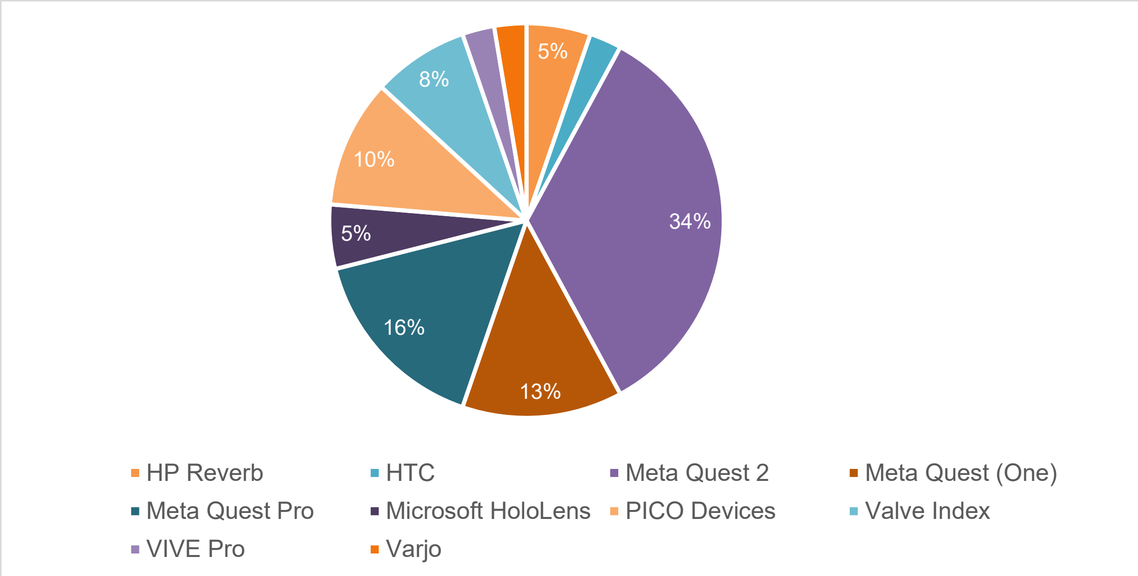

Figure 4 *Some of the VR Devices in use by the participants*

The participants discussed multi-user VR applications that they actively employed in their professional environment—including their use for meetings, collaborations, team building exercises, and even business development. Among the applications mentioned by the majority of participants, Engage and AltSpaceVR[2] stood out, closely followed by Immersed, Rec Room, and Meta Horizon Workrooms. A summary of the most frequently cited multi-user VR applications is provided in Figure 5 below.

[2] *AltSpaceVR was shut down in March 2023 (The Verge, 2023).*

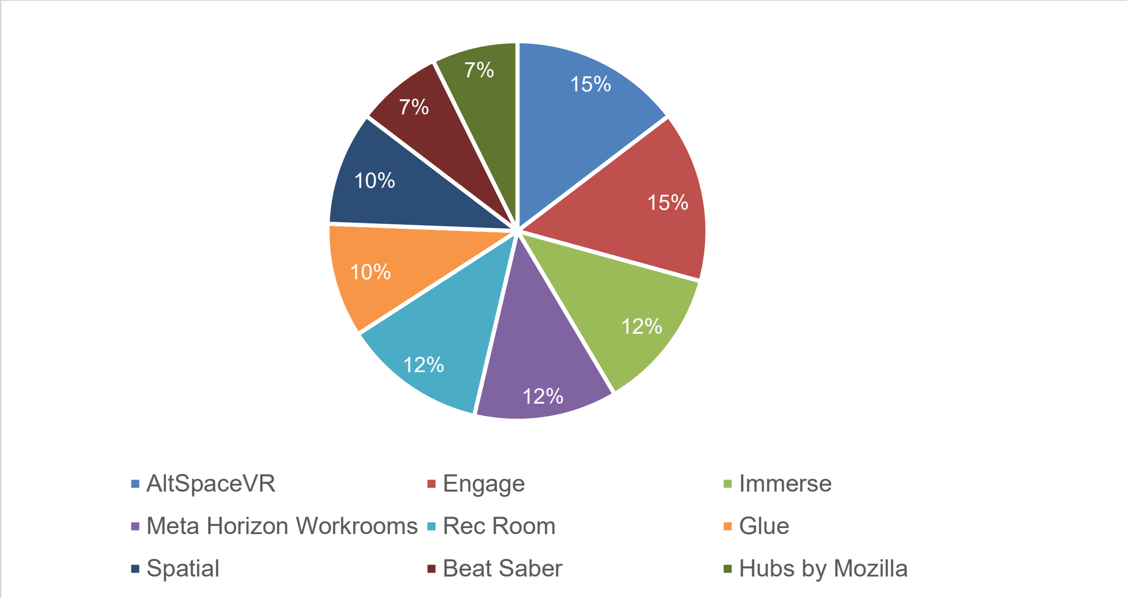

Figure 5 *Some of the multi-user VR applications mentioned by the participants*

In the following sections, the findings of different categories of technostressors and strains that emerged from the interviews are discussed. The categories have been summarized in Table 10 and 11, based on the coding scheme described in Section 4.3 above:

Table 10 Coding scheme for the SVR Technostressors

Stress-creating categories	Stress-creating conditions
Hardware	Ergonomics
	VR controls
	Battery life
	Obsolescence Cycle
	Social isolation from physical reality
	Affordability and ownership
Software	VR reliability
	VR usefulness
	VR Content
	Platform Variability

Stress-creating categories	Stress-creating conditions
	Virtual objects
	VR accounts and set up
	Lack of inclusivity and accessibility features in VR
Social	VR efficacy of team members or fellow users
	Unwanted social interactions
	Avatar Design
	Avatar design misfit to the context
	Uncanny Valley
	Social awkwardness
	Avatars behaving unnaturally
	Language Barrier
	AI-driven avatar interaction
	VR self-efficacy
Coping with virtual-physical realities	Managing the virtual and physical identities simultaneously
	Disruption in the immersive experience
	Unmet expectations from VR
	Switching between virtual and physical realities
	Physical awareness

Table 11 Coding scheme for the strains due to VR/SVR use

Category	Strain
Physiological	Visual fatigue

	VR sickness
Behavioral	Reduced productivity
	Reduced motivation
	Discontinuance

6.2 Stressor category I: Stress creating conditions related to hardware

The hardware-related stress-creating conditions focused on aspects related to VR equipment that affected user comfort and experience. These stress-creating conditions have been described, with an example directly quoted from the interviews summarized in Table 12 and discussed in detail below. The ‘n’ in the tables denote the number of times the stress creating conditions were referenced in all twenty interviews.

Table 12 Descriptions of hardware related stress creating conditions with examples from the interviews

n	Stress creating conditions	Description	Example(s) from the interviews
22	Ergonomics	The degree of physical ease and overall ergonomic design provided by an HMD during prolonged usage. It encompasses various aspects that contribute to the user's comfort, such as the fit, weight distribution, cushioning, ventilation, visual clarity, audio quality, adjustability of the headset, etc.	*“The weight of the headset after one and a half hours is unbearable. It's too heavy.” – Event Host/Organizer, Netherlands* *“When you are using VR headsets for long periods of time, it becomes stressful to find the ergonomics right, finding the comfort zone.” – Chief Executive Officer, USA*

n	Stress creating conditions	Description	Example(s) from the interviews
9	VR controls	The input methods used to interact with and navigate virtual environments in VR experiences.	*"There are no standards or conventions. There are certain buttons that just do certain things."* – *Managing director, Türkiye*
6	Battery life	The amount of time a VR device (HMD or controller) can function on a single charge before needing recharging or battery replacement.	*"Most stressful is the battery life."* – *Event Host/Organizer, Netherlands* *"People start doing something in VR, getting excited, then recognizing after an hour or something, the battery is done, so they'll have to recharge. So, they go back to their initial medium like their computer or something. Then they stay there because they say well battery life is too short to really work."* – *Coordinator of technology education, Finland*
4	Obsolescence Cycle	Shorter shelf life that leads to frequent replacements, higher costs, and rising market challenges due to rapid innovation—necessitating constant upgrades to	*"The shelf life for VR headset is short, they tend to get old in 2-3 years. After that, either the hardware gets obsolete, or the manufactur-*

n	Stress creating conditions	Description	Example(s) from the interviews
		maintain competitiveness.	*ing company stops supporting older devices." – Chief Executive Officer (A), Finland*
3	Social isolation from physical reality	VR creates a super private and isolating experience for users due to its individualized setup.	*"I think one factor of VR is that it's not socially acceptable, you know, to be sitting in your room wearing your headset on your own." – Managing director, Türkiye*
3	Affordability and ownership	Limited accessibility of VR experiences due to expensive VR technology and relatively limited ownership of VR headsets.	*"I have students who wanted to join the club, for example, but they couldn't because they couldn't afford the headset." – Member Education Leadership, Romania*

6.2.1 Ergonomics

The degree of physical ease and overall ergonomic design provided by HMDs during prolonged usage was a source of stress for many users. The stress factors included the fit, weight distribution, cushioning, ventilation, visual clarity, audio quality, and adjustability of their headsets. Some users faced challenges with the HMDs fitting well on their heads due to unique physical characteristics, leading to discomfort and bruising. As someone mentioned:

"I have a big bridge of an eyebrow and a very tall forehead. So, [VR device] just kind of sits up there on top. I believe it should be spread across a larger area. Right now, it is hitting a peak and I have a bruise on my forehead. Like it's not just red, there is a bruise and now I have to wear a hat when I go out in public." – Lead Technical 3D Artist, USA

Others mentioned headaches and pain due to pressure on the forehead and discomfort from wearing glasses while using VR headsets. Users noted that VR headsets could become sweaty during use, impacting comfort. Additionally, concerns were raised about the heaviness of certain headsets, causing tears in the eyes and discomfort after extended periods of usage. As one user pointed out:

"Hours of headset of five hundred grams on your head. It gets quite heavy. But especially with the lenses being so close to your eyes—you get tears because of the strain. It's too sharp." – Event Host/Organiser, Netherlands

6.2.2 VR controls

Users expressed their dissatisfaction with inconsistent button layouts, the absence of standardized controls, and unclear button combinations. As one user mentioned:

"There should be standards… I am always thinking 'You want me to do this. How am I supposed to do this? What? What is the button? What is the button combination?' Everybody goes through that and even now on occasion it can be a frustration. This is so arbitrary." – Managing Director, Türkiye

Some users explained that the ambiguity of joystick movements, while others mentioned certain interaction methods, such as using triggers instead of grips was a cause of stress for them. The lack of testing and adherence to design conventions also contributed to user frustration. Based on the interviews, these included the ease and intuitiveness of controls and the VR's individualized setup leading to social isolation from physical reality.

6.2.3 Battery life

There were various aspects of the battery life of VR devices (HMDs or controllers) that were stressful to most users. Many emphasized the limited battery span, leading to interruptions during important meetings or activities. Some users mentioned using external battery packs to avoid relying on wires but acknowledged the stress of remembering to charge them. The short battery life was considered a limiting factor, especially when users wanted to engage in extended VR sessions without knowing how long they could last. Running out of battery mid-session was disruptive to their VR experience and required the users to pause and recharge, impacting their engagement and productivity. As one user stated:

"The battery span of [the VR device] is very low, especially for when I'm doing something important there. So, let's say we had many meetings with my business partner [in VR],

the battery runs out in the middle of them, and the meetings run short as we have to pause to charge [the VR devices] again." – Founder/student, Finland

6.2.4 Obsolescence cycle

The relatively short shelf life of VR technology, which leads to frequent replacements and higher costs was a stressful aspect for some users. Several users mentioned the rapid innovation in the VR industry, which necessitates constant upgrades, making it difficult for them to keep up with the latest advancements. Some users also mentioned that the constant upkeep (upgraded devices, training IT and the users in the office) resulted in additional expenses, contributing to their apprehension about investing in VR technology. One user explained:

"You buy a headset, and you know it'll be outdated in a year. Sometimes, a leading competitor in the field will release their headset three months later and then the one that you just purchased is already outdated. It's like you feel like a drug addict. You have to buy the newest, hottest device for the crazy amount of money that you have to work for. And the moment when you use it, you already know that there is a newer, hotter version out there." – Chief Executive Officer, Germany

6.2.5 Social isolation from physical reality

The users highlighted that the private and isolating nature of VR experiences due to its individualized setup can be stressful. One participant mentioned that VR can be limiting as it lacks the social aspect of playing games with friends, unlike console gaming where one can have fun together. Another participant pointed out that VR is not socially acceptable as people might feel uncomfortable wearing headsets in public spaces, which hinders its widespread adoption. Additionally, the desire to interact with familiar people rather than meeting new individuals in VR environments further influences the usage patterns of some participants. These insights collectively suggest that the individualized nature of VR experiences may be hindering its potential for broader social engagement. As one user elaborated:

"VR is a super private set up. It is hard to play with friends. You know you can play Mario Kart on console or have fun in a group, but VR is always isolating in a way. So, I think that it's kind of limiting its uses a bit." – Product Manager, Germany

6.2.6 Affordability and ownership

The limited accessibility of VR experiences, primarily due to the expensive VR technology and the relatively low ownership of VR headsets was stressful to many users. Some users mentioned that the VR setups are costly, making them more suitable for niche enthusiasts rather than the public, schools, or businesses. Some users mentioned that while many people express interest in joining VR, they are unable to do so because of financial barriers. It was discussed during the interviews that companies tend to support experiences that can be accessed on mobile devices, given their widespread use, whereas VR headsets have a smaller user base. As a user mentioned:

"VR devices like PC VR, for example, will probably be for niche people for a long time, for those who somehow really love [VR] because you need to set [the VR device] up often and they are bit expensive and it's just too complex for people—not to mention for schools or businesses." – Chief Executive Officer (B), Finland

6.3 Stressor category II: Stress creating conditions related to software

Software-related stress-creating factors in VR include usability challenges, platform variability, reliability issues, limited inclusivity, virtual object interactions, content availability, and account set up complexities. These stress-creating conditions have been described, with an example directly quoted from the interviews summarized in Table 13 and discussed in detail below. The 'n' in the tables denote the number of times the stress creating conditions were repeated by the twenty participants in all twenty interviews.

Table 13 Descriptions of software related stress creating conditions with examples from the interviews

n	Stress creating conditions	Description	Example(s) from the interviews
16	VR reliability	The extent to which VR systems perform consistently without technical glitches (lag, bugs, audio/video issues, etc.)	*"One more mental stress every time is that 'is this going to work'. When I have a meeting in VR and it's always a pain that is it going to be me or is it going*

n	Stress creating conditions	Description	Example(s) from the interviews
			to be the other person who is not going to get their device to work. It's really embarrassing as I have to be a professional and still, I cannot rely on the fact that everything would work properly." – Chief Executive Officer (A), Finland *"Sometimes there is a bug, and the avatar is invisible, so people can't see you or you can't see them." – Chief Executive Officer, USA*
13	VR usefulness	The extent to which technology characteristics improve job performance. (Moore & Benbasat, 1991; Ayyagari, 2011). In this study, the technology would be VR/SVR.	*"There's not much added value in the VR meeting compared to 2D online meetings. The resolution of most headsets is still bad, so why to stare at a .ppt file in a virtual meeting room instead of Zoom? After a VR meeting you tend to feel more exhausted than after 2D online meeting. The virtual environment adds cognitive load." – Chief Executive Officer (A), Finland*

n	Stress creating conditions	Description	Example(s) from the interviews
9	VR Content	Digital multimedia and interactive experiences designed specifically for VR platforms.	*“There's a lack of content in VR at this point, so it just kind of feels like there is not much to do there.” – Founder/student, Finland* *“[In terms of dangerous content] Not everybody who plays shooter games is going do school massacre in the end because they educate themselves. But even if there's five people in a decade who trained themselves in a shooter game and then go to school and shoot the other pupils and teachers, it's five too much. We know that you can train yourself much better in VR and we know that some people are affected by this very immersive medium.” – Chief Executive Officer, Germany*
7	Platform Variability	Differences among various platforms or systems in the context of VR technology. This includes range of hardware, software, and configurations available for VR experiences, which	*“It takes some time to get used to the different platforms and for example, how to move in the platform, how to access different options, how to use it*

n	Stress creating conditions	Description	Example(s) from the interviews
		may vary significantly from one platform to another.	*efficiently? So that's another element [of stress.] ...What works on one machine doesn't work on another." – Lead Technical 3D Artist, USA*
6	Virtual objects	Digital or computer-generated three-dimensional (3D) entities that exist within the virtual environment. These objects can be interacted with and manipulated by users, providing a sense of presence and immersion in the virtual world.	*"If we have to take notes in the meeting, it's always, always also a terrible user experience." – Chief Executive Officer (A), Finland* *"Another [stressful] thing is the writing. I think that would be the second most important thing because it's pretty difficult to search on the Internet. It's pretty difficult to chat with somebody." – Educational Leadership Member, Romania*
6	VR accounts and set up	The process of creating user accounts and configuring VR devices and software to enable users to access and use VR experiences.	*"More time is spent on trying to set it up than actually keeping it on board." – Technology Expert, Finland* *"I think something really stressy is the friction to get into some of these [VR] applications. So, Workrooms is a great example. You have to log in, you have to*

n	Stress creating conditions	Description	Example(s) from the interviews
			join an organization, you have to be invited by e-mail to an organization. So not the hardware, not the comfort, not the nausea, but from the software side. Anything that stops you from getting into an experience is a real great stress for me." – Product Manager, Germany
4	Lack of inclusivity and accessibility features in VR	Lack of implementation of features and functionalities in VR to accommodate users with physical disabilities or limitations.	*"The people who are handicapped due to biological reasons or influenced by sensory impairments often struggle with VR technology and cannot use it in the same way as others, and then they feel very much left behind." – Chief Executive Officer, Germany*

6.3.1 VR reliability

Users commonly experienced technical glitches and issues in VR systems, causing them stress. These problems included connectivity challenges, audio, and video glitches and lagging. For instance, some platforms had frame rate and synchronization issues, leading to disorientation during interactions. As one user mentioned:

"Glitches. They get you… The frame rate that the person moves with, is very important, and it being in sync with the other person is also important because otherwise, you have that two second delay. It is disorienting for the person you're talking to and for yourself, seeing your [avatar] react seconds later." – Lead Technical 3D Artist, USA

Users also encountered software bugs, crashes, and rendering problems that resulted in motion sickness and wasted work time. Additionally, issues with hardware, such as controllers and headsets were highlighted as contributors to stress arising from the lack of reliability. As a user shared their experience:

"Whenever I need to cast what I'm seeing to a bigger screen, it's always an effort to make it work. And sometimes the controllers don't work the way they should. Sometimes, when I want to teleport myself to a certain place, something gets stuck. Sometimes, the tracking is lost…" – Chief Executive Officer (A), Finland

6.3.2 VR usefulness

Users expressed scepticism about the usefulness of VR, particularly in comparison to traditional 2D online meetings. As one user explained:

"You are going to Horizon Workrooms, and you are just sitting there like a useless Zoom meeting because [it feels like] it doesn't have added value." – Chief Executive Officer (B), Finland

Some of the stressful aspects mentioned by the users included resolution limitations, cognitive load from prolonged usage of the virtual environments, and the absence of motivation to use VR long-term as meetings in VR do not always offer added value compared to other online meeting platforms. As one user described their experience:

"I always say that you have to have the added value. You put on the headset because yes, there's stress involved. It's hardware you have to wear it on your head, so you have to have a reason to go in VR, you have to think that you get added value." – Head of Sales, Finland

6.3.3 VR Content

Users expressed concerns about the lack of content and variety in VR experiences. Some apps were free, while others required payment, leading to limitations for certain users. The gaming industry faced criticism by the users for relying on the same popular games without introducing new ones. Additionally, discussions arose regarding the potential negative impact of immersive VR experiences on individuals with mental health issues, with the concern that the medium's realism could blur the line between reality and virtual reality. Users also sought novel and diverse experiences to avoid repetition and maintain engagement in VR environments.

"It is the lack of content in the end… If you look at the apps that are best-selling in VR, they have been the same for like five years. There is just nothing new." – Chief Executive Officer (B), Finland

6.3.4 Platform variability

VR platforms and systems vary significantly in terms of hardware, software, and configurations, leading to differences in user experiences. Users mentioned facing a learning curve when getting used to different platforms and their navigation methods. According to users, transitioning between platforms leads to confusion and frustration, even among the experienced VR users. Compatibility issues were brought up by the users—stating that when they join meetings via VR headsets while others use laptops or mobile devices, it leads to varying functionalities and interactions. In shared activities, users mentioned that different devices limit certain users' abilities, requiring extra effort to coordinate tasks, which is stressful. As one user explained:

"You have to be very aware that you're making one transition to another transition in VR. Understanding that you have the command of your environment helps out, but sometimes people don't understand. What works on one application [platform] does not work on another. You're standing here and the next thing you know, you teleport to another position, and now you're facing a wall, without knowing how you got there or how to get out." – Educator in STEAM, USA

6.3.5 Virtual objects

Users mentioned some limitations when interacting with digital 3D entities in the virtual environment, which contribute to stress when using VR. For example, writing in VR is time-consuming and cumbersome due to the need to navigate with a cursor, making it unsuitable for writing, for some users. Others mentioned writing and searching on the internet to be challenging on some VR platforms. Additionally, taking notes during meetings using speech-to-text caused disruptions due to inaccuracies in the transcription, especially for non-English speakers, which was stressful for the user. As one user mentioned:

"You can mute yourself when you do speech to text like I want to do speech text. Nobody else is hearing that I take notes. But of course, when my mother language is not English, the transcript is going not going correctly and then the editing is terrible as you know it's always an issue to work with the text in a VR environment and that always causes disruption in the meetings as well." – Chief Executive Officer (A), Finland

6.3.6 VR accounts and set up

Setting up and configuring VR experiences was cited as a source of stress for users. Users mentioned that the friction in the software, such as the need for multiple logins and verification processes, creates barriers to accessing VR platforms and experiences. Users preferred platforms with simpler access, like those that only require a link to join. Users also mentioned linking VR accounts to social media accounts or dealing with lengthy verification processes to be quite frustrating. In some cases, team members faced delays in joining meetings due to complicated login procedures and unintuitive user interfaces. As one user shared:

"As a team, we visit different apps just to do some exploration. And when we're doing that, team members will be late because there are different login procedures which can take quite a long time, just finding a private spaces for our team to organize because the UI is complicated or there's a lengthy login process that asks you to get into the headset, fill out your email, then go back and check your email to verify it so that you can go back in. Yeah. And, and then once you're in, it's not very intuitive what you're supposed to do. So, in my company we are VR professionals, but we still have trouble getting into meet-ings in some apps. So yeah, that's always a disappointment." – Product Manager, USA

6.3.7 Lack of inclusivity and accessibility features in VR

The users highlighted the lack of implementation of features and functionalities in VR to accommodate users with physical disabilities or limitations to be quite stressful. Some users mentioned the difficulty of using VR with one hand, which can be challenging for people with physical disabilities affecting their arm movements. Issues with vision were also mentioned, as some users discussed how it becomes difficult to use VR effectively, when there is limited vision in one eye or lack of stereo optic vision. Some users also mentioned that the current VR software and interactions are not well-adapted to the needs of people with disabilities, and there is a lack of proper support for those using wheelchairs or lying in hospital beds etc. As one user explained

"Most of the manufacturers or most of the software providers are assuming that VR is super barrier free because you can sit in a wheelchair and put it on. You can even lie in a hospital bed, and you can put the headset on. But that's not true because then you have to recognize that there are other aspects influencing that as well. …The medium is not barrier free." – Chief Executive Officer, Germany

6.4 Stressor category III: Stress creating conditions related to social aspects

Social aspects in VR can create stress in individuals, including VR self-efficacy, unwanted interactions, social awkwardness, language barriers, avatar design, unnaturally behaving avatars, AI-driven interactions, and the *Uncanny Valley* effect. These stress-creating conditions have been described, with an example directly quoted from the interviews summarized in Table 14 and discussed in detail below. The 'n' in the tables denote the number of times the stress creating conditions were repeated by the twenty participants in all the interviews.

Table 14 Descriptions of stress creating conditions related to social aspects—with examples from the interviews

n	Stress creating conditions	Description	Example(s)
19	VR efficacy of team members or fellow users	The user's assessment of their team members or fellow VR users on how effectively they utilize VR technology, including their proficiency within VR environments.	*"It is quite stressful if we have several new people at the same time, and it becomes pretty common that say one third or even half of them never actually manage to enter the virtual space. They have some issues that we can't resolve remotely. That's really a big issue for us." – Technology Expert, Finland* *"It is always stressful when there are always technical issues like 'I don't find that! Where are you now? Are you in the same server? How do I teleport myself into the place where you are?' So those kinds you*

n	Stress creating conditions	Description	Example(s)
			have to know very well that who is the person you are going to be? What is the maturity level of them being in a VR environment, are they comfortable with the with the controllers etc." – Chief Executive Officer (A), Finland
13	Unwanted social interactions	Experiences where users encounter interactions that are disruptive, uncomfortable, or distressing during their SVR sessions.	*"I've seen and experienced a lot of situations related to, I could only say, bigotry. So whether it's sexism, homophobia, racism, and also expressions of hatred and violence and you find it very commonly." – Product Manager, USA* *"Another huge stressor is kids that come into the public rooms. So, on a free app that is open to anyone who wants to join, there's no way to stop kids come from coming in. And so, you get kids that come in every day, causing disruptions." – Chief Executive Officer, USA*
12	Avatar Design	Creating and customizing digital representations of users or characters that	*"It is stressful when VR platforms are forcing me to have an avatar that they*

n	Stress creating conditions	Description	Example(s)
		embody their presence within the virtual environment.	*decided, as a platform, looks like me enough that someone would see me and say ohh that I know that person, that is that person." – Managing Director, Türkiye*
8	Avatar design misfit to the context	Instances in multi-user VR environments where the appearance or characteristics of avatars do not align appropriately with the specific virtual environment or the nature of the interaction. The characters may seem out of place or mismatched with the virtual setting, theme, or purpose of the VR experience.	*"When you go into a digital environment, one of the stressors may be that you don't know what you're gonna run into. You don't know how you're gonna respond. You know, you're expecting the person about your height to come up to you and talk to you. But next thing you know, you're talking to someone that's half your height or even taller or even in a butterfly avatar. So, you may have to look up or back up. And that's the stress right there." – Educator in STEAM, USA*
6	Uncanny Valley	Phenomenon where virtual representations of humans or avatars closely resemble real humans but still exhibit subtle and unnatural features or behaviours.	*"There's this uncanny valley experience that means that actually, it is you. Yes, it's quite close to you but you are slightly dead or at*

n	Stress creating conditions	Description	Example(s)
			least sick and that's stressful. I don't want to see that you have dead eyes or whatever so that's the problem." – Head of Sales, Finland
4	Social awkwardness	The discomfort and unusual social dynamics that can arise in multiuser environments.	*"In multiuser environments for events and discussions, when someone comes and either cannot speak or does not speak…. It's just a very weird effect, which is a stressor because you keep thinking as like the organizer, the speaker that am I being rude because maybe this person wants to speak, but they are shy, and you know how often do I keep turning to the person? But maybe that person absolutely does not want to speak or engage. They just want to sit with an embodied sense in the room." – Managing Director, Türkiye*
3	Avatars behaving unnaturally	Situations in multi-user VR environments where virtual representations of individuals or characters exhibit actions or movements that	*"When the headset loses the tracking of your controllers, then yeah, that the hands might fly away or*

n	Stress creating conditions	Description	Example(s)
		are perceived as strange, awkward, or unrealistic.	*whatever." – Head of Sales, Finland*
2	Language Barrier	Challenges and limitations that arise when users from different linguistic backgrounds interact in virtual environments	*"The language barrier is stressful. Someone may be speaking in a different language, and you're trying to interpret and understand them and make some type of connectivity." – Educator in STEAM, USA*
2	AI-driven avatar interaction	Use of artificial intelligence (AI) algorithms to control avatars' actions and behaviours in virtual reality, resulting in unpredictable and unrealistic interactions	*"Two people may be talking to each other, but suddenly when you walk by their eyes suddenly turn to you, which actually is not happening, it's just trying to simulate a social experience, but what it's actually doing is doing something very creepy." – Product Manager, USA*
1	VR self-efficacy	The user's assessment of their own abilities to effectively organize and carry out the necessary actions to achieve specific performance goals. (Bandura, 1997) In our case, it is VR experiences.	*"The biggest source of frustration is a lack of proficiency and the insecurity and lack of confidence that comes from knowing that you're not proficient and being around peers that you have to perform a job you could do every day physically, but you have to*

n	Stress creating conditions	Description	Example(s)
			learn how to do it in a different context." – Managing Director, Türkiye

6.4.1 VR efficacy of team members or fellow users

The user's team members or fellow VR users' proficiency in utilizing VR technology was a cause of stress for various users. Technical issues with VR technology, such as temperamental devices and room limits, caused frustration and hindered smooth interactions at work. Lack of VR proficiency and familiarity with VR controls by the team member also led to discomfort and inefficiency during meetings and collaborations. Battery life and charging problems, as well as difficulty setting up VR applications and accounts, created obstacles for the participants. In some cases, other participants were unable to join VR spaces due to equipment limitations or slow internet speeds, leading to an unproductive work meeting. Overall, these challenges impacted team collaboration and user experiences of the users in virtual environments, resulting in stress.

"I would say that if you tried to put somebody else in the metaverse, then it's usually much worse because the people struggle with that … What I found is if you put somebody in a headset and they're just standing at the same place, they don't have to move around, and they just have to talk. Everybody can do that, you know, they hold the controls in their hands and they talk and that's that. That works very well. But you ask somebody to do that with an avatar, and they're like, 'where should I look? My avatar? Where should I put my avatar then?' and that is stressful." – Product Manager, Germany

6.4.2 Unwanted social interactions

During social VR sessions, users encountered disruptive and distressing interactions that ranged from inappropriate behavior to harassment and trolling. In open spaces (like Rec Room), users experienced instances of swearing and mistreatment, while others expressed concern about gossip and disturbing content shared by certain individuals. Additionally, the presence of kids in public VR rooms led to disruptive behavior and discomfort for the users. Harassment, sexism, homophobia, and racism have been observed, especially towards identifiable users like women, as one user shared their experience:

"I remember going into a social VR environment with a female colleague and she basically immediately was abused and mistreated, so that is obviously an issue on public multiuser platforms." – Product Manager, Germany

The anonymity of users in social VR environments enabled some individuals to act out and cause discomfort through insults and bad intentions. Users also mentioned that the emotional impact of these interactions was heightened due to the immersive nature of VR, making it more disturbing than traditional online interactions. As one user explained:

"I've seen and experienced a lot of situations related to, I could only say, bigotry. So, whether it's sexism, homophobia, racism, and also expressions of hatred and violence and you find it very commonly, especially directed towards women because they are identifiable by the clothing that they wear. So, they might attract sexist harassment from other people there. It usually happens in contexts where it's a general space, like, a hub world because trolls, I find, they tend to linger in hub world." – Product Manager, USA

6.4.3 Avatar design

Users had varying opinions about avatars and their representation. A user mentioned that the lack of greater diversity and personalization in avatar design was a source of stress for her. Some found the avatars to be unrealistic, cartoon-like, or lacking customization options and instead preferred avatars that resembled them to some extent but not entirely, as they said they enjoyed the sense of being themselves without full replication. As one user mentioned:

"I don't like them [avatars] if they're too much like yourself." – Coordinator of Technology Education, Finland

"Due to limitations, the avatars are very comic like and that's not so nice." – Senior Software Engineer, Germany

Others appreciated more realistic avatars that conveyed emotions and fostered eye contact, creating a more immersive experience. For some users, the mismatch between their real appearance and avatar was a source of discomfort or unwanted judgment from others.

6.4.4 Avatar design misfit to the context

In multi-user VR environments, there are cases where the appearance or characteristics of avatars do not align appropriately with the specific nature of the interaction in the virtual environment, causing stress in some users. There were some users who preferred realistic avatars as they tend to identify more with them and behave normally, while others found certain avatars strange or plastic, adding to their stress. Some users mentioned that having too many avatar customization options leads to distractions and behavioral changes. Users mentioned that the unpredictability of encountering various avatars in the digital environment adds to the stress. as one user mentioned:

“Young generations are going to VR and they have choice in how they look like but all other generations, they are okay with being a man in a suit or a woman in a skirt. It's all fine. But then, if you give them more options, they get too much distracted and because of it, they become stressed and they stop using VR.” – Event Host/Organizer, Netherlands

6.4.5 Uncanny valley

The phenomenon avatars closely resembling real humans but exhibiting subtle and unnatural features or behaviors is commonly known as the "uncanny valley." Many users found this aspect problematic and disturbing. Some users found more cartoony avatars less distracting, as they did not expect them to behave like humans, while others found the more realistic avatars with ‘dead eyes’ or slight deviations from natural human appearance due to uncanny valley to be particularly uncomfortable.

“So yes, I have felt that this uncanny valley is really annoying because yeah, it’s a little bit you, but maybe your elbow is here or your face is dead, so it’s horrible to see you dead. It's not nice feeling.” – Head of Sales, Finland

6.4.6 Social awkwardness

In multiuser environments, discomfort and unusual social dynamics can arise when someone faces microphone issues or cannot speak during events or discussions, which is stressful for the users. Users pointed out that such a situation is rarely encountered in real-life interactions, and therefore can be frustrating and awkward. One user mentioned that social awkwardness can be stressful, especially when there is a gender imbalance in participation, and some individuals hesitate to speak or engage. As they explained:

“In multiuser environments for events and discussions, when someone comes and either cannot speak or does not speak…. It’s just a very weird effect, which is a stressor because you keep thinking as like the organizer, the speaker that am I being rude because maybe this person wants to speak, but they are shy, and you know how often do I keep

turning to the person? But maybe that person absolutely does not want to speak or engage. They just want to sit with an embodied sense in the room." – Managing Director, Türkiye

Furthermore, the challenge of reading body language and facial expressions in virtual environments was highlighted, and the lack of communicative facial expressions in current VR technology was also mentioned as a stress factor contributing to social awkwardness.

6.4.7 Avatars behaving un-naturally

In multi-user VR environments, there are situations where virtual representations of individuals or characters exhibit actions or movements perceived as *strange, awkward, or unrealistic* by the users. Some users provided mixed feedback on character movement, comparing it unfavorably to even computer games that offer better representations. Additionally, issues with controller tracking cause avatar hands to behave oddly, like flying away, which is disruptive during official meetings and stressful to some users.

"When the headset loses the tracking of your controllers, then yeah, that the hands might fly away or whatever." – Head of Sales, Finland

6.4.8 Language barrier

The challenges and limitations arising from users of different linguistic backgrounds interacting in virtual environments, causing them stress. One user expressed her concern that while some VR devices offer menus and settings in different languages, many VR games and applications may not support those languages, leading to difficulties for users who don't speak the dominant language. The language barrier itself can be stressful, as some users struggled to interpret and understand conversations with others speaking different languages, making it challenging to establish meaningful connections. As one user explained:

"One thing I have noticed which some of the people have the problem with, is the language selection because you can get the Oculus glasses, you can get it in Finnish and it has the menu and everything in Finnish, but most of the games—like I don't know any game that works in Finnish. So, some people start using games that are not easy to them or there is the language difference. So those are some somethings that are kind of limiting." – Coordinator of Technology Education, Finland

6.4.9 AI-driven avatar interaction

In virtual reality, AI algorithms control avatars' actions and behaviors, resulting in unpredictable and sometimes unrealistic interactions, causing stress to the users. Avatars have features like eye contact and expressions based on the AI's listening and interpretation of users' voices. While some users appreciate these features and find them engaging, others found them 'creepy' or 'stressful', especially when avatars appeared to look at them even when they were not interacting directly. Another user also brought up the issue of forced facial expressions, where avatars appeared to be 'smiling' even though the user himself was not intending to do so. This was particularly stressful for the user during a serious conversation where a happy reaction was not needed.

"Two people may be talking to each other, but suddenly when you walk by their eyes suddenly turn to you, which actually is not happening, it's just trying to simulate a social experience, but what it's actually doing is doing something very creepy." – Product Manager, USA

6.4.10 VR self-efficacy

The users' assessment of their own abilities to effectively organize and carry out VR experiences can be affected by proficiency issues and a lack of confidence, resulting in stress. According to a user, in a work context, the biggest frustration arises from the need to relearn basic skills to perform tasks in a different context. The presence of hierarchies based on different devices adds to the complexity. As one user explained:

"The biggest source of frustration in a work-setting VR is a lack of proficiency and the insecurity and lack of confidence that comes from knowing that you're not proficient and being around peers that you have to perform a job you could do every day physically, but you have to learn how to do it in a different [VR] context." – Managing Director, Türkiye

6.5 Stressor category IV: Stress creating conditions related to coping with virtual-physical realities

The stress-inducing conditions that arise while coping with virtual-physical realities stem from the challenges of managing and adapting to interactions and experiences when the user is navigating between virtual and physical environments. These stress-creating conditions have been described, with an example directly quoted from the interviews summarized in Table 15 and discussed in detail below. The ‘n’ in the tables denote the number of times the stress creating conditions were repeated by the twenty participants in all the interviews.

Table 15 Descriptions of stress creating conditions related to coping with virtual-physical realities—with examples from the interviews

n	Stress creating conditions	Description	Example(s)
16	Managing the virtual and physical identities simultaneously	Navigating and coordinating one's presence and actions in both, virtual environment, and the physical world simultaneously with a sharp cognitive awareness.	*“What's really another frustrating thing is your body positioning in VR. I want to present myself the way I want to present myself. Where can I put my hand? My controllers for the next 20 minutes?” – Managing Director, Türkiye*
10	Disruption in the immersive experience	Factors that interrupt or break the sense of presence and engagement experienced by a user while immersed in a virtual environment. Immersion is the feeling of being fully engaged in a virtual environment, to the point where the user perceives it as real, despite knowing it's a digital simulation. It can be social, actional, symbolic or sensory.	*“The other negative thing is that the technology doesn't allow you to just track your full body, but only hands and face. So, you can't really show your full body there. So, it just feels like it's not a very immersive experience yet.” – Founder/student, Finland*
8	Unmet expectations from VR	When anticipated outcomes and experiences	*“It is a problem when people often expect that VR is*

n	Stress creating conditions	Description	Example(s)
		that users associate with VR technology before engaging in VR activities are not fulfilled as expected.	*the same as this reality and that the world is virtual reality. So that is kind of the problem." – Chief Executive Officer (B), Finland*
7	Switching between virtual and physical realities	Moving or switching between the immersive digital environment of virtual reality and the real-world physical environment.	*"Coming in and out of the headset can be stressful. I'm much more comfortable if I can just stay working in the headset and not have to come out for meetings that are outside of the headset." – Chief Executive Officer, USA*
7	Physical awareness	The user's consciousness and attention to their real-world surroundings and the physical limitations of the VR environment.	*"I am doing VR in my home office right now and I am always conscious when I use VR at home that I'm gonna do a quick move and hit accidentally hit my girlfriend. I was way less stressed when I was living alone, because nothing could happen." – Content Creator, France* *"So, the kind of limited space sometimes limits what I can actually do in the virtual space as well. I have to be aware of both the physical and the virtual space at the same time." –*

n	Stress creating conditions	Description	Example(s)
			Technology Expert, Finland

6.5.1 Managing the virtual and physical identities simultaneously

For most users, the stress-creating conditions related to navigating and coordinating one's presence and actions in both virtual and physical environments simultaneously involved challenges with facial movements and expressions, communication gaps due to limited cues, issues with managing real-world objects in the virtual environment, difficulties in switching between different platforms, and the cognitive load of managing two separate realities. Users expressed frustration with the lack of facial expressions in VR, the need to manage their avatars and physical actions simultaneously, and the disruption caused by interruptions in both realms. Additionally, issues with body positioning, technical competency, and the presence of others not fully engaged added to the stress of coping with virtual-physical realities. As one user mentioned:

"It is quite difficult in the way that you have to move the avatar and make the right gestures, and this is difficult when you have to present, talk, manage, manage the topic, be enthusiastic and move the body of the avatar." – Marketing Manager, France

6.5.2 Disruptions in the immersive experience

Factors that interrupted the sense of presence and immersion experienced in virtual reality included limitations in the technology, such as pixel quality and the inability to track the user's full body, leading to a less immersive experience for the user. Distractions from the real world, such as phone notifications or external noises, can also disrupt the user's engagement with the VE. Concerns about potential accidents or interruptions in the physical space while immersed in VR can create stress and anxiety for users. Additionally, the fear of being observed or photographed while using VR can further impact the feeling of presence and immersion. Overall, these factors contribute to the challenges in maintaining a seamless and fully engaged experience within the virtual environment. As a user explained:

"Some people are even sensitive for if they know that there are people in the room because they are not alone, they know that they might be pictured, for example, without recognizing it. This can even be stressful for people because you know how many pictures are out there are people with their headset and doing something, and the only ones who did not know that they get pictures are the people with the VR headset. So I know people who are constantly stressed if they get pictured while having the headset on." – Chief Executive Officer, Germany

6.5.3 Unmet expectations from VR

According to some users, their anticipation of VR technology often les to unrealistic expectations, as they expected VR to replicate the real world, which was not the case in reality. VR is a different format with its own unique features, characters, and experiences. Early experiences with VR were met with excitement, but users quickly realized the limitations and discrepancies between their expectations and the actual technology. The transition from traditional media to VR was challenging, as users encountered lower resolutions, pixelation, and difficulties with equipment. This gap between excitement and disappointment was evident during showcases and demonstrations, where some users expressed frustration and discomfort, while others remained unenthusiastic. Moreover, users' desired for novelty and variety in VR experiences, which can lead to fatigue with repeated environments, prompting them to seek new and exciting content.

"The gap between super excitement and super disappointing has been super close to each other." – Chief Executive Officer, Germany

6.5.4 Switching between virtual and physical realities

For many users, switching between the immersive digital environment of virtual reality and the real-world physical environment was challenging and stressful. There was a user who was using VR to teach and chose to remain on her laptop during virtual reality sessions to ease the switch between the two realities. For users using VR as a tool for business development and work meetings, constantly coming in and out of the headset for meetings was stressful as they said they needed to maintain a professional appearance. Interruptions from family, pets, or messages on the phone in the physical reality disrupted focus and productivity in the virtual reality, which necessitated frequent removal of the VR headset, causing stress to the users. As one user said:

"Doing something else in between switching [VR] with switching context outside of work and then getting back in [VR] can cause [stress] issues. So reconnecting, logging back

into your PC then you don't have a stable connection. The VPN is again on, the company VPN can't reconnect correctly and there are a lot of additional steps involved. And I'm always surprised when I get fed up with VR and say, OK, now I put it beside and I just click it, plug in my monitor, that's working. That's it. It's working just after directly plugging. That is the part that is not present in VR currently, that's making me a bit sad. I want to have a solution that's working." – Senior Software Engineer, Germany

Moreover, transitioning from online meetings to VR meetings was creating awkwardness and additional issues among some users.

6.5.5 Physical awareness

To some users, the consciousness and attention needed to maintain in order to avoid accidents or disruptions in both realms was quite stressful. Users expressed the stress about limited physical space, potential collisions with real-world objects, and the need to maintain awareness of their surroundings while immersed in the virtual environment. Some users felt stressed about being observed by others during VR experiences, especially in shared living spaces, and worried about accidentally bumping into furniture or hitting others while in VR. Additionally, other users mentioned that the need to consider the physical limitations of the VR setup and the space required to use VR as a workspace also contribute to the stress. As one user described:

"So, the kind of limited space sometimes limits what I can actually do in the virtual space as well. I have to be aware of both the physical and the virtual space at the same time." – Technology Expert, Finland

The next section highlights the two strain categories i.e., the resulting behavioral and physiological effects of stress, which were experienced by the users.

6.6 Strain category I: Physiological strain

The users experienced physiological strains like VR sickness and discomfort in their eyes as a consequence of using VR in the organizational setting, as seen in Table 16 below. The 'n' in the tables denote the number of times the stress creating conditions were repeated by the twenty participants in all the interviews.

Table 16 Descriptions of physiological strains, with examples from the interviews

n	Strain	Description	Example(s)
34	VR sickness	Instances of nausea, dizziness, motion sickness, headaches or disorientation while using VR technology.	*"Unfortunately, I think that nausea, headaches, these kinds of things. They're so serious that basically, you end up taking the [VR device] off." – Product Manager, Germany* *"There were times where I would have to leave work early because the headaches were that bad." – Lead Technical 3D Artist, USA*
6	Visual fatigue	Experiences of discomfort, fatigue, or visual disturbances in the user's eyes after prolonged or excessive use of VR technology.	*"I am having issue with my eyes, though. My eyes are getting all wonky. I feel like it is because I am using way too much VR." – Content Creator, France*

The users experienced discomfort and strain in their eyes after prolonged use of VR technology. The users described issues such as 'wonky eyes' and tiredness. Some users found it challenging to recognize the fatigue, leading to headaches and disorientation.

Users highlighted nausea, intense headaches, and motion sickness as consequences to the stress they get from VR. They reported varying frame rate, control methods, and low-quality content in VR to be some of the reasons for VR sickness. Additionally, VR experiences involving movement, especially roller coaster-like scenarios, often led to motion sickness and discomfort. The symptoms varied between the users, with some adapting to VR over time, while others continued to face difficulties.

6.7 Strain category II: Behavioral strain

The behavioral strains highlighted by the users because of stress included reduced efficiency and effectiveness in tasks, decreased enthusiasm for VR, and users wanting to quit or quitting engagement with VR technology and applications. The descriptions along with examples have been summarized in table 17 below. The 'n' in the tables denote the number of times the stress creating conditions were repeated by the twenty participants in all the interviews.

Table 17 Descriptions of behavioral strains, with examples from the interviews

n	Stress creating conditions	Description	Example(s)
8	Discontinuance	Act of users quitting or wanting to quit their engagement with virtual reality technology and its applications.	*"There have been conversations with my coworkers, early on, like it [VR] was so janky that I was like, if I didn't work here, I would have thrown this out the window and we got to improve this because this is horrible." – Lead Technical 3D Artist, USA* *"One of my teammates he stopped and said no, I have my 4-screen setup at home. I'm perfectly fine. I don't wanna spend the additional amount of time to configure my VR screens." – Senior Software Engineer, Germany*

n	Stress creating conditions	Description	Example(s)
2	Reduced productivity	Decline in the efficiency and effectiveness of work or tasks performed within virtual reality environments.	*"For me personally, I cannot use VR for more than a couple of hours, it's too draining." – Chief Executive Officer, Lisbon*
2	Reduced motivation	Decrease in the user's willingness to engage with virtual reality experiences, resulting in a lack of interest or enthusiasm towards using VR technology or applications.	*"I am demotivated to use VR when there is like a update and like how the battery life and stuff like those kind of things. And it's like I just want to do the simple stuff and it's so annoying if you have been ready to do something and then there is like surprise update and it's like you cannot continue without updating it and there is no skip or doing it later option. So those are like super annoying and it's like OK not today." – Coordinator of technology education, Finland*

The users highlighted draining effect of using VR for extended periods. The user mentioned that they felt demotivated to use VR due to issues with updates, battery life, and connectivity, especially when using VR in a group setting. Surprise updates without a skip or postpone option was annoying and disruptive to their VR experience. Additionally, the user found VR less appealing when experiences became repetitive for them, leading them to take breaks from VR after a month or two.

Some users found the experience problematic due to discomfort, such as headaches and nausea, leading them to take breaks or permanently discontinue usage. Others cited a lack of compelling content as a deterrent to using VR regularly. Additionally, technical issues, such as difficulty in setup and configuration, frustrated the users and discouraged them from using VR consistently. Moreover, fatigue and the need for frequent pauses during VR sessions contributed to reduced engagement by the users in VR.

7. INSIGHTS ON THE COMMON PATTERNS

This section discusses the observations drawn by identifying and examining the common patterns that surfaced from the interview data.

7.1 Common patterns in the stress creating conditions

The interviews unveiled several significant technostressors that caused stress for users using VR. These technostressors encompassed various aspects of the VR experience, impacting users' well-being and comfort. From ergonomic concerns related to discomfort caused by VR headset design and weight distribution to issues with the effectiveness of VR for team collaboration and interaction, users highlighted many stressors encountered while using VR in an organizational setting.

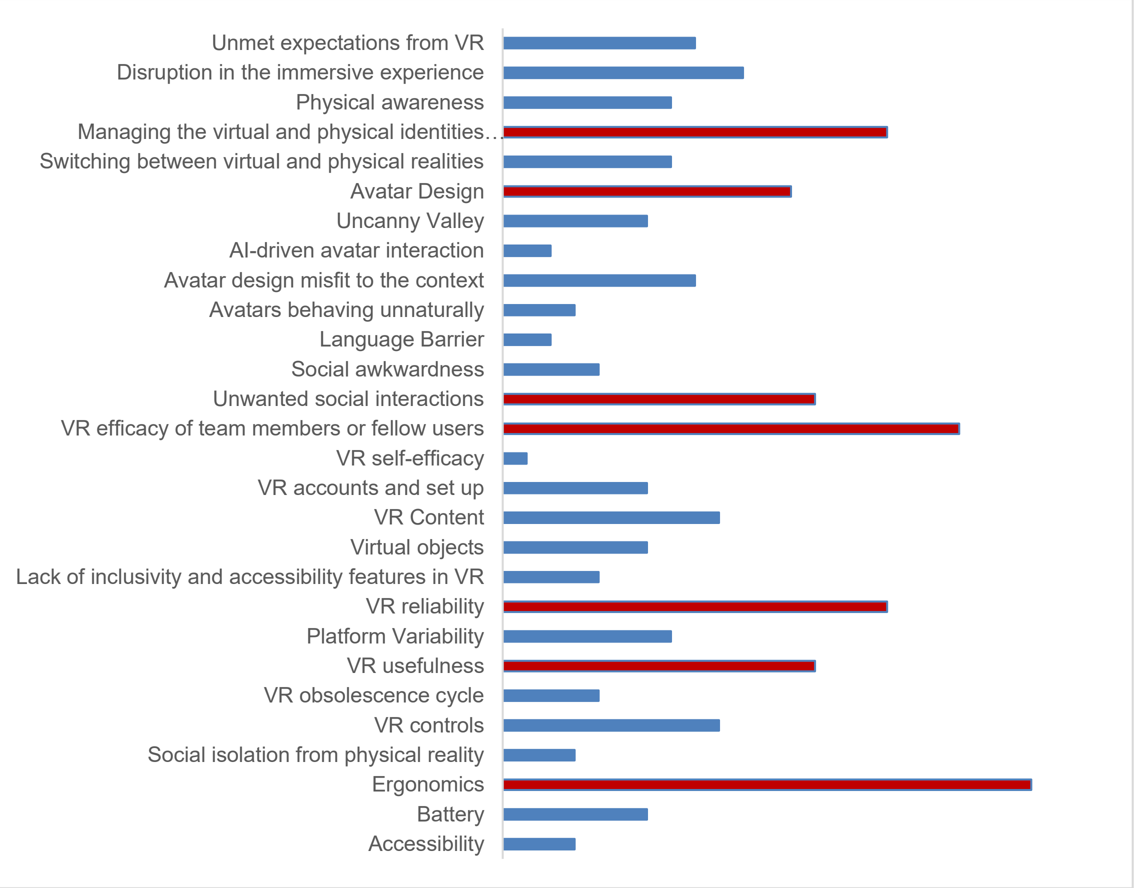

Figure 6 *Summary of stress creating conditions contributing to technostress in users using VR in organizational setting*

Figure 6 above illustrates the frequency or number of times each technostressors was mentioned or highlighted during the twenty interviews. Based on the frequency of references, the top six stress-inducing conditions (highlighted in red in Figure 6) with the most significant impact are Ergonomics, VR efficacy of team members or fellow users, VR reliability, Managing the virtual and physical identities simultaneously, VR usefulness and Unwanted social interactions. The impact of these technostressors has been discussed in detail in Chapter 6 above.

7.2 Common patterns in the stressor and strain categories

Based on the four stressor categories, it was observed that the most stress-inducing factors emerged from the 'Social' category, followed by the 'Software' category. This has also been illustrated in Figure 7 below.

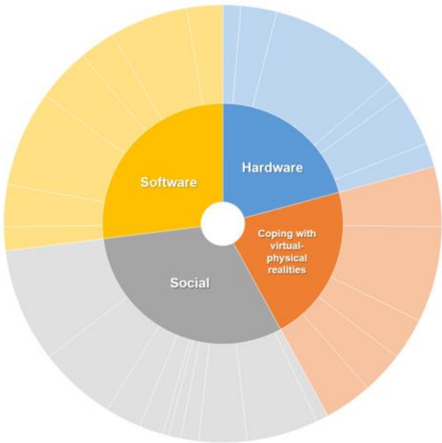

Figure 7 *Stressor categories and their common patterns*

Next, the stress-inducing factors that were highlighted by the participants within each stressor category were examined and illustrated in Figure 8.

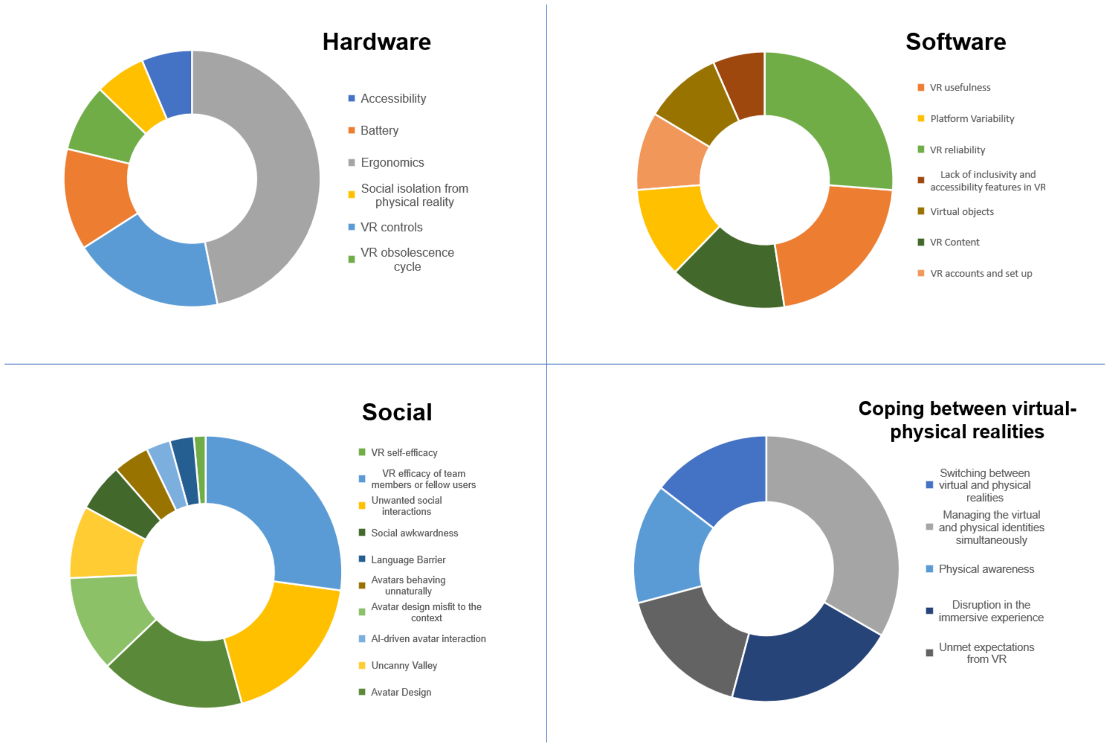

Figure 8 *Stress creating conditions within each stressor category*

As seen in Figure 8, within Stressor Category-I, 'Hardware,' the most prominent stress-creating conditions discussed extensively by the users were *Ergonomics, VR controls,* and *Battery*. Moving on to Stressor Category-II, 'Software,' the factors that had the most significant impact on users were *VR reliability*, followed by *VR usefulness* and *VR content*. In Stressor Category-III, 'Social Aspects,' the stressors most frequently highlighted were the *VR efficacy of team members or fellow users*, *Unwanted social interactions*, and *Avatar design*. Lastly, in the Stressor Category-IV, focusing on 'Coping between virtual-physical realities', the most impactful stressors identified were *Managing the virtual and physical identities simultaneously* and *Disruption in the immersive experience.*

During the interviews, the users highlighted different stress creating conditions that contributed to the behavioral and physiological strain. The most prominent strains mentioned by the users most frequently were *VR sickness* from 'Physiological Strain' category followed by *Discontinuance* from 'Behavioral Strain'. The trend was illustrated in Figure 9 below:

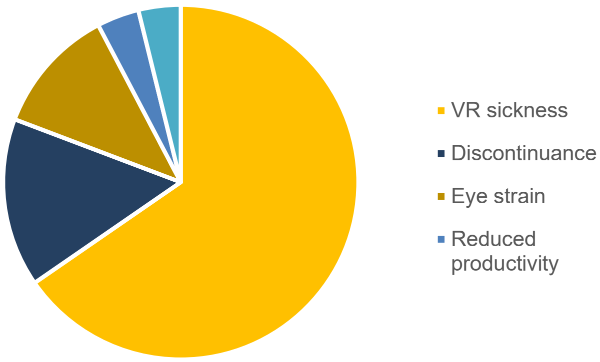

***Figure 9** Behavioral and physiological strains*

7.3 Strains and their associated stressors

During the interviews, it was discussed how technostressors affected the users, resulting in reduced productivity, experiences of VR sickness, and diminished motivation to continue using VR. This has been summarized in Table 18 below.

Table 18 Summary of highlighted strains and their associated stressors

Strain categories	Strains	Associated stress-creating conditions	Stressor categories
Behavioral	Reduced productivity	Battery	Hardware
		Platform variability	Software
		VR efficacy of team members	Social
		Switching between realities	Coping with virtual-physical realities
	Discontinuance	Obsolescence cycle	Hardware
		VR content	Software
		Unwanted social interactions	Social
	Reduced motivation	VR usefulness	Software

Strain categories	Strains	Associated stress-creating conditions	Stressor categories
		Virtual objects	
		VR efficacy of team members	Social
		Unmet expectations	Coping with virtual-physical realities
Physiological	VR sickness/Visual fatigue	Ergonomics	Hardware
		VR controls	
		VR reliability	Software
		Switching between re-alities	Coping with virtual-physical realities

7.3.1 Behavioral strains and associated stressors

The behavioral strains that were brought up by the users included reduced motivation, reduced productivity, and discontinuance. For **reduced productivity**, the following stress creating conditions were highlighted in the interviews:

Battery: The issue of poor battery life resulted in reduced productivity as users could not accomplish much due to frequent disruptions caused by battery depletion. As one user mentioned;

"Yeah, because you can't continue working on something in the [VR] medium that you started with. As you're in the process and then the battery is done, then you have to pause while you have been in the real mood, right? And when you're really just in the moment when you really got into it, the battery is done. Of course, it stops you and it takes you away." – Chief Executive Officer, Germany

Platform variability: In the VR environment, different devices, headsets, controllers, and software applications are not always compatible with each other, leading to a decrease in productivity due to challenges in seamless integration and usage by the user. As one user mentioned taking longer than usual to adjust to a platform, causing a dent in his productivity;

“Sometimes, when I haven’t used a platform for a while, even an advanced user like me takes some time to readjust. What I could have sorted out in about 30 seconds usually, it takes me a minute and a half to figure out what [the platform] was about. It is, to this day, a major stressor and just basically a hurdle to be dealing with it.” – Managing Director, Türkiye

Switching between virtual and physical realities: According to the users, switching between virtual and physical realities result in reduced productivity due to readjustment challenges. As one user explained how switching between the realities affect his productivity;

“I just use my [VR] headset as a tool, so if I have four calls in a day, I have to go in and out in and out, in and out [of VR]. It's stressful. It's stressful because I have to brush my hair, put on the nicer shirt, shave, get out of my pyjamas and keep up an appearance of a professional. And so that is, I guess, a little bit stressful for sure.” – Chief Executive Officer, USA

In discussions about **discontinuance**, users frequently mentioned the following stress-creating conditions:

Obsolescence cycle: Users also mentioned that the shorter shelf life of the device and the overall obsolescence cycle of VR led them to almost discontinue their usage of VR in an organizational setting. As one user specified:

“The IT departments gets yet another device that they need to maintain, control and update. IT dept. needs new skills to do this, and it takes time, so it adds costs, and you wonder if its worth the effort, time, and cost [to continue using VR].” – Chief Executive Officer (A), Finland

VR content: As per the interview data, it was highlighted that VR content can cause discontinuance in users if it lacks diversity, is of low quality, induces motion sickness, or fails to align with users' interests and needs. As one user said;

“What might prevent me from using VR – and I think not only me but most of the people is the lack of content actually, if you take for example, Microsoft HoloLens, you know it doesn't have any content there. But you know, it's just that there isn't, like, often enough big reasons to use [VR]” - Chief Executive Officer (B), Finland

Unwanted social interactions: Unwanted social interactions in VR can lead to discontinuance when users feel uncomfortable, invaded, or harassed in the virtual environment.

Negative or distressing social experiences can discourage users from further engaging with VR, leading to a decision to discontinue its usage. As a user explained:

"There's young kids who doesn't really know how to have social skills and how those kind of places work, just being annoying around there. So yes, this is why that I haven't really used to VR chat or anything else like that in a long time…. I know that people are not using it or like they don't have the social skills to use it. [These factors] really does impact my decision on if I ever want to try [social VR platforms] again." - Coordinator of Technology Education, Finland

For **reduced motivation**, the following stress creating conditions were highlighted by the users:

VR usefulness: The perceived lack of usefulness in VR experiences led to reduced motivation among users to use VR in an organizational setting. As it was narrated;

"Many VR applications right now are replicas of what can be done into these screens already. So, it doesn't really add that much of a new value or it's not easier or better to have a meeting there than having the zoom call." – Founder/Student, Finland

Virtual objects: Virtual objects can lead to reduced motivation if they lack realism or fail to meet users' expectations. As one user specified;

"For example, one of the things I'm using is the PostIt. Obviously if you start using it in VR headset, it is very annoying because you write one letter at a time and you just have to go with the cursor you know and it's time consuming, but on the computer, it works pretty fast. That's why, for example, I don't use the 3D environment for writing when teaching. It's very limited, this part." - Educational Leadership Member, Romania

Unmet expectations from VR lead to reduced motivation: According to the discussions in the interviews, unmet expectations from VR can lead to reduced motivation among users. When users had higher expectations for the technology, like anticipating groundbreaking experiences, flawless immersion, or transformative applications, but found that their actual VR experiences do not meet the expectations, it resulted in feelings of disappointment and disillusionment. As one user stated:

"Let's go back to the beginning when everybody was super excited about the new [VR] technology and the headsets. We've been super excited as well but recognized very early that nothing really works. Nothing really works as it was anticipated…. So, the gap between super excitement and super disappointing has been super close to each other." – Chief Executive Officer, Germany

VR efficacy of team members leading to reduced motivation, reduced productivity, and discontinuance: When team members struggle to effectively use VR and its applications, it can lead to reduced motivation among the team. The difficulty in navigating and utilizing VR tools may lead to time wastage of the team, leading to frustration and demotivation. As one user mentioned:

"A couple of companies I know have been trying to introduce VR into their companies to do meetings. But then when they get into the meeting, it's like if 50 percent of the time of the meeting is just for technical support. And it's like 'no click it here', 'no click', 'no', 'don't do that'. As a result, the one-hour meeting is now just 30 minutes because you just spent 30 minutes trying to figure out the VR tech." – Chief Executive Officer, Lisbon

7.3.2 Physiological strains and associated stressors

The interviews highlighted physiological strains like VR sickness and visual fatigue. Users discussed several stress-inducing conditions that they believed were responsible for these physiological strains.

Ergonomics: Poor ergonomics, such as ill-fitting headsets or improper positioning of controllers, were identified as contributing factors to VR sickness (headaches, nausea, motion sickness) by the users. As one user clarified:

"I have the Bobo head strap and all the additional things, but even then, I get headaches and I get just pain with the pressure on the forehead." – Product Manager, Germany

VR controls: The users mentioned that the VR controls can contribute to VR sickness when conflicting or unpredictable movements in the virtual environment are introduced as this mismatch between the user's physical movements and the virtual response can lead to a phenomenon called "motion-to-photon" latency. One user shared their experience, stating;

"I've still noticed that it's especially in VR where you are depending on the control method of the character, if you have to use a joystick for movement. I notice that I get motion sickness in those cases." – Managing Director, Türkiye

VR reliability: According to the users, VR reliability or the lack thereof, can cause VR sickness when the system exhibits inconsistencies, delays, or technical glitches that disrupt the VR interactions. As one user explained;

"The only thing that could possibly make me uncomfortable is when there's a low frame rate. So, suddenly the frame rate drops a lot. So, you experience a lag in the scene and

couple that with a lot of movement and then it can make me uncomfortable." – Product Manager, USA

Switching between virtual and physical realities: Another user explained how the difference between the two realities can lead to VR sickness:

"Basically, you're moving in the [VR] experience, but your body in real life is not moving. Therefore, you may encounter motion sickness difficulties, which can vary." – Marketing Manager, France

8. DISCUSSION

This thesis contributes to the existing knowledge by presenting a synthesis of how technostress emerges among individuals who use multi-user VR environments for work-related purposes. It also aims to provide future avenues of research in this key area. While researching the previously unexplored areas, special attention was paid to the leading technostressors and the subsequent consequences of the phenomena. The search for prior literature encompassed articles that had conducted empirical studies on one or both elements. These empirical findings were then summarized in Table 19 below, based on their focus on technostress.

This study extends the research of technostress when it comes to working in an organization and using VR as the preferred medium for interaction and engagement. The technostressors have been classified into four comprehensive categories—encompassing hardware-related factors, software-related factors, social dynamics, and coping with virtual-physical realities. The study also discusses the subsequent strains into two categories i.e., behavioral, and physiological strains.

8.1 Confirmation and extension of previous findings

Table 19 Summary of previously covered and uncovered empirical findings

Stress creating conditions	VR Context		Organizational Context		VR use in an organizational context
	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress
Hardware					
VR Controls	Knierim et al. (2018);	Geiger at. al (2018);	-	-	Souchet et al (2023)
Social isolation from physical reality	Merkx & Nawijn (2021);	Mütterlein and Hess (2017); Apostolakis et. al (2020);	-	-	-
Obsolescence cycle	-	-	Kahn et al. (1981)	Bradley & Dawson (1998); Rajeswari & Anantharaman (2003);	-
Ergonomics	Kim and Shin (2018); Yan et al. (2019); Le at al., (2021); Rebenitsch & Owen (2021)	Dehghani et al. (2021); Szopa and Soares (2021); Saghafian et al. (2021)	-	-	Souchet et al. (2023)

Stress creating conditions	VR Context		Organizational Context		VR use in an organizational context
	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress
Battery	-	Jalo et al. (2021)	-	-	-
Affordability and ownership	-	Slater et al., (2016); Jalo et al. (2021);	-	-	-
Software					
VR usefulness	-	Tost & Economou (2009)	Ayyagari (2011); Harahap and Effiyanti (2015);	-	-
Platform variability	-	-	-	-	-
VR reliability	Palmisano et al., 2019; Rebenitsch & Owen, 2016;	Stanney et al., 2020b; Chang et al., 2020;	Ayyagari (2011); Åborg & Billing (2003); Butler & Gray (2006);	Abdel-Hamid 1999; Ba et al. 2001; Austin 2001;	

Stress creating conditions	VR Context		Organizational Context		VR use in an organizational context
	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress
Accessibility	Creed et al., 2023; Gerling et al., (2020), Gerling & Spiel, (2021), Mott et al., (2020); Malu & Findlater (2014); Baker et al., 2019; Baker et al., 2020; Roberts et al., 2019	-	Boyd et al., 2018; Motti, 2019; D'Cunha et al., 2019;	-	-
Virtual objects	-	-	-	-	-
VR content	Souchet et. al, 2022; Hu et al., 2019; Porcino et al., 2017; Allue et al., 2016; Islam et al., 2020;	-	-	-	-
VR accounts and set up	-	-	-	-	-

Stress creating conditions	VR Context		Organizational Context		VR use in an organizational context
	Empirical findings focused on technostress	**Empirical findings on non-technostress aspects**	**Empirical findings focused on technostress**	**Empirical findings on non-technostress aspects**	**Empirical findings focused on technostress**
Social					
VR avatars and their impact: Design, AI-driven interactions, misfit to context, behavior	-	Peck et al. (2021); Ventrella (2011); Kim et al. (2021); Peck et al. (2013); Won et al. (2015); Sun et al. (2015); Liu et. al. (2017); Baylor & Kim (2009); Staler et. al (2016); Theng & Aung (2011); Scott et. Al (2015); Noël et al. (2009); Dyck et al. (2008); Oh et al. (2016);	-	-	-
VR Efficacy: Self and team members	-	-	Ragu-Nathan (2008); Dragano & Lunao (2020), Tarafdar et al.	-	Souchet et. al (2023)

Stress creating conditions	VR Context		Organizational Context		VR use in an organizational context
	Empirical findings focused on technostress	**Empirical findings on non-technostress aspects**	**Empirical findings focused on technostress**	**Empirical findings on non-technostress aspects**	**Empirical findings focused on technostress**
			(2020); Weinert et al., (2020)		
Unwanted social interactions	-	Benyon & Mival (2008)	-	-	-
Social awkwardness	Helminen et al., 2019; Zimmer et al., 2019;	-	-	-	-
Language barrier	-	-	-	-	-
Coping with virtual-physical realities					
Switching between virtual and physical realities / Managing the virtual and physical identities simultaneously	Saredakis et al. (2020); Merhi er al. (2007);	Bourdin et al. (2019)	Tarafdar et al. (2011)	-	-
Physical awareness	-	-	-	-	-

Stress creating conditions	VR Context		Organizational Context		VR use in an organizational context
	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress	Empirical findings on non-technostress aspects	Empirical findings focused on technostress
Disruption in the immersive experience	-	-	Tarafdar et al. (2011)	-	-
Unmet expectations from VR	-	-	-	-	-

Aligned with the findings of this study, previous research concerning hardware-related factors has indicated that stress can be induced by VR controls due to increased cognitive demands and gripping techniques (Knierim et al., 2018; Geiger et al., 2018). Additionally, the affordability and ownership of VR devices have emerged as noteworthy stress-inducing elements (Slater et al., 2016; Jalo et al., 2021), alongside the sense of isolation from physical reality (Merkx & Nawijn, 2021; Apostolakis et al., 2020). The notion of stress stemming from obsolescence has also been explored, drawing parallels with the realm of information technology (Kahn et al., 1981). The significance of VR ergonomics in relation to stress factors, encompassing aspects like cybersickness and cognitive overload, has also been underscored in the previous literature (Souchet et al., 2023).

This study has also expanded on the different software-related stress-creating conditions while using VR in an organizational setting. The previous literature has highlighted the stress implications of reliability of ICT, shedding light on sources of frustration and quality concerns (Ayyagari, 2011; Åborg & Billing, 2003). Additionally, accessibility challenges for immersive technologies and their associated stress effects have been addressed in prior studies, for example in the works of Creed et al., (2023) and Mott et al., (2020). The implications of stress originating from VR content have also been explored in discussions by Souchet et al. (2022) and Porcino et al. (2017).

Furthermore, this study delves into various conditions that generate social stress, especially the role of avatars and their interactions that cause user stress. While not explicitly discussed, there have been implicit discussions regarding the influence of VR avatars on cognitive processes and behavior (Peck et al., 2021), along with the impact of avatar design, contextual incongruence, and virtual interactions on the virtual experience (Ventrella, 2011; Kim et al., 2021; Liu et al., 2017) in prior studies. Furthermore, aspects such as social awkwardness, unwanted social interactions, and stress related to public speaking within multiuser settings have also been discussed (Allen et al., 2017; Zimmer et al., 2019).

This study has highlighted several challenges that the users face to cope with virtual-physical realities such as the switching and managing the two identities, and immersive experience disruption, which affects the users' stress and strain levels. While prior literature on this stressor category is nascent, there have been discussions on users adjusting arm movements subconsciously (By Bourdin et al., 2019), cybersickness due to static physicality (Saredakis et al., 2020; Merhi et al., 2007), and disruptions during immersive experiences (Tarafdar et al., 2011).

Along with the stressors, there has been prior literature highlighting the consequences of technostress (strains) in the context of VR as well as organizational setting. The study by Tarafdar et al., (2007) demonstrated an inverse relationship between productivity and technostress in organizations which inferred that reduced ICT-based technostress corresponds to increased productivity and vice versa. Similar findings were discussed in other papers by Tarafdar et al., (2011) and (2020). Mittelstaedt, Wacker, and Stelling (2019) have discussed the connections of cybersickness and cognitive performance in users of VR. The discontinuation of IT usage has been examined in previous studies by Maier et al., in 2015 and 2022.

While direct empirical evidence may be limited, the implicit discussions on the technostress aspects of VR and work-related settings laid the groundwork for understanding the potential impact of multi-user VR within organizational contexts. Further research is required to close this knowledge gap and offer more tangible insights into how social VR impacts technostress within work environments.

8.2 Research contribution

Overall, this study categorised the factors of technostress into four major categories of stressors i.e., stress creating conditions which are related to: a) hardware, b) software, c) social aspects and d) coping with the virtual-physical realities and two major strain categories i.e., behavioral, and physiological strains. In the current research on technostress, examining the specific technostress creators have been overlooked often (Salo et. al, 2022). Therefore, the findings of this study offer new perspectives for examining these technostress factors in future research.

This thesis significantly enhances the understanding of technostress within organizational contexts. It reaffirms the relevance of well-established technostress factors associated with the use of IT in the workplace. These factors, including *techno-complexity, techno-insecurity, techno-uncertainty,* and *usability issues*, have been extensively discussed in prior research by Tarafdar et al. (2007, 2011), Ragu-Nathan et al. (2008), Yun et al. (2012), Ayyagari et al. (2011), Sellberg & Susi (2014), Harris et al. (2022), Kim & Lee (2021), and numerous others.

While prior literature has addressed technostress in the context of using VR, and in the context of IT-use within organizations, this study advances the field by uncovering novel factors unique to the multi-user VR environment that contribute to technostress in an organizational setting. For example, it sheds light on technostressors such as *AI-driven avatar interaction, avatar design,* and *avatar design misfit to the context*. Notably, this research highlights the pivotal role of avatar perception as a potential source of stress among users of social VR in an organizational context, providing a foundation for further investigation in this area. These insights were in-line with previous research, as evidenced in the literature review in Chapter 3, where it was elucidated how avatars can evoke varied reactions from users, subsequently influencing their attitudes, behaviours, and social interactions, as discussed by Slater & Steed (2001), Johnston & Thomas (1982), Smith (2001), and others.

This study expands the understanding and importance of immersion, presence, and co-presence in social VR and the subsequent stress that follows. As highlighted in Chapter 3, the significant difference between the other multi-user VEs and SVR is the aspect of spatial interactivity and immersion due to its contribution to the user experience of co-presence (Schultze, 2010; Torro et. al, 2021). Through this study, the critical aspects of the stress creating conditions related to coping with virtual-physical realities like *Managing the virtual and physical identities simultaneously, Disruption in the immersive experience, switching between virtual and physical realities,* for example, have been highlighted.

This study not only sheds light on common patterns between stress-inducing conditions and their subsequent strains in a work-related context when using multi-user VR but also contributes to the broader understanding of virtual reality-induced symptoms and effects, initially introduced by Cobb et al. (1999) and how VRISE can affect individuals using SVR within an organizational setting. For instance, the paper underscores the impact of technostressors on users of VR, leading to decreased productivity, experiences of VR sickness, and reduced motivation to continue using VR. These findings align with the work of Tarafdar et al. (2007, 2011), Ragu-Nathan et al. (2008), Yun et al. (2012), Ayyagari et al. (2011) who discussed these subsequent strains in the context of IT-use in the workplace. These findings also align with the work of Souchet (2023), who has discussed the effect of VRISE on a user in a work-related setting. Furthermore, this study reaffirms the presence of strain categories, specifically behavioral and physiological strains, as identified by Cooper et al. (2001).

8.3 Practical contribution

This study has practical implications that can be taken into consideration in organizations that are currently using multi-user VR—including their use for meetings, collaborations, team building exercises, and even business development.

By categorizing and detailing the stress creating conditions across the four categories i.e., hardware, software, social aspects, and virtual-physical integration, this study equips organizations with a comprehensive understanding of potential stressors related to the use of multi-user VR technology. This insight enables proactive identification and mitigation of these stressors. The study also provides organizations with actionable insights for designing interventions, which enables the development of targeted strategies to address each factor's impact on employees' well-being and performance.

The study's discussion on work-context technostressors triggered by multi-user VR experiences like social awkwardness and coping with virtual-physical realities highlights the importance of providing training and support to employees. Organizations can offer guidance on navigating social dynamics in VR and provide resources for managing the transition between virtual and physical realities. The organizations can also better equip their employees when it comes to the devices as well as the space needed in the physical environment to navigate in the virtual environment. Organizations can also develop well-being initiatives tailored to address stressors unique to VR technology. The study's connection between technostressors and their strains, such as reduced motivation and productivity, informs organizations about potential long-term impacts. This knowledge aids in formulating strategies to maintain employees' engagement, well-being, and performance over extended periods of VR technology usage.

The study's emphasis on VR self-efficacy and team members' efficacy highlights the importance of comprehensive training programs. Organizations can design training that not only imparts technical skills but also enhances users' confidence and competence in navigating VR environments.

In summary, these practical contributions would help empower organizations to make informed decisions, design effective interventions, and create a supportive and stress-minimized work environment as they implement and utilize VR technology.

8.4 Limitations of the study

While the empirical results derived from this study contribute to addressing the research question, it is advisable to pursue additional investigation into this subject. To begin with, the conclusions drawn are reliant on qualitative data gathered from a limited number of participants, potentially introducing bias, and limiting the generalizability of the results to a broader population. To enhance the validity and comprehensiveness of the findings, it would be beneficial to expand the sample size for interviews and ensure a more diverse representation across various industries, businesses, and user demographics when examining technostress in the context of VR usage in the workplace.

The reliability and applicability of this qualitative research study was assessed based on the criteria by Lincoln & Guba (1985). For credibility, the study was assessed based on Korstjens & Moser (2018) credibility checks. First, the semi-structured interviews were conducted deliberately to encourage open and unrestrained discussions in line with the study's research focus, which ultimately enhanced the study's credibility. Second, the interview participants were selected based on their experience with VR usage in organizational contexts, aiming to gather more focused data. During these interviews, the researcher further validated responses with real-world examples and posed follow-up questions to gain deeper insights. Additionally, interviewee anonymity was ensured to foster openness. Also, the interview transcripts underwent a non-linear and iterative coding and analysis process to consolidate and facilitate effective data interpretation. However, due to limited interviewee availability, member checks were not employed.

The transferability and dependability of this study was substantial as per the criteria outlined by Korstjens and Moser in 2018. The study offered a comprehensive account of both the participants and the research approach within the study's specific context, in Chapter 5. The study provides the description of the research process, which encompasses details about participant selection criteria, the methodology for engaging participants, the approach to data analysis, and a coherent interpretation of the study's results from Chapter 5 to 8.

For confirmability check, as discussed by Korstjens & Moser (2018), the interview questions were designed to gather insights about technostressors associated with SVR within organizational settings. In some instances, additional follow-up questions were spontaneously posed during interviews to allow interviewees to provide further details on specific topics. These questions were not leading but aimed at facilitating a more comprehensive discussion. To minimize researcher bias, the researcher extensively familiarized themselves with the existing literature on VR, social VR, technostress, and technostressors, presenting a comprehensive overview in the theoretical background in Chapter 2 through 4.

As VR technology evolves rapidly, the findings may be subject to temporal limitations. Emerging advancements in VR hardware, software, and design could impact the relevance of the study's conclusions to current and future VR environments. For instance, the interviews were conducted in early 2023 for this study. Most participants had mentioned using ‘AltSpaceVR’ and discussed the software and design of the application. However, the application was shut down by the time the analysis of this paper began.

While conducting interviews, since some participants were representing a company or a business that was actively developing for VR environments, some responses to the interviews felt influenced by social desirability as well as self-promotion and organisational advocacy bias. This was eliminated by ensuring anonymity, using neutral language, emphasizing on honesty, and prompting contextualization during the interviews.

A notable limitation of the study stems from the limited availability of literature directly addressing technostress in users of multi-user VR within work-related contexts. Due to this, much of the information was drawn implicitly or deduced from tangentially relevant papers, where implications were extrapolated to fit the study's focus.

8.5 Future avenues of research

This thesis serves as a foundation for many prospective research avenues. Building upon the comprehensive findings of this study in the context of multi-user virtual reality within work-related settings, several promising directions emerge for further research. For instance, researchers can illuminate the nuances of technostress, consequent strains, and also conduct in-depth research on the VR characteristics that contribute to technostress in multi-user VR environments in work-setting as well as the mitigation measures.

Furthermore, based on this study, it would be a very promising aspect to investigate how the design and personalization of avatars being used in a work context influences technostress. This includes studying how users perceive themselves as being present within their avatars and investigating how factors like avatar design fidelity, realism, and customization influence users' sense of embodiment, comfort, and overall immersion in the virtual environment in a work-related setting. It would also be beneficial to investigate the link between avatars' appearances and behaviours (including AI-driven interactions) and the quality of social engagements, and how these factors contribute to overall technostress levels in users. It would also be interesting to study the long-term impact of technostress and avatar interactions over extended periods. Longitudinal studies could provide insights into how these factors evolve and influence users' experiences over time.

Another aspect that would a promising research topic would be to examine the psychological implications of users' integration of physical and virtual identities through avatars. Investigating how seamlessly users can switch between their real-world self and their avatar representation, and how this transition affects stress levels and overall comfort during multi-user VR interactions would be very beneficial to the overall research on technostress.

Based on this study, it would be a promising research topic to delve into technical improvements and design innovations, both for hardware and software aspects of multi-user VR environments. Investigating ergonomic enhancements to optimize comfort and usability of VR hardware remains a priority. Additionally, standardized platforms could be explored further to enhance compatibility and streamline user experiences. In the context of software, there's room for exploring inclusive and accessible VR design through features catering to diverse user needs. Psychological aspects and user training interventions is another dimension that can be pursued. Strategies to enhance VR self-efficacy, team members' efficacy, and mitigation of social awkwardness could be investigated. Additionally, delving into the long-term impact of technostress on employee well-being, motivation, and productivity within the context of VR technology usage can provide a holistic understanding of sustained effects.

9. CONCLUSIONS

In summary, this paper addresses the emergence of technostress in multi-user VR environments for work-related purposes, shedding light on stress-inducing factors across hardware, software, social dynamics, and coping with virtual-physical realities with existing discussions on technostress in broader technological contexts, highlighting their relevance in the multi-user VR environment. This study emphasizes the significance of ergonomic considerations, affordability challenges, and the impact of VR content quality on the users and delves into the complexities of social interactions and coping mechanisms within SVR. The correlation between identified stressors and their resulting strains emphasizing the impact of the stress creating conditions on the users.

In terms of contributions, this study deepens the understanding of technostress by outlining its impact within SVR work environments. It brings to light previously unexplored stressors, underscoring the need for holistic assessments of stress in multiuser VR environments under work-related settings. Overall, the research provides valuable insights for individuals and organizations navigating the evolving landscape of multi-user VR.

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