June 2024

TECHNOSTRESS IN WORK-RELATED USE OF SOCIAL VIRTUAL REALITY

Bakhtawar Aurangzeb Khan
Tampere University, bakhtawar.khan@tuni.fi

Henri Pirkkalainen
Tampere University, henri.pirkkalainen@tuni.fi

Markus Salo
University of Jyväskylä, markus.t.salo@jyu.fi

TECHNOSTRESS IN WORK-RELATED USE OF SOCIAL VIRTUAL REALITY

Completed Research Paper

Bakhtawar Khan, Tampere University, Tampere, Finland, bakhtawar.khan@tuni.fi

Henri Pirkkalainen, Tampere University, Tampere, Finland, henri.pirkkalainen@tuni.fi

Markus Salo, University of Jyväskylä, Jyväskylä, Finland, markus.t.salo@jyu.fi

Abstract

The global virtual reality market is undergoing substantial growth, and within this landscape, social virtual reality has emerged as a key communication platform by offering features like shared spaces, avatar-based interactions, and tools for remote collaboration. Despite the increasing integration of virtual reality and social virtual reality in organizational contexts, a notable gap exists in our understanding of the stress experienced by users within social virtual reality environments. This paper addresses this gap by applying the concept of technostress. While existing literature has explored challenges and stress-inducing conditions and their consequences (i.e., strains) in organizational and virtual reality settings, little is known about the emergence of technostress in users of social virtual reality for work purposes. A qualitative analysis was employed in this paper to highlight the stress-creating conditions and consequent strains related to using social virtual reality in the organizational context—paving the way for further research in this field.

Keywords: Technostress, Social Virtual Reality, Metaverse, Organizational Context.

1 Introduction

Social virtual reality (VR) can be defined as "virtual reality solutions that prioritize communication and social interactions" (Torro, 2023). Such solutions encompass multiuser attributes, including avatar-based interactions, shared spaces, and tools that facilitate remote collaboration (Mütterlein et al., 2018; Torro et al., 2021). Due to technological progress that has enabled VR to host immersive social experiences, social VR applications have undergone substantial growth in recent years (Trahan et al., 2019; Jalo et al., 2020; Torro et al., 2021).

The active utilization of information technology (IT) is a necessity across various industries. As organizations seek new ways to achieve innovation and performance improvement through IT, it becomes essential for them to become familiar with the potential adverse consequences associated with IT usage. Despite the growth trajectory of VR, there is very little research on its negative organizational and social impacts. One such negative consequence is technostress, which is defined as stress induced in individuals due to the use of IT (Tarafdar et al., 2020). Technostress in 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). As organizations are increasingly integrating social VR into their work processes, including team meetings and collaborations, understanding its influence on individuals and organizations in terms of technostress is imperative. Unlike other work-related communication tools, such as videoconferencing and chatting applications (e.g., Zoom and Microsoft Teams), social VR immerses users in virtual environments where they interact through customizable avatars, effectively blurring the line between the virtual and physical worlds (Torro, 2023; Mütterlein, 2018;). As individuals engage in these immersive experiences while concurrently performing work-related tasks, they can experience cognitive dissonance in which their brains perceive virtual interactions as "real" (Mütterlein, 2018; Souchet et al., 2023), potentially leading to technostress. For instance, VR-related studies have shown that individuals can suffer from cybersickness and cognitive overload due to heightened immersion (Breves et al., 2023). There is a gap in our understanding of the psychological and behavioral outcomes of working in social VR, and further research is needed to bridge this gap and provide more concrete insights into how social VR affects technostress in work environments.

To understand technostress in the work-related use of social VR, this paper aims to answer the following research question: *What are the emerging stress-creating conditions and consequent strains in social VR environments used for work-related purposes*?

To address this research gap and gain insight into stress experiences in VR, we conducted 20 semi-structured interviews with individuals who had used social VR environments for work. Qualitative content analysis followed the guidelines of Lune and Berg (2017). Our contributions to information systems (IS) research extend the current understanding of stress-creating conditions and strains by explaining unique conditions related to the work-related use of social VR and understanding social VR in work settings in the broader context of the metaverse. Furthermore, this study offers practical implications for individuals and organizations that utilize social VR for various purposes, including meetings, collaborations, team building, and business development.

2 Theoretical Background

2.1 Virtual reality and social virtual reality

Virtual reality has been defined in several ways, as it can be characterized not only as a technology but also as an application or experience (Pallavicini et al., 2019). Jason Jerald (2015) defined VR technology as "a computer-generated digital environment that can be experienced and interacted with as if it were real," where the primary goal is to immerse and fully engage the individual in the virtual environment. VR has been perceived as isolating due to its emphasis on single-user experiences (Kim et al., 2013). However, the advent of social VR has introduced a new trend, allowing multiple users to interact within the same virtual space through avatars (Perry, 2015).

Social VR can be used for many communication purposes and include various participants through the use of attributes such as shared space, interaction through avatars, and tools that facilitate remote collaboration (Torro et al., 2021). The main difference between social VR and other multiuser virtual environments (e.g., virtual worlds accessed from computer screens), as well as two-dimensional communication tools (e.g., Zoom and Microsoft Teams), is spatial interactivity and immersion, which contributes to the user experience of co-presence (Schultze, 2010). Social VR has the capacity to intuitively simulate face-to-face interaction and has gained recognition as an "ideal" platform for communication and collaboration (Slater and Sanchez-Vives, 2016, p. 27). Social VR can also be seen as an aspect of the metaverse, as the metaverse facilitates unique and immersive telepresence experiences (Xi et al., 2023). The metaverse is commonly depicted as a seamless network comprising interconnected 3D virtual realms. Diverse technologies, such as VR, can serve as gateways to this expansive digital environment, which is intended to cater to multiuser purposes (Ball, 2022; Trevett, 2022). The potential for collaboration in the metaverse is evident; recent efforts, such as the Metaverse Standards Forum, have sought to establish common standards for interoperability (Koziol, 2022). Given that the metaverse is still in its nascent phase, these open standards are deemed essential for facilitating more extensive social interactions within that digital space (Ritterbusch and Teichmann, 2023). However, there remains limited understanding of how the metaverse can be effectively utilized for collaborative purposes (Park et al., 2023).

Social VR is uniquely defined by three key characteristics: presence, immersion, and interactivity (Bailenson et al., 2008; Mütterlein, 2018). Presence, as described by Schultze (2010), involves the feeling of “being there” in the VR environment—creating a coherent place through simulated sensory data and user perception. Immersion is psychological engagement in the virtual environment and is influenced by factors such as sensory realism, panoramic displays, and contextual avatars (Schultze, 2010). Enhanced immersion can lead to an effective sense of presence. Interactivity is the way users can interact with the virtual objects and avatars of other users in the virtual environment, and it varies based on individual perspectives and experiences with VR (Mütterlein, 2018). Mütterlein and Hess (2017) highlight social VR’s promising applications, particularly in enhancing professional collaboration. For instance, in fields like architecture, engineering, and construction, social VR can be valuable because it facilitates shared spatial understanding of proposed designs, thereby improving collaboration between end-users and designers (Paes et al., 2017). Social VR’s diverse use cases in developing comprehensive collaboration within virtual environments have been recognized by practitioners, indicating its potential to enhance organizational performance by fostering collaboration among stakeholders across industry value chains. It also enables seamless teamwork, particularly in scenarios where in-person meetings are impractical (Jalo et al., 2020; Torro and Pirkkalainen, 2022). However, the literature on social VR’s utility in an organizational context remains sparse.

2.2 Technostress, stress-creating conditions, and strain

Technostress encompasses negative impacts on human behavior (including attitudes, thoughts, and psychology) caused by using technology (Tu et al., 2005). The theoretical basis for technostress originates from the prior literature on stress. Lazarus (1966, 1993) emphasized that it is the individual’s perception of the demand conditions, rather than the requirements themselves, that might make for a stressful situation. One of the predominant theoretical frameworks for understanding technostress has been the transactional view of stress (Lazarus, 1966; Lazarus and Folkman, 1984). Comprising stressors and strains as its primary components, this framework posits that when an individual interprets certain circumstances as posing a threat to their well-being (i.e., stressors), these conditions can lead to adverse outcomes (i.e., strains) for the individual (Fischer and Riedl, 2017; Tarafdar et al., 2007).

Stress-creating conditions are the IT-use-related factors that cause technostress (Califf and Brooks, 2020; Li and Wang, 2021). These factors are perceived as threatening or demanding by the individual as the IT use exceed the individual’s available resources (Ayyagari et al., 2011; Ragu-Nathan et al., 2008; Tarafdar et al., 2019). Technostress has emerged, for example, due to the use of social networking sites (Salo et al., 2019; Whelan et al., 2022) and artificial intelligence (Xia, 2023). It has been discussed in terms of economic and organizational perspectives (Wang et al., 2008), medical field (Arnetz and Wiholm, 1997), and psychology (Brod, 1984). In professional settings, technostress is linked to the extensive use of workplace IT devices and applications (Ayyagari et al., 2011; Tarafdar et al., 2007, 2019). Literature on IS is increasingly discussing the significance of technostress in workplaces across different industries and its documented detrimental effects on the well-being and performance of employees (Ayyagari et al., 2011; Pirkkalainen and Salo, 2016; Tarafdar et al., 2015).

As organizations actively pursue innovation and performance enhancement through IT, it is imperative that they acquaint themselves with potential drawbacks, such as technostress, associated with IT usage. Ayyagari et al. (2011) and Tarafdar et al. (2007), among many other researchers, have provided evidence that the conditions that induce technostress usually stems from technology use–related demands in the workplace. Ragu-Nathan et al. (2008) established a set of five stress-creating conditions experienced by employees who utilize IT in their work: techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty. Other established conditions include role conflict and role ambiguity (Hwang and Cha, 2018), work–home conflict, privacy invasion, and job insecurity (Ayyagari et al., 2011). Technostress can also stem from interruptions caused by IT (Tams et al., 2018), a breakdown of IT systems (Riedl et al., 2012), and prolonged use (Afifi et al., 2018). Previous literature has provided empirical findings on technostress aspects in organizational settings related to usefulness (Ayyagari, 2011; Harahap and Effiyanti, 2015), reliability (Ayyagari, 2011; Butler and Gray, 2006), and efficacy of self and team members when using IT (Dragano and Lunau, 2020; Ragu-Nathan et al., 2008). Strains (and other outcomes) refer to the subsequent behavioral, physiological, and psychological effects of stress (Cooper et al., 2001). Various technostress studies have highlighted strains in the workplace setting, which include loss of productivity (Tarafdar et al., 2007), declining work performance, lower job satisfaction (Ayyagari et al., 2011; Tarafdar et al., 2014), turnover intention (Califf and Brooks, 2020), and burnout (Zhao et al., 2022). In the context of VR, prior literature has addressed empirical findings related to hardware-related challenges, such as VR controls (Knierim et al., 2018), social isolation from physical reality (Merkx and Nawijn, 2021), and ergonomics (Yan et al., 2019). Similarly, prior studies have explored software-related issues in VR, such as VR reliability (Palmisano et al., 2019; Rebenitsch and Owen, 2016) and accessibility (Creed et al., 2023; Gerling and Spiel, 2021), as well as social awkwardness (Helminen et al., 2019; Zimmer et al., 2019). The VR context can include challenges related to cybersickness, visual fatigue, muscle fatigue and musculoskeletal discomfort, and cognitive overload (Souchet et al., 2023).

While previous research has explored challenges related to utilizing VR and technostress in organizations that utilize IT, there is a gap in understanding of technostress that arises specifically from the use of social VR in organizational settings. As organizations increasingly adopt VR for team collaborations and meetings, scholarly focus is extending beyond its social aspects to encompass its role in enhancing productivity and facilitating critical work tasks in organizations (e.g., training and design activities). Understanding how the use of social VR influences individuals and organizations in terms of technostress is imperative, considering social VR's integral role in modern work processes and its impact on employee well-being and organizational effectiveness.

3 Research Methodology

Semi-structured interviews (Brinkman, 2014) were conducted to capture users' perspectives on VR-related technostress. Using semi-structured interviews as the primary data collection tool allowed insight into various aspects that have not been covered in prior studies, along with context-specific explanations of VR use (Venkatesh et al., 2013). The data collected in this study, therefore, were based on VR users' actual experiences instead of hypothetical scenarios (van der Heijden, 2012).

3.1 Data collection

In this study, 20 semi-structured interviews were conducted with employees who actively use social VR environments for work-related activities (e.g., attending networking events or running team meetings). Purposeful sampling (Patton, 1990) ensured that the selected participants represented diverse professional backgrounds, roles, and experience levels with VR technology within various organizations. The selection efforts included contacting potential participants through professional networks, industry forums, and online platforms related to VR technology and the organizational use context. The snowball technique was also applied—participants were asked to recommend other potential participants (Babbie, 2016; Lopes et al., 1996).

During the interviews, the participants were asked to share insights into their backgrounds, VR device usage, and organizational applications of VR, particularly in social VR settings. The interview structure, influenced by Myers and Newman's (2007) guidelines, covered VR usage patterns, followed by questions about negative experiences and broader technological stressors in VR, causes of stress while using VR in an organizational setting, reactions to said stress-creating conditions, interruptions and discomfort, security and privacy concerns, and the impact of external factors on VR experiences. This approach aimed to delve into real-life examples, minimize recall bias by anchoring questions in actual events, and foster open communication through empathetic reactions and flexibility during interviews. In terms of the researcher–subject relationship, the participants were allowed to choose which stressful experiences to share and to express themselves in their own words without interruption. As the participants shared their stressful experiences related to social VR use, they often used strong language to describe their 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 of the measures taken to ensure confidentiality and anonymity, and the interviews were recorded with the consent of the participants.

The interviews took place in early 2023, lasted between 35 and 90 minutes, and leveraged video conferencing tools, such as Microsoft Teams and Google Meet. The diverse professional backgrounds of participants included CEOs (25%), product/marketing managers (15%), educational experts (15%), sales and marketing experts (15%), web development and software engineering experts (10%), Extended Reality (XR) specialists (5%), managing directors (5%), 3D artists (5%), and content creators (5%). They worked in industries such as VR development, EdTech in VR, VR sales and marketing, and startups. Among these 20 participants, 6 were from Finland, 4 were from the United States of America, and 3 each were from France and Germany; there was 1 participant each from Portugal, the Netherlands, Romania, and Türkiye. On average, the participants reported using VR for approximately 2 to 3 hours per day—some as little as 15 minutes a day, others up to 6 hours. Many used more than one VR device; 34% used Meta Quest 2, 16% Meta Quest Pro, and 13% Meta Quest One. During the interviews, the participants recounted utilizing social VR for various work-related purposes and shared insights into their active utilization of social VR applications within their professional settings, such as for meetings, collaborative work, team-building exercises, and even business development. Engage and AltspaceVR (which was shut down in 2023) were most frequently mentioned for social VR use (15% of participants), while 12% users mentioned using Immersed, Rec Room, and Meta Horizon Workrooms.

3.2 Data analysis

This study focused on examining individual users' perceptions of technostress related to their use of social VR in an organizational setting. The qualitative data analysis followed Berg's (2004) guidelines, involving the identification of 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. Subsequently, the data were (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, with which text portions were labeled with descriptive tags corresponding to their respective classifications. These descriptive tags represented the stress-creating conditions that contribute to technostress, for example "VR platform disparity," "VR unreliability," etc. A similar approach was used for the strain descriptive tags (e.g., "discontinuance" and "lack of motivation"). Next, similar descriptive labels were grouped together to form categories linked to the general classifications. For instance, stress-creating conditions like "VR platform disparity" and "VR unreliability" were combined to form the "software-related" stressor category. This led to the creation of a coding scheme comprising the names, descriptions, and examples for three stress-creating categories: hardware-related, software-related, and social stress-creating conditions. We sourced category names from the existing literature whenever possible. Nine of the 16 categories had not previously been identified in technostress research. The remaining seven categories shared similarities with those identified in prior technostress studies and were named accordingly. Similarly, all four strain categories had been identified in prior studies (see Tables 1 and 2). This approach helped organize and effectively structure the qualitative data for analysis. To ensure the accuracy of the sorting process, the newly examined data were 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.

4 Results

Based on the discussions with the participants, the conditions responsible for creating technostress were ordered into three categories: hardware-related stress-creating conditions, software-related stress-creating conditions, and social stress-creating conditions. These categories, which are based on the coding scheme described in Section 3, are summarized in Table 1.

Hardware-related stress-creating conditions	**Description**	**Software related stress-creating conditions**	**Description**	**Social stress-creating conditions**	**Description**
Poor ergonomics (Souchet et al., 2023)	The discomfort of wearing a head-mounted device during extended use, including factors such as poor fit, poor audio/visual quality, inadequate weight distribution etc.	VR unreliability (Ayyagari, 2011)	System performance affected by technical glitches, such as lag, bugs, and audio/video issues.	Limited VR efficacy of self and team members/fellow users (Identified from the data)	Limited proficiency of the user and fellow team members/fellow users when using VR technology.
VR controls ambiguity (Identified from the data)	Ambiguity in joystick movements, alternative interaction methods, like triggers instead of grips, insufficient testing etc.	Lack of VR usefulness (Weinert et al., 2020)	Concerns regarding the extent of VR usefulness in terms of performance.	Unwanted social interactions (Identified from the data)	Instances in social VR sessions where users face disruptive, uncomfortable, or distressing interactions.
Battery performance limitation (Identified from the data)	The limited amount of time a VR device can function on a single charge before needing recharging or battery replacement.	VR platform disparity (Identified from the data)	VR systems varying in terms of hardware, software, and configurations, leading to differences in user experiences.	Uncanny valley (Identified from the data)	Virtual representations of humans closely resemble real humans but still exhibit subtle and unnatural features or behaviors.
Technological obsolescence (Bradley and Dawson, 1998)	Shorter shelf life leading to frequent replacements, higher costs, and rising market challenges—necessitating constant upgrades to maintain competitiveness.	Challenges with virtual objects (Speicher et al., 2018)	Challenges manipulating digital entities within a virtual environment that are designed for user interaction and immersion.	Social awkwardness (Identified from the data)	The discomfort and unusual social dynamics that can arise in multiuser environments.
Social isolation from physical reality (Merkx and Nawijn, 2021)	Isolating experience for users due to its individualized setup.	Challenges with VR accounts and setup (Identified from the data)	Configuring VR devices and software to facilitate access and use of VR experiences.		
Limited affordability and ownership (Identified from the data)	Limited accessibility of VR experiences due to expensive technology and relatively limited ownership of VR headsets.	Accessibility barriers in VR (Creed et al., 2023)	Lack of implementation of functionalities in VR to accommodate users with physical disabilities or limitations.		

Table 1. Stress-creating conditions related to social VR in an organizational setting.

4.1 Hardware-related stress-creating conditions

The hardware-related stress-creating conditions focused on user comfort and how the experience is affected by VR equipment. Prolonged usage of head-mounted displays (HMDs) created stress and issues involving fit, cushioning, ventilation, audio and visual quality, and adjustability. Users experienced headaches and pain due to pressure on the forehead or discomfort with glasses. The weight of certain headsets led to tears in the eyes after extended periods of use. As one user explained:

"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

Users expressed stress due to the ambiguity of joystick movements and certain interaction methods, such as using triggers instead of grips. The lack of testing and adherence to design conventions further contributed to user frustration. Interviews highlighted concerns about the ease and intuitiveness of controls, along with VR's individualized setup, which can lead to social isolation.

"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

Many users highlighted that the limited battery life of VR devices was stressful, as it led to interruptions during important meetings or extended VR sessions. 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.

"Most stressful is the battery life." – Event Host/Organizer, Netherlands

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 that the rapid innovation in the VR industry, which necessitates constant upgrades, made it difficult for them to keep up with the latest advancements. Some users also mentioned that the constant upkeep (upgrading devices; training IT and users in the office) resulted in additional expenses, contributing to their apprehension about investing in VR technology.

"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

The users highlighted that the private and isolating nature of VR due to its individualized setup can be stressful, as it lacks the social aspect of playing games with friends in the same room (unlike console gaming). 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.

"VR is a super-private setup. 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

The cost of VR technology and the relatively low ownership of VR headsets were stressful to many users. Some mentioned that VR setups are costly and more suitable for niche enthusiasts than for public use in schools or businesses. Some mentioned that while many people express interest in participating in VR, they are unable to do so because of financial barriers.

"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

4.2 Software-related stress-creating conditions

Users commonly experienced technical glitches and issues in VR systems, causing 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. Users also encountered software bugs and rendering problems that resulted in motion sickness and wasted work time.

"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 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

Users expressed skepticism about the usefulness of VR, particularly in comparison to traditional 2D online meetings. Some of the stressful aspects mentioned by the participants included resolution limitations, cognitive load from prolonged usage of the virtual environments, and the absence of motivation to use VR over the long term, as meetings in VR do not always offer added value compared to other online meeting platforms.

"*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 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 a 2D online meeting. The virtual environment adds cognitive load." – Chief Executive Officer (A), Finland*

VR platforms differ in hardware, software, and configurations, resulting in varied user experiences and a learning curve when navigating different systems. Users, even experienced ones, expressed frustration when transitioning between platforms, citing confusion and compatibility issues. According to the participants, joining meetings with mixed device usage led to functional disparities, causing challenges in coordination during shared activities and increased overall stress.

"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 efficiently. So that's another element [of stress]." – Lead Technical 3D Artist, USA

Users mentioned some limitations when interacting with digital 3D entities in the virtual environment that contribute to stress when using VR. For example, writing in VR is cumbersome due to the difficulty with cursor navigation. Additionally, taking notes during meetings using speech-to-text caused disruptions due to inaccuracies in the transcription, especially for non-English speakers, which was deemed stressful.

"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

Setting up and configuring VR experiences was stressful for users. They mentioned that friction in the software, such as the need for multiple logins and verification processes, creates barriers to accessing VR platforms and experiences. In some cases, team members faced delays in joining meetings due to complicated login procedures and unintuitive user interfaces.

"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 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

The participants highlighted that the lack of functionalities in VR to accommodate users with physical disabilities or limitations was stressful for them. Some users noted that it becomes difficult to use VR effectively when there is limited vision in one eye or a lack of stereoscopic vision. Some mentioned that there is a lack of proper support for those using wheelchairs, lying in hospital beds, or similar.

"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

4.3 Social stress-creating conditions

Users cited multiple social aspects in VR that can create stress, such as fellow VR users' proficiency in utilizing VR technology. Lack of VR proficiency and familiarity with VR controls by the team members also led to discomfort and inefficiency during meetings and collaborations. Technical issues with VR, such as temperamental devices and room limits, caused frustration and hindered smooth interactions at work. In some cases, 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 in virtual environments, resulting in stress.

"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

During social VR sessions, users encountered disruptive 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 shared content. Additionally, the disruptive presence of children in public VR rooms led to discomfort:

"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 from coming in. And so, you get kids that come in every day, causing disruptions." – Chief Executive Officer, USA

Harassment, sexism, homophobia, and racism have been observed, especially toward identifiable users like women. The 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.

"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

Many users found the aspect of the uncanny valley to be disturbing during VR use. Some users found more cartoony avatars less distracting, as they did not expect them to behave like humans, and others found the comparatively realistic avatars with "dead eyes" or slight deviations from natural humans to be particularly uncomfortable.

"There's this uncanny valley experience that means that, actually, it isn't you. Yes, it's quite close to you, but you are slightly dead or at 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

In social VR environments, discomfort and unusual social challenges arise when someone faces microphone issues or cannot speak during events or discussions, which is stressful for users. Participants pointed out that such a situation is rarely encountered in real-life interactions; therefore, it can be quite awkward. 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.

"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

The users' assessments of their ability to effectively organize and carry out VR experiences was affected by proficiency issues and a lack of confidence, resulting in stress. According to one user, in a work context, the biggest frustration arises from the need to relearn basic skills to perform tasks in a different context.

"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 learn how to do it in a different context." – Managing Director, Türkiye

4.4 Strains related to social VR use

During the interviews, one of the most important findings was about how stress-creating conditions affected the users at behavioral and physiological levels. This is summarized in Table 2.

Strains	**Associated stress-creating conditions**	**Stressor categories**	**Strains**	**Associated stress-creating conditions**	**Stressor categories**
Reduced productivity (Pirkkalainen et al., 2019)	Battery performance limitation	Hardware	Reduced motivation (Weil and Rosen, 1997)	Lack of VR usefulness	Software
	VR platform disparity	Software		Challenges with virtual objects	
	Limited VR efficacy of self and team members/fellow users	Social		Limited VR efficacy of self and team members/fellow users	Social
Discontinuance (Maier et al., 2015)	Technological obsolescence	Hardware	VR sickness/Visual fatigue (Souchet et al., 2023)	Ergonomic risks	Hardware
	Unwanted social interactions	Social		VR controls ambiguity	
				VR unreliability	Software

Table 2. Summary of strains and associated stress-creating conditions.

Various factors have contributed to the reduced productivity of VR and the discontinuance of its use. Productivity was impacted by battery limitations and compatibility issues among devices and applications. Discontinuance was driven by technological obsolescence, which discouraged users from utilizing VR in organizational settings. Unwanted social interactions in VR caused discomfort for the users, deterring further engagement, while reduced motivation stemmed from a perceived lack of usefulness, interaction overload, and challenges in effective team usage. Additionally, difficulties in navigating VR tools led to time wastage, frustration, and demotivation. The interviews also highlighted physiological strains, such as VR sickness and visual fatigue. Users attributed these strains to poor ergonomics and unpredictable VR control movements, e.g., the motion-to-photon latency. Additionally, inconsistencies, delays, and technical glitches further induced physiological strains in users during their VR interactions.

5 Discussion and Contributions

5.1 Theoretical contributions

This study has produced two main contributions. First, our paper contributes to the existing literature on technostress by introducing the stress-creating conditions and strains within social VR in an organizational setting. While our study corroborates the empirical findings of prior research (e.g., Ayyagari, 2011; Knierim et al., 2018; Tarafdar et al., 2020; Yan et al., 2019), it introduces hardware-related stress-creating conditions that are prevalent in the use of social VR in an organizational setting, including technological obsolescence and limited affordability and ownership. Our study introduces novel stress-creating conditions, such as challenges with virtual objects and VR platform disparity. Regarding social aspects, our study validates previous empirical findings on social stress-creating conditions such as social awkwardness (Helminen et al., 2019; Zimmer et al., 2019), as well as introduces unique stress-creating conditions such as the uncanny valley, limited VR efficacy of self and team members, and unwanted social interactions. Our study not only validated prior findings but also expanded on the stress-creating conditions in the three categories (i.e., hardware-, software-, and social-related) specific to VR—including VR controls ambiguity, social isolation from physical reality, poor ergonomics, VR platform disparity, and challenges with VR accounts and setup. This expansion provides a foundation for further investigation into stress-creating conditions specific to social VR environments in an organizational setting. Furthermore, our findings point out novel forms of stress-creating conditions that differ from other communication tools (e.g., videoconferencing in Zoom or Microsoft Teams). For instance, uncanny valley, challenges with virtual objects, limited VR efficacy of self and team members/fellow users, and social isolation from physical reality are examples of conditions that arise due to the immersiveness of social VR—when the user perceives the virtual environment as “real” (Mütterlein, 2018; Torro, 2023).

This paper presents initial evidence linking stress-creating conditions to strains reported by participants, offering an important first step toward a holistic understanding of technostress within social VR environments in organizational settings. Additionally, our work aligns with prior studies on strain and stress-creating conditions, expanding the concept of technostress and serving as a foundational guide for future research and interventions aimed at mitigating technostress in social VR environments.

Second, this study aligns with the emerging field of metaverse research, as social VR is a key building block of the metaverse. IS research recognizes that immersive VR plays a pivotal role as an interface to the metaverse, as pointed out by Dincelli and Yayla (2022, p. 1). According to their findings, immersive VR presents a significant strategic opportunity for organizations, given the distinctive technological capabilities that set it apart from similar technologies. Therefore, comprehending the distinctiveness of immersive technology compared to non-immersive alternatives is crucial for understanding the potential offered by the metaverse and its implications for organizations. This paper serves as an important step toward understanding the unintended negative consequences of the metaverse, given that social VR can be viewed as a representative example of the metaverse.

5.2 Practical implications

This study offers valuable practical implications for individuals and organizations utilizing social VR technology for various purposes, including meetings, collaborations, team building, and business development. By categorizing and thoroughly detailing stress-creating conditions across hardware, software, and social aspects, the research equips individuals and organizations with a comprehensive understanding of potential stress-creating conditions related to VR technology, allowing them to proactively identify and mitigate these issues. Moreover, the study can help provide actionable insights for designing interventions, offering guidance on navigating social aspects and ensuring employees are well-equipped for VR experiences. It emphasizes the importance of addressing VR-related stress-creating conditions to maintain employee well-being, motivation, and productivity over extended periods of VR technology usage. Furthermore, it underscores the significance of comprehensive programs in enhancing VR self-efficacy and team members' efficacy, which can help avoid the strains identified in this study. These programs might include stress-management training and guidelines at the workplace (like awareness programs and training sessions) to educate employees about the potential stressors and coping mechanisms. In essence, these practical contributions empower organizations to make informed decisions, implement effective interventions, and foster a supportive and stress-minimized work environment when incorporating VR technology.

5.3 Limitations and future research topics

There were certain limitations to our study. For instance, the study relied on a relatively small sample size of 20 participants for qualitative interviews. While these interviews provided rich data for analysis, the findings may not be generalizable to broader populations of social VR users in organizational contexts. Future research could benefit from larger and more diverse samples to enhance the generalizability of the findings. Furthermore, the study primarily focused on identifying stress-creating conditions and strains in social VR environments; it did not extensively explore potential situational/moderating factors that could influence the stress-creating conditions, strains, and their relationships. Factors such as individual differences, organizational culture, and technology characteristics could play significant roles in shaping users' experiences of technostress in social VR environments and warrant further investigation. To improve the depth of our exploration of technostress in the context of social VR usage in the workplace, it may be advantageous to conduct targeted studies that focus on specific scenarios related to social VR. For instance, investigating how employees navigate virtual team meetings or collaborative projects in a social VR environment and exploring the impact of extended social VR use on individual well-being in remote work scenarios. This approach would provide a nuanced understanding of the diverse situations in which VR is employed across various industries, businesses, and user demographics, thereby enhancing the overall comprehensiveness and applicability of our findings. Additionally, it is plausible that as social VR becomes more widely adopted, users will be likely to experience new stress-creating conditions, so the results of this paper should not be viewed as an exhaustive list of the possible stress-creating conditions in social VR. However, it is an important first step in understanding technostress in social VR.

Building upon the findings of this study in the context of social VR within work-related settings, several promising directions emerge for further research. For instance, researchers might illuminate the nuances of technostress and the consequent strains by conducting in-depth research on the VR characteristics that contribute to technostress in social VR environments in work settings. Furthermore, it would be a valuable addition to the research to study coping-mechanisms and mitigation measures for the stress-creating conditions of social VR. Design innovations are another promising topic about which more information may help to avert technostress in social VR environments. Additionally, standardized platforms could be explored further to enhance compatibility and streamline user experiences. In the context of software, there is room for exploring inclusive and accessible VR design through features that cater to diverse user needs. Additionally, delving into the long-term impact of technostress on employee well-being, motivation, and productivity within the context of VR technology usage would provide a holistic understanding of sustained effects.

Acknowledgments

This research has been partly supported by the ECIU University (612521-EPP-1-2019-1-NL-EPPKA2-EURUNIV), ECIUn+ (101089422), Academy of Finland (341359), the Emil Aaltonen Foundation, and The Foundation for Economic Education.

References

Afifi, T. D., Zamanzadeh, N., et al. (2018). “WIRED: The impact of media and technology use on stress (cortisol) and inflammation (interleukin IL-6) in fast paced families,” *Computers in Human Behavior* 81, 265-273.

Arnetz, B. B. and Wiholm, C. (1997). “Technological stress: Psychophysiological symptoms in modern offices,” *Journal of Psychosomatic Research* 43, 35-42.

Ayyagari, R., Grover, V., and Purvis, R. (2011). “Technostress: Technological antecedents and implications,” *MIS Quarterly* 35 (4), 831-858.

Babbie, E. (2016). *The practice of social research*, 14th Edition.

Bailenson, J., Patel, K., Nielsen, A., et al. (2008). “The effect of interactivity on learning physical actions in virtual reality,” *Media Psychology* 11, 354376.

Ball, M. (2022). *The metaverse: And how it will revolutionize everything*. Liveright Publishing.

Berg, B. L. (2004). *Qualitative research methods for the social sciences*. Boston, MA: Pearson Education.

Bradley, M. and Dawson, R. J. (1998). “An analysis of obsolescence risk in IT systems,” *Software Quality Journal* 7 (2).

Breves, P. and Stein, J.-P. (2023). “Cognitive load in immersive media settings: The role of spatial presence and cybersickness,” *Virtual Reality: The Journal of the Virtual Reality Society* 27 (2), 1077-1089.

Brinkmann, S. (2014). “Unstructured and semi-structured interviewing,” in: Leavy, P. (ed.) *The Oxford handbook of qualitative research* (pp. 277-299). Oxford University Press.

Brod, C. (1984). *Technostress: The human cost of the computer revolution*. Addison Wesley Publishing Company.

Butler, B. S. and Gray, P. H. (2006). “Reliability, mindfulness, and information systems,” *MIS Quarterly* 30 (2), 211-224. https://doi.org/10.2307/25148728.

Califf, C. and Brooks, S. L. (2020). “An empirical study of technostressors, literacy facilitation, burnout, and turnover intention as experienced by K-12 teachers,” 157. 10.1016/j.compedu.2020.103971

Cobb, S. V. G., Nichols, S., Ramsey, A., and Wilson, J. R. (1999). “Virtual reality induced symptoms and effects (VRISE),” *Presence: Teleoperators & Virtual Environments* 8, 169-186.

Cooper, G. L., Dewe, P. J. N., and O’Driscoll, M. P. (2001). *Organizational stress: A review and critique of theory, research, and applications*. Thousand Oaks: Sage Publications Inc.

Creed, C., Al-Kalbani, M., Theil, A., Sarcar, S., and Williams, I. (2023). “Inclusive AR/VR: Accessibility barriers for immersive technologies,” *Universal Access in the Information Society*. 23 (1), 59–73.

Dincelli, E. and Yayla, A. (2022). “Immersive virtual reality in the age of the metaverse. A hybrid-narrative review based on the technology affordance perspective,” *The Journal of Strategic Information Systems* 31 (2), 101717.

Dragano, N. and Lunau, T. (2020). “Technostress at work and mental health: Concepts and research results,” *Current Opinion in Psychiatry* 33, 407-413.

Fischer, T. and Riedl, R. (2017). “Technostress research: A nurturing ground for measurement pluralism?” *Communications of the Association for Information Systems* 40, 375-401.

Gerling, K. and Spiel, K. (2021). “A critical examination of virtual reality technology in the context of the minority body,” *CHI Conference on Human Factors in Computing Systems*, 1-14.

Harahap, K. and Effiyanti, T (2015). “Technostress among educators: A revisit of social cognitive perspective.”

Helminen, E. C., Morton, M. L., Wang, Q., and Felver, J. C. (2019). “A meta-analysis of cortisol reactivity to the Trier Social Stress Test in virtual environments,” *Psychoneuroendocrinology,* 110104437–104437.

Hwang, I. and Cha, O. (2018). “Examining technostress creators and role stress as potential threats to employees’ information security compliance,” *Computers in Human Behavior* 81, 282-293.

Jalo, H., Pirkkalainen, H., Torro, O., et al. (2020). "Enabling factors of social virtual reality diffusion in organizations," *28th European Conference on Information Systems (ECIS):* An Online AIS Conference, June 15-17, 2020., 7, Association for Information Systems, pp. 1-15

Jerald, J. (2015). *The VR book: Human-centered design for virtual reality*. Morgan & Claypool.

Kahn, R. D. M., Wolfe, R. P., Quinn, J. D., and Snoek. (1981). *Organizational stress: Studies in role conflict and ambiguity*. Malabar, FL: Krieger.

Kim, M. J., Wang, X., Love, P. E. D., Li, H., et al. (2013). "Virtual reality for the built environment: A critical review of recent advances," *Electronic Journal of Information Technology in Construction* 18, 279-305.

Knierim, Pascal & Schwind, Valentin & Feit, Anna & Nieuwenhuizen, Florian & Henze, Niels. (2018). Physical Keyboards in Virtual Reality: Analysis of Typing Performance and Effects of Avatar Hands. 1-9. 10.1145/3173574.3173919.

Koziol, M. (2022). *The metaverse needs standards, too—The big players have founded a "forum"—But will it make the place come to life any sooner?* URL: https://spectrum.ieee.org/metaverse-standards-forum (visited on March 18, 2024).

Lazarus, R. S. (1966). *Psychological stress and the coping process*. New York: McGraw-Hill.

Lazarus, R. S. (1993). "From psychological stress to the emotions: A history of changing outlooks," *Annual Review of Psychology* 44, 1-21.

Lazarus, R. S. and Folkman, S. (1984). *Stress, appraisal, and coping*. New York: Springer.

Lei, C. F. and Ngai, E. (2014). "The double-edged nature of technostress on work performance: A research model and research agenda," in: *Thirty Fifth International Conference on Information Systems,* Auckland, New Zealand.

Li, L. and Wang, X. (2021). "Technostress inhibitors and creators and their impacts on university teachers' work performance in higher education," *Cognition, Technology & Work* 23(2), 315-330.

Lopes, C. S., Rodrigues, L. C., and Sichieri, R. (1996). "The lack of selection bias in a snowball sampled case-control study on drug abuse," *International Journal of Epidemiology* 25 (6), 1267-1270.

Lune, H. and Berg, B. L. (2017). "Qualitative research methods for the social sciences," 9th Edition. Harlow: Pearson.

Maier, C., Laumer, S., Weinert, C., and Weitzel, T. (2015). "The effects of technostress and switching stress on discontinued use of social networking services: A study of Facebook use," *Information Systems Journal* 25 (3), 275-308.

Merkx, C. and Nawijn, J. (2021). "Virtual reality tourism experiences: Addiction and isolation," *Tourism Management (1982)* 87, 104394.

Mütterlein, J. (2018). "The three pillars of virtual reality? Investigating the roles of immersion, presence, and interactivity," in: *51st Hawaii International Conference on System Sciences (HICSS*). 10.24251/HICSS.2018.174.

Mütterlein, J. and Hess, T. (2017). "Immersion, presence, interactivity: Towards a joint understanding of factors influencing virtual reality acceptance and use," in: *23rd Americas Conference on Information Systems (AMCIS),* Boston, USA.

Mütterlein, J., Jelsch, S., and Hess, T. (2018) "Specifics of Collaboration in Virtual Reality: How Immersion Drives the Intention to Collaborate" (2018). *PACIS 2018 Proceedings*. 318. https://aisel.aisnet.org/pacis2018/318

Myers, M. D. and Newman, M. (2007). "The qualitative interview in IS research: Examining the craft," *Information and Organization* 17 (1), 2-26.

Paes, D., Arantes, E., and Irizarry, J. (2017). "Immersive environment for improving the understanding of architectural 3D models: Comparing user spatial perception between immersive and traditional virtual reality systems," *Automation in Construction* 84, 292-303.

Pallavicini, F. and Pepe, A. (2019). "Comparing player experience in video games played in virtual reality or on desktop displays: Immersion, flow, and positive emotions," in: *Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts (CHI PLAY '19 Extended Abstracts),* New York, USA.

Palmisano, S., Szalla, L., and Kim, J. (2019). "Monocular viewing protects against cybersickness produced by head movements in the oculus rift," in: *25th ACM Symposium on Virtual Reality Software and Technology,* New York, USA.

Park, H., Ahn, D., and Lee, J. (2023). "Towards a metaverse workspace: Opportunities, challenges, and design implications," in: *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, Article 503, 1–20. https://doi.org/10.1145/3544548.3581306

Patton, M. (1990). *Qualitative evaluation and research methods*. Beverly Hills, CA: Sage.

Perry, T. S. (2015). "Virtual reality goes social," *IEEE Spectrum* 53 (1), 56-57.

Pirkkalainen, H., et al. (2019). "Deliberate or instinctive? Proactive and reactive coping for technostress," *Journal of Management Information Systems* 36 (4), 1179-1212.

Pirkkalainen, H., & Salo, M. (2016). Two Decades of the Dark Side in the Information Systems Basket: Suggesting Five Areas For Future Research. *In ECIS 2016: 24th European Conference on Information Systems, Tel Aviv, Israel, June 9-11, 2014 (pp. 101).* Retrieved from http://aisel.aisnet.org/ecis2016_rp/101.

Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S., and Tu, Q. (2008). "The consequences of technostress for end users in organisations: Conceptual development and empirical validation," *Information Systems Research* 19 (4), 417-433.

Rebenitsch, L. and Owen, C. (2016). "Review on cybersickness in applications and visual displays," *Virtual Reality* 20, 101-125.

Riedl, R., Kindermann, H., Auinger, A., and Javor, A. (2012). "Technostress from a neurobiological perspective: system breakdown increases the stress hormone cortisol in computer users," *Business and Information Systems Engineering* 4 (2), 61-69.

Ritterbusch, G. D. and Teichmann, M. R. (2023). "Defining the metaverse: A systematic literature review," *IEEE Access*, 12368-12377.

Salo, M., Pirkkalainen, H., and Koskelainen, T. (2019). "Technostress and social networking services. Explaining users' concentration, sleep, identity, and social relation problems," *Information Systems Journal* 29 (2), 408-435.

Schultze, U. (2010). "Embodiment and presence in virtual worlds: A review," *Journal of Information Technology* 25 (4), 434-449.

Slater, M. and Sanchez-Vives, M. (2016). "Enhancing our lives with immersive virtual reality," *Frontiers in Robotics and AI* 3 (74), 1-47.

Souchet, A. D., Lourdeaux, D., Pagani, A., and Rebenitsch, L. (2023). "A narrative review of immersive virtual reality's ergonomics and risks at the workplace: Cybersickness, visual fatigue, muscular fatigue, acute stress, and mental overload," *Virtual Reality: The Journal of the Virtual Reality Society* 27 (1), 19-50.

Speicher, M., Feit, A. M., Ziegler, P., and Krüger, A. (2018a). "Selection-based text entry in virtual reality," in: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, New York, USA.

Speicher, M., Hell, P., Daiber, F., et al (2018b). "A virtual reality shopping experience using the apartment metaphor," in: *Proceedings of the 2018 International Conference on Advanced Visual Interfaces*, New York, USA.

Tams, S., Legoux, R., and Leger, P.-M. (2018). "Smartphone withdrawal creates stress: A moderated mediation model of nomophobia, social threat, and phone withdrawal context," *Computers in Human Behavior* 81, 1-8.

Tarafdar, M., et al. (2007). "The impact of technostress on role stress and productivity," *Journal of Management Information Systems* 24 (1), 301-328.

Tarafdar, M., Cooper, C. L., and Stich, J. (2019). "The technostress trifecta—Techno eustress, techno distress and design. Theoretical directions and an agenda for research," *Information Systems Journal* 29 (1), 6-42.

Tarafdar, M., Pirkkalainen, H., Salo, M., and Makkonen, M. (2020). "Taking on the 'dark side'—Coping with technostress," *IT Professional* 22, 82-89.

Tarafdar, M., Pullins, E. B., and Ragu-Nathan, T. S. (2015). “Technostress: Negative effect on performance and possible mitigations,” *Information Systems Journal* 25, 103-132.

Tarafdar, M. Q., Tu, B. S., and Ragu-Nathan, T. S. (2007). “The impact of technostress on role stress and productivity,” *Journal of Management Information Systems* 24, 301-328.

Tarafdar, M., Tu, Q., Ragu-Nathan, T., and Ragu-Nathan, B. (2011). “Crossing to the dark side: Examining creators, outcomes, and inhibitors of technostress,” *Communications of the ACM* 54 (9), 113-120.

Torro, O. (2023). *Social virtual reality: Design and potential for social exchange and cohesion in virtual teams*. Tampere University.

Torro, O., Jalo, H., and Pirkkalainen, H. (2021). “Six reasons why virtual reality is a game-changing computing and communication platform for organizations,” *Communications of the ACM* 64 (10), 48-55.

Torro, O. and Pirkkalainen, H. (2022). “How to get things done in social virtual reality—A study of team cohesion in social virtual reality–enabled teams,” in: *2022 Hawaii International Conference on System Sciences.*

Trahan, M. H. et al. (2019) Past, Present, and Future: Editorial on Virtual Reality Applications to Human Services. *Journal of technology in human services*. [Online] 37 (1), 1–12.

Trevett, N. (2022). *Evolving an interoperable metaverse*. Metaverse Standards Forum.

Tu, Q., Wang, K., and Shu, Q. (2005). “Computer-related technostress in China,” *Communications of the ACM* 48 (4), 77-81.

Van der Heijden, H. (2012). “User acceptance of electronic commerce: Contributions from the BLED eConference,” *BLED* 2012 (Special Issue).

Venkatesh, V., Brown, S. A., and Bala, H. (2013). “Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems,” *MIS Quarterly*, 21-54.

Wang, K., Shu, Q., and Tu, Q. (2008). “Technostress under different organizational environments: An empirical investigation,” *Computers in Human Behavior* 24, 3002-3013.

Weil, M. and Rosen, L. (1997). *TechnoStress: Coping with technology @work @home @play*. John Wiley & Sons Inc.

Weinert, C., Maier, C., Laumer, S., et al. (2020). “Technostress mitigation: An experimental study of social support during a computer freeze,” *Journal of Business Economics* 90, 1199-1249. https://doi.org/10.1007/s11573-020-00986-y.

Whelan, E., Golden, W., and Tarafdar, M. (2022). “How technostress and self-control of social networking sites affect academic achievement and wellbeing,” *Internet Research* 32 (7), 280-306.

Xi, N., Chen, J., Gama, F., et al. (2023). “The challenges of entering the metaverse: An experiment on the effect of extended reality on workload,” *Information Systems Frontiers* 25, 659-680. https://doi.org/10.1007/s10796-022-10244-x.

Xia, M. (2023). Co-working with AI is a double-sword in technostress? An integrative review of human–AI collaboration from a holistic process of technostress,” *SHS Web of Conferences* 155, 3022.

Yan, Y., Chen, K., Xie, Y., Song, Y., and Liu, Y. (2019). “The effects of weight on comfort of virtual reality devices,” in: Rebelo, F. & Soares, M. M. (eds.) *Advances in Ergonomics in Design* (pp. 239-248). Cham: Springer International Publishing.

Zhao, G., Wang, Q., Wu, L., and Dong, Y. (2022). “Exploring the structural relationship between university support, students’ technostress, and burnout in technology-enhanced learning,” *The AsiaPacific Education Researcher* 31 (4), 463-473.

Zimmer, P., Buttlar, B., Halbeisen, G., Walther, E., and Domes, G. (2019). “Virtually stressed? A refined virtual reality adaptation of the Trier Social Stress Test (TSST) induces robust endocrine responses,” *Psychoneuroendocrinology 101*, 186-192.