Technostress from Persuasion: Wearable Users' Stressors, Strains, and Coping

Completed Research Paper

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Abstract

The use of persuasive technologies to improve users' personal health outcomes are becoming increasingly pervasive in the health context. While early research on persuasive technologies highlighted the technology's individual and societal potential, recent empirical evidence has hinted about the adverse effects of their use. However, little is known about the causes of, experiences with, and coping reactions to these adverse effects. To fill this gap, we conduct an exploratory study of wearable technologies' adverse effects on users based on twenty-five narrative interviews. Employing a technostress lens, we find two distinct patterns–control stress and validation stress–that show that users experience these adverse effects by revolving through a circular process of technostress and relying on various mechanisms to cope with it. We describe contributions to the literature and implications for research and practice.

Keywords: Technostress, persuasive technology, wearable, stress, coping, dark side.

Introduction

Persuasive technologies are socio-technical information systems (IS) that are designed to change users' attitudes or behaviors (Fogg 2003). They are prevalent in the health context, where they are used to induce their users to engage in healthful behaviors to improve personal health outcomes through persuasion (Lehto and Oinas-Kukkonen 2015). In their most prominent forms—fitness apps and wearable self-tracking devices—they have found their way into mainstream users' lives. Given their behavior-changing properties, they can help to improve personal and public health outcomes, thereby reducing strain on the healthcare system (Gimpel et al. 2013). However, striking attrition rates and pessimistic study results on the technologies' effectiveness have put their capacity to induce long-term changes in users' health behaviors into question (Jakicic et al. 2016; Ledger and McCaffrey 2014; West et al. 2016).

Recent studies in IS have broached the subject of adverse effects related to the use of persuasive health technologies and noted the importance of looking into the adverse cognitive and behavioral effects of using them (Schmidt-Kraepelin et al. 2019). These studies have found that users' motivation (Schmidt-Kraepelin et al. 2019), intention to continue (Rockmann 2019), achievement of exercise goals (Liu et al. 2016), perceived self-efficacy, compliance with system requests (Rieder et al. 2019b), and wellness outcomes (e.g., James et al. 2019) may be negatively affected by these technologies. While these studies have provided evidence of adverse effects related to persuasive technology use, more insights into the causes of adverse effects, the patterns of use they cause, and users' reactions to cope they give rise to are needed so providers can develop appropriate countermeasures that allow these technologies to live up to their potential to change behavior. Our research question asks: *Why do users encounter adverse effects when using persuasive technology?*

To address this research question, we conducted an exploratory study using narrative interviews with twenty-five users of wearables, one of the most popular kinds of persuasive technology. Our data analysis was guided by the technostress lens (Ayyagari et al. 2011; Tarafdar et al. 2017) which IS researchers have used extensively to investigate a variety of dark-side phenomena (e.g., Maier 2015; Salo et al. 2019). In providing a process view of users' experiences of adverse effects of technology use, it is a suitable perspective through which to view the phenomenon. Our findings indicate that the technostress experienced by users–who describe repeatedly passing through the perception stressors that arise from technology use and the resulting strains–is related to two drivers of wearable use: controlling one's behavior and obtaining normative approval. We find two distinct patterns of technostress (i.e., stressors, strains, and coping mechanisms) for these drivers: control stress and validation stress.

Our study expands the body of literature on the adverse effects of persuasive technology used in the health context by explaining how and why users experience technostress. Our study also contributes to technostress research by applying the technostress perspective to individual IS with a focus on changing users' health behaviors. We offer important implications for practice–particularly for designers of persuasive technologies and health interventions–that can help to improve persuasive technologies' ability to mitigate their negative effects on users and leverage their full potential to change behavior.

The paper is structured as follows. Section 2 discusses the theoretical background, particularly the concepts of persuasive technology and technostress. Section 3 describes our methodological approach. Section 4 presents the results of our study, followed by a discussion in section 5 and limitations and avenues for future research in section 6.

Theoretical Background

Persuasive Technology

Persuasive technologies are computing systems, devices, and applications that are designed to change users' attitudes or behaviors in a predetermined way (Fogg 2003). To do so, persuasive technologies use techniques that induce changes in behavior (Oinas-Kukkonen 2013), such as self-monitoring, rewards and threats, goal-setting, and social comparison (Mercer et al. 2016). Such persuasive elements may range from simple user-interface-design elements to more holistic features.

Persuasive technologies are prevalent in the health context (Lehto and Oinas-Kukkonen 2015); they have been employed and studied in the domains of mental health (e.g., Kuonanoja et al. 2015) and physical health, influencing physical exercise (Khalil and Abdallah 2013; Lim and Noh 2017), food consumption (Ronen and Te'eni 2013), and smoking cessation (Myneni et al. 2016). With the emergence of mobile apps, wearable devices, and the novel kinds of interactions they afford (e.g., automated tracking and analysis of daily activity, sports, nutrition, or sleep), these systems have become the ubiquitous platforms for the delivery of health-related interventions (Oinas-Kukkonen 2013). Central to health-persuasive technologies is that they not only allow users to track health-related parameters but also help them to alter offline behaviors to promote healthful outcomes (Ogbanufe and Gerhart 2020). For instance, they support users in abandoning detrimental behaviors like smoking or in adopting health-promoting ones like regular exercise.

IS studies have investigated the individual and societal effects of persuasive health technologies. For example, James et al. (2019) demonstrated a positive effect of wearable use on subjective vitality if internal motivators were present with users. Another qualitative study on wearable technology indicated that wearables may reinforce existing health and exercise habits and give rise to new ones (Rieder et al. 2019a). In an evaluation of a persuasive system for diabetes self-management, Chatterjee et al. (2018) noted promising effects on health-related indicators (e.g., steps per day, weight, blood glucose, and idle time). Some of the trials in the medical and nutritional sciences performed to determine the effectiveness of persuasive technologies on health-related outcomes have had promising results regarding their capacity to increase users' physical activity and reduce sedentary periods and caloric intake, while other studies have presented a more pessimistic outlook questioning these technologies' ability to induce behavioral change given the absence of significant effects on such parameters as physical activity, aerobic fitness, body weight, and body composition (e.g., Slootmaker et al. 2009; West et al. 2016). Moreover, a trial with a two-year observation period found that the beneficial effects observed in the short term were usually not sustained in the long term (Jakicic et al. 2016). (For a comprehensive review, see Brickwood et al. (2019).)

IS researchers have also begun to raise concerns about persuasive technologies in light of increasing evidence of adverse effects related to users' cognitions and behaviors. In a review of IS literature on the negative effects of gamification in health behavior change support systems, Schmidt-Kraepelin et al. (2019) identified five categories of unintended side effects: adverse motivational effects, informational noise, reduced integrity of exercise, demoralization, and overstepping boundaries. Focusing on the acceptance phase of use, Matt et al. (2019) noted that users of wearables reported that limited reliability, perceived functional constraints, and limited support were deficiencies that may hamper their ability to transition to continuous use of wearable devices. Liu et al. (2016) investigated the negative effects of social norms-based mobile health interventions and found that messages containing references to social norms were related to lower rates of achievement of physical activity goals, perhaps because of a reduction in users' intrinsic motivation that arose from the social-norm cue or because social-norms cues predominantly attract weak users who then set unattainable goals. In an effort to explain users' continuance intentions, Rockmann (2019) found that the motivational affordances of fitness apps may negatively affect users' perceptions of their own competence. Specifically, rewards and social recognition features may put pressure on users and lead them to seek goal attainment for non-autonomous motives. Similarly, Rieder et al.'s (2019b) exploratory study on the behavioral effects of wearable use revealed that adverse effects (i.e., low self-efficacy and non-adherence to wearable requests) were traceable to wearable use's occurring in unfavorable personal or contextual circumstances. James et al. (2019) investigated users' selection of feature sets and the psychological well-being outcomes that result from the use of fitness technology and found that using fitness technologies yielded positive outcomes for the well-being of both highly self-determined and completely unmotivated users, while less self-determined users whose motivations for exercising were external saw a negative relationship between technology use and psychological well-being. Mettler and Wulf (2019) elaborated on the constraints wearable users perceived, but since they were studied in an occupational setting, most constraints related to the adverse effects of being forced by an employer to use a wearable device in an organizational context, so the findings are transferable to the individual IS context to only a limited extent. De Moya and Pallud (2020) offered one of the few studies to investigate the ambivalent influences of wearable use. They showed that, in imposing constant surveillance (through the wearable) on themselves, wearables exerted empowering as well as disempowering influences on users. Disempowering influences included such effects as users' accepting the wearables' standards and goals without reflection, which diminished their self-determination, and patterns of mental punishment and self-presentational issues (De Moya and Pallud 2020).

However, despite providing empirical evidence of the complex and multi-layered nature of the phenomenon of persuasive technology use, most of these studies did not investigate its adverse effects. A more comprehensive understanding of users' experiences of the adverse effects of persuasive technology use is needed to leverage the technologies full potential to change behavior. Specifically, we need to identify the processes along which users experience adverse effects, that is, what causes them, the patterns of use and adversity they generate, and the coping reactions to which they give rise. To address this need, we draw on the technostress perspective, which provides a process view of users' experience of adverse effects (i.e., stress) when they use technology.

Technostress

Technostress describes the stress that individuals may experience from using technology (Ayyagari et al. 2011). As the psychological reference literature has indicated, stress occurs if individuals perceive the demands placed upon them by the environment as exceeding their coping capabilities and threatening their well-being (Cooper et al. 2001; Lazarus 1991). Therefore, "stress" refers to the overall transactional process in the course of which individuals encounter stressors—that is, events or properties of events that invoke individuals' psychological responses, referred to as strains.

Building on this tradition, IS scholars have conceptualized technostress as a process in which individuals evaluate technology's characteristics in terms of whether stressors are present that may give rise to strains (cf. Ayyagari et al. 2011; Tarafdar et al. 2017). Technology *characteristics* may encompass ease of use (Ayyagari 2011), reliability (Jiang et al. 2002), multipurpose functionality (Salo et al. 2018), and ubiquity (Tarafdar et al. 2017). These characteristics may then lead to individuals' perceptions of such technology *stressors* as overload, invasion, uncertainty, and complexity (e.g., Tarafdar et al. 2007; Maier et al. 2015; Barley et al. 2011). Technology characteristics and technology stressors are linked by the concept of primary appraisal, which refers to the individual's evaluation of the adverse situation (Tarafdar et al. 2017). This cognitive appraisal process is shaped by factors that reside with the individual, such as workload, digital literacy, involvement, and attitude toward IS, (e.g., Barber and Santuzzi 2015; Barley et al. 2011; Tarafdar and Ragu-Nathan 2010), which shape the magnitude of the perception of stressors. In response to the technology stressors, *strains* arise, which are adverse emotional, cognitive, and behavioral outcomes that manifest as, for example, decreased well-being, exhaustion, low productivity, poor performance, low commitment, and burnout (Maier et al. 2015; Ragu-Nathan et al. 2008; Salo et al. 2018). To mitigate the impact of technology strains, individuals may employ *coping* responses (Salo et al. 2018; Tarafdar et al. 2017) like adapting how they use the IS or disregarding some requirements (Salo et al. 2015; Stein et al. 2015).

Even though stress, including technostress, is related to both negative (e.g., distress) and positive (e.g., eustress) outcomes (cf. Lazarus 1966; Tarafdar et al. 2017), stress has primarily been applied in IS in investigations of dark side-phenomena.

IS research that has used the technostress concept has predominantly investigated organizational and workplace IS (e.g., Ayyagari et al. 2011; Chandra et al. 2019; Ragu-Nathan et al. 2008; Tarafdar et al. 2007; 2011; Turel and Ma 2019). Researchers have examined technostress experienced by employees in various industries (e.g., Shu et al. 2011) and job functions (e.g., Tarafdar et al. 2015), focusing on both the use of various work-related IT devices and their associated applications (e.g. Ayyagari et al. 2011) or the application of a particular IT device, such as a mobile phone (Hung et al. 2015). Studies on organizational and workplace IS have concluded that technostress may be due to stressors that are related to job characteristics and workplace relationships (Ayyagari et al. 2011). Related strains include reduced productivity, job dissatisfaction, and burnout (Ragu-Nathan et al. 2008; Srivastava et al. 2015; Tarafdar et al. 2007).

Recently, IS scholars have adopted the technostress lens to study phenomena related to individual and leisure use of IS (e.g., Lee et al. 2014; Luqman et al. 2017; Maier et al. 2015; Salo et al. 2017; 2018) to explain the adverse effects of smartphones and social networking sites and services (e.g., Brooks et al. 2017; Lee et al. 2014; Maier et al. 2015), so the technology stressors and strains these studies identified were related to users' private spheres and their leisure-time use of the technology, rather than occupational factors. For instance, Salo et al. (2017) identified two classes of strains from leisure-related technostress: the individual strains of concentration and sleep problems and the social strains of identity and social relationships.

Following Baskerville's (2011) notion of individual IS, we argue that the idiosyncratic needs, motives, and preferences that drive the use of such IS may shape the technostress process in ways that are distinct from those related to organizational IS use. For example, in terms of coping behaviors, users of individual IS may freely decide to discontinue using the IS, which might not be possible with IS at the workplace. As individual IS, persuasive systems in the personal health context may invoke a technostress process that differs from that observed in organizational contexts—particularly because persuasive systems intend to influence individuals' (offline) behaviors, which holds potential for inner conflict (cf. de Moya and Pallud 2020).

Method

Our research uses a technostress perspective to investigate the occurrence of adverse effects and their impact on users' cognitions and behaviors when they use persuasive technology. Since empirical evidence of the adverse effects of persuasive technology use is scarce, we used a qualitative approach to obtain in-depth personal descriptions of individuals' adverse experiences. As wearables are a prominent category of persuasive technology, we used them as our research context and conducted narrative interviews with twenty-five long-term users of commercially available wearable devices.

Research Context

With the development of wearables, a new category of health-related persuasive technologies has emerged. Wearables are electronic computing devices, worn on the body, that use sensor technology so users can track their personal activities and parameters like steps, sleep, sports activities, and food consumption (Benbunan-Fich 2019; Mettler and Wulf 2019). Our analysis focuses on devices that take the form of wristbands and watches and that track physical activity, which are also called wearable activity trackers– the most widely proliferated category of wearables (IDC 2018). Leading providers include Apple, Xiaomi, Fitbit, and Garmin (Statista 2019). Wearable devices that are limited to tracking other health-related parameters, such as fertility, blood pressure, or blood glucose levels, are not part of our investigation.

Through self-tracking, wearables enable users to gain insight into their physical performance. Interaction and reviewing the data is facilitated through the devices' screens or via accompanying software applications, which are typically accessible by a smartphone. Wearables are usually advertised to support users in improving health behaviors, so they incorporate various behavior-change techniques (Mercer et al. 2016; Ogbanufe and Gerhart 2020), rendering them persuasive technologies (Oinas-Kukkonen 2013). For example, by adding walks to daily schedules or by replacing existing eating habits with more healthful ones, users may form or alter their behavioral patterns. Wearables may also help to reinforce desirable behaviors, and the provision of workout histories and statistics may help make exercise habits more appealing.

Data Collection

We follow a qualitative approach, conducting narrative interviews to capture in-depth descriptions of users' experiences of adverse effects while they use persuasive technologies (Küsters 2009; Myers 1997). In this kind of interview, the interviewee gives an account of a past event, using his or her own organization and structuring. Since the interviewer does not interrupt the narrative, the technique avoids common biases like social desirability, patterns of interaction in the interview, issues related to wording and placement of questions, and topics and terminology brought in by the interviewer (Küsters 2009). We consider the narrative interview a suitable technique with which to address our research question for several reasons. First, in asking the interviewees to reproduce past events and experiences, we obtain data in a narrative that has a largely sequential structure. We found that the sequential nature of data is particularly well-suited to obtaining insights into users' processes of use, adverse effects, and coping behaviors and to viewing the data that are conceptualized as a process, such as stress in general, and that is, in this case, specifically technostress (cf. Folkman and Moskowitz 2004; Salo et al. 2019). Second, because of the minimal interference from the interviewer, we discover only those adverse effects and consequences that the users actually experienced, without risking triggering answers or topics that are not related to the users' experience.

We interviewed twenty-five wearable users from Switzerland. One of the most advanced markets for wearables in Europe, wearables in Switzerland had a market penetration of 7.6 percent in 2018 (Statista 2018). Using purposive sampling (Miles and Huberman 1994), we followed pre-defined selection criteria to guide the participant-recruitment process. First, interviewees were required to be continuous intermediate- to long-term wearable users (i.e., past the trial phase) and to be using the device in private life. The focus on continuous users of wearables allowed us to identify the adverse effects that users encountered during their habitual use of the technology and the strategies they developed and behaviors they employed to cope with any adversity. The interviewees were not selected based on their activity levels, health status, wearable use habits, or previous negative experiences but were required only to be users of wearables for self-tracking purposes. Second, we tried to achieve maximum (socio-) demographic variation by including male and female students and professionals across a large age range. The interviewees were recruited from the authors' broader social networks through personal acquisition and with the help of social networking sites. The interviews were conducted between November 2019 and January 2020. All twenty-five interviews were held in person and recorded by a voice recorder. The interviewees were guaranteed anonymity.

In line with the narrative interview technique, no interview guideline was used (Küsters 2009; Myers 1997); instead, we used a pre-formulated stimulus to ignite the narratives and provide contextual information: *"Please tell me the story of your wearable, how it started until today."* After the interviewees had recognizably finished their narratives, we took up topics they had mentioned that were related to adverse effects they had encountered to encourage additional accounts of the situations, circumstances, and consequences of adverse effects. The duration and elaboration of the accounts varied across the interviews, which is reflected in the wide range in length, from 20 to 105 minutes (excluding preliminary talk and instructions). We transcribed the interviews verbatim so we could rigorously analyze the data. Interviews and transcriptions were done in German and processed by native German speakers, so the quotations presented here were given in German and then translated into English.

Our interviewees, students and professionals who had been using their wearables continuously for at least eight months, were thirteen women and twelve men between nineteen and fifty-four years of age. While all of the students were studying in the fields of medicine, business, or psychology, the professionals were working in various industries (e.g., construction, education, health care, IT, transportation, financial services) and in various positions (e.g., assistants, managers, executives). Table 1 presents an overview of the study's participants. The frequency of the wearables' use varied across interviewees depending on the individuals' reasons for using them. Nineteen of the interviewees used the device in their everyday lives, thirteen wore it even at night, and six used it only during exercise. The interviews revealed a large number of detailed instantiations of adverse effects of wearable use and the associated cognitive and behavioral responses. Twenty-three of the interviewees recounted experiences with technostress, with no differences in this regard between users who used their wearables in their everyday lives vs. those who used them only while exercising. Gaining rich, in-depth narratives from twenty-five interviewees was deemed sufficient, as themes and instances began to repeat, signaling saturation (Corbin and Strauss 2008).

Full sample	#	*(%)*
N	25	*(100)*
Gender	#	*(%)*
Women	13	*(52)*
Men	12	*(48)*
Occupation	#	*(%)*
Students	9	*(36)*
Professionals	16	*(64)*

Age			
Mean	Median	Min	Max
35.6	33	19	54

Devices used[1]	#	*(%)*
Fitbit	12	*(48)*
Apple	10	*(40)*
Garmin	10	*(40)*
Other[2]	4	*(16)*
Use duration	#	*(%)*
6-12 months	4	*(16)*
13-24 months	8	*(32)*
> 24 months	13	*(52)*

[1] Interviewees had used multiple devices of different brands.

[2] Other brands included devices by Samsung (1), Whoop (1), Suunto (1), and TomTom (1).

Table 1. Sample characteristics

Data Analysis

In analyzing our interview data, we broadly followed the procedure for interpretive data analysis proposed by Corbin and Strauss (2008). First, we used open coding (cf. Corbin and Strauss 2008) to identify concepts related to instances of adverse effects from wearable use that were salient in the interview data. In this step, we kept our minds open to the emergence of new concepts from the data. This process resulted in more than 130 descriptive codes, which we then grouped into more abstract categories. To ensure the credibility of our data analysis (Wallendorf and Belk 1989), coding and categorization were done by the first and second authors in an iterative process involving frequent discussions. As an example of the categorization, the two following quotations were aggregated into the *over-transparency* category because the resulting strain was based on overwhelming transparency in both cases:

> *1) You can do some pretty good research for your age and weight and whether that is actually a good minimum heart rate, and you just can't escape it. (Male self-employed interviewee, age 36)*
>
> *2) When I was losing a competition, I would get this notification: "Your friend is ahead, catch up." (Female business student, age 26)*

Second, in a step similar to axial coding (Corbin and Strauss 2008), we organized the identified categories to represent the sequential pattern of events in the data. This step was sensitized by the technostress concept, as proposed by Ayyagari et al. (2011). The concept of technostress proved to be an appropriate lens, as we found that, in the course of using wearables and thereby being exposed to technology characteristics, users perceived an array of stressors that gave rise to strains in the emotional, cognitive, and behavioral domains. This step also entailed linking the coping behaviors users employed to the technostress sequences. On linking these sequences, we realized that the described processes were not self-contained, onetime occurrences for most users. Instead, the data indicated that users passed through the processes multiple times until they described acquiring coping behaviors. To ensure the confirmability of our analysis, the sequences and interpretations obtained in this step were presented to a researcher on the team who was not involved in collecting or analyzing the data for the researcher's judgment about the dependability and plausibility of the inferences and interpretations (Wallendorf and Belk 1989). The next quotation illustrates how the accounts in our data could be viewed through the technostress lens:

> *If my wearable tells me prior to a competition that my fitness level has decreased, it will affect how I approach the competition mentally. I am susceptible to this kind of information. If it says my fitness level has increased, I am much more motivated. Therefore, I decided to disbelieve this metric because I don't want it to influence me. Usually, these algorithms are not that smart, but rather simplistic. After all, there might be good reasons that your fitness level has dropped. Then the frustration is not that strong, so I can handle it. (Female nurse, age 52)*

While in this case the fitness-level metric describes a *technology characteristic*, the discrepancy with the feedback the interviewee wished for and the actual feedback is the *stressor*. This stressor caused *strains* in the user's cognitive domain in the form of frustration and lowered confidence. To circumvent the strains, the interviewee engaged in *coping behaviors*—in this case, rationalizing and distrusting the metric.

In the third step, we revisited the data for accounts of contextual information and drivers and motivations of use that could explain the observed patterns of technostress and coping behaviors. After linking the patterns of technostress, coping behaviors, and contextual information to obtain a holistic picture of the adverse effects the users encountered, we looked for the drivers of the technostress patterns in each interview. We found two drivers of wearable use—control and validation—that, in driving use, also evoked distinctive technostress patterns among wearable users and their coping behaviors in response.

Results

Our data analysis reveals that wearable users may experience adverse effects that are closely related to the concepts of technostress. While the instantiations in our data corresponded to the concepts from the technostress perspective, we noticed differences in their sequence. Specifically, our data indicated that technostress is a circular process that users undergo multiple times as they interact with technology characteristics, perceive technology stressors, and experience strains. As the situations, stressors, and strains repeated, learning and anticipation became important elements in shaping how users' coping behaviors helped them avoid the expected strains. Moreover, we found two technostress patterns in our data–control stress and validation stress–that were related to the drivers of wearable use. Control stress arises from users' drive to control themselves and their performance, while validation stress is related to users' pursuit of validation from the wearable regarding their performance and health status.

The following sections first outline our notion of a circular technostress process, which will serve as a basis for elaborating on the two technostress patterns with wearable use. Then we present separately the two patterns, control stress and validation stress, found in our data.

Circular Technostress Process

The data analysis made evident that wearable users pass through a circular technostress process that involves appraising wearable characteristics, which leads to the appearance of the wearable stressors that stimulate strains. Our data show that users undergo these process steps multiple times and, consequently, build coping mechanisms and apply coping behaviors to reduce or eliminate the stress. In the following, we outline the technostress process and the categories represented in our data to illustrate its circular nature. Table 2 summarizes the individual categories and the drivers of wearable use, which will be useful in differentiating between the two technostress patterns in the following sections.

Drivers of wearable use	***Wearable characteristics***	***Wearable stressors***	***Wearable strains***	***Coping mechanisms***
•Control: Controlling performance and/or health outcomes •Validation: Seeking approval for behaviors	•Device-handling •Automated data management and evaluation •Goal management and rewards •Self-tracking •Social comparison features •Activity reminders	Related to technological properties: •Inaccuracy •Unreliability •Complexity •Inflexibility Related to transparency and evaluation: •Over-transparency •Over-dependence •Discrepancy between feeling and data	Emotional and cognitive strains: •Feeling restricted in usage •Feeling rejected •Demotivation •Lack of recognition •Guilt •Evaluation issues Behavioral strains: •Obsessive behavior	•Tolerance •Unwillingness to adjust •Distancing •Rationalizing •Compensation •Gaming the system •Alternative validation

Table 2. Technostress categories in wearable use

While users reported that wearable devices generally offered them good support in, for example, making their performance transparent and visible, evaluating their activities, and offering motivational cues for behavioral change, we identified six wearable characteristics that could provoke stressors: *device-handling*, *automated data management and evaluation*, *goal management and rewards*, *self-tracking*, *social comparison features*, and *activity reminders*. Device-handling relates to the actions users need to take to make the wearable function. The other characteristics are more specifically linked to wearables' functionalities and features. Automated data management and rewards refers to wearables' ability to collect health-related data automatically and to analyze, evaluate, and display it to users in visual dashboards. In contrast, self-tracking must be activated by the user to enable data collection. Such was the case with tracking specific exercises that the wearable did not track automatically, so users had to activate the feature. Goal management and rewards includes setting behavioral goals, receiving status updates with regard to the goals, and recognition for goal attainment. The social comparison features refer to the online social network through which users may share their data and engage in challenges and competitions with others. Finally, activity reminders are automated health-related alerts that ask users to perform a specific behavior, such as taking a number of steps or engaging in a breathing exercise.

In the face of adversity, such as when the device was not fully charged, when users forgot to activate self-tracking of their exercise, and when alerts were received when adherence was not possible, users perceived stressors from wearable use. We found stressors that related to the devices' technical properties and stressors that arose from the transparency and evaluation the system provided. Stressors from the technical properties were the (perceived) inaccuracy of the collected data (e.g., inaccurate pulse measurement), unreliability regarding expectations of a function (e.g., problems with display visibility or battery longevity), complexity in using the device as needed (e.g., difficult to understand the meaning of the data), and inflexibility with regard to adhering to requests (e.g., constant and compliant use needed to obtain reliable data). Stressors related to the transparency created by the system included over-transparency by making past and current performances visible, controllable, and comparable at any time (e.g., reminding the user of unsatisfactory performance), users' over-dependence on the wearable data (e.g., heavy reliance on data for performance decisions during activity), and discrepancies between users' feeling and the data (e.g., users expecting that they achieved more than what was reflected in the data).

Based on the stressors, various strains occurred. Our data revealed two classes of strains: 1) emotional and cognitive strains, and 2) behavioral strains. Some users reported feeling restricted in their use when their desire to control parameters was not supported, which gave rise to negative emotions like anger. Others stated they felt abandoned by the device when it was missing or not working as expected, which led to insecurities about health-related decision-making and decreased performance. Moreover, users experienced feelings of demotivation, disappointment, guilt, and even pressure when the data on their performance did not meet their expectations, leading to a perceived absence of recognition for their efforts. Finally, some users experienced difficulties in evaluating themselves when the wearable displayed unsatisfactory or unexpected data, which made them doubt what they felt in their bodies or adapt their feelings to what the devices represented (e.g., feeling less rested as a response to bad sleep data). On the behavioral side, users reported obsessive tendencies, as some of them started focusing extensively on the device and initiated harsh and likely unsustainable changes in their health-related habits.

Our data indicate that users repeatedly passed through the technostress process and its individual elements, and learning processes were set in place because of repeated exposure to stressors and strains. They began to understand and anticipate the situations in which stressors were likely to be present that had led them to experience strains. As a response to such learning and anticipation, users employed coping mechanisms that gave rise to coping behaviors used in various stages of the technostress process. Hence, before they could have appropriate coping behaviors at hand, users needed to experience technostress at least once to set in motion the processes of learning and anticipation.

A female user described undergoing technostress when she felt the wearable was intruding on her life and pressuring her. She addressed learning and anticipation processes as she spoke of that time and about how she figured out an appropriate coping strategy–in her case, adjusting the value she assigned the data and the wearable so it would not negatively influence her:

> *I think I just tried to set up a routine and tried to improve how I get things done. This can be a positive or negative experience. I think in a negative sense, it happened that it put me under extreme pressure. The device has a huge tendency to intervene with or influence my life, and I think I just had to learn and find out for myself how far I wanted this thing to get involved in my life and how important the data was me. I needed to figure it out by using the device. I think that everyone has to find out for themselves where the limit is and how they feel about it, as everyone experiences it in a different way. I think there is a fine line between pressure and motivation. Now I think I have found my way of using it, and I am happy with it. I use the things that have become important to me and I have turned off things I do not want. (Female consultant, age 29)*

Control Stress

Our data indicates that users in a control stress pattern used their wearables to gain control of their performance and health outcomes. Wearables have a variety of features and characteristics that enable users to control and steer themselves. For example, while some users used self-tracking features to control their calorie intake, others controlled their daily activity by leveraging characteristics like goal management and rewards. Some users tried to control their health status by comparing it with their peers using the wearables' social comparison features. Users also used automated data management and evaluation to control activities like running or swimming during or after exercise. In this context, a user who was training to run a marathon emphasized the importance of the wearable data in the training and the wearable as a control and correction device:

> *The watch has a surveillance role that helps me tackle my training with more moderation. For instance, if I want to run a little slower and achieve a more consistent performance, or if I want to have a moderate start and do a fast final kilometer, then I start thinking about the pace that I need to keep to do so, and I need the watch to see if I have the right pace. But the watch does even more, as I can also observe my pace in real time, so when I aim to have four minutes twenty seconds per kilometer during an interval run, then I can check if I am in the range during the run or check it if I feel like I have slowed down. The wearable really has a good control function." (Male CEO, age 53)*

Even though the interviewees generally saw these characteristics as supporting their goal attainment, they could also give rise to stressors. In this pattern, the stressors were related either to the wearables' technical properties' restricting users' desire for control or to situations in which the wearable provided excessive transparency that exceeded users' desire for control. The most prevalent stressors were unreliability, over-transparency, over-dependence, and inaccuracy. Stressors that resulted from wearables' technical properties included failure to collect data accurately, failure to function as expected or intended, and perceptions of complexity. In addition, some users experienced too much dependence on the wearable when they relied heavily on the device to fulfill their desire for control. All these stressors have in common that they result from restricting users' ability to implement control because of inaccurate information or failure to support them in their performance. A female user who relied on her wearable to control her dietary intake explained how unreliability and inaccuracy in capturing and monitoring her activities made it difficult for her to balance her nutrition:

> *Last Saturday, when I was playing golf, I was very unhappy because the wearable did not recognize that I was engaged in sports for three hours, and my wearable does not allow you to set it up yourself afterward, so I'm a bit dissatisfied because this watch doesn't capture certain activities. Also, according to these trackers, I should have very low calorie consumption, which means that I should only eat 1,000 calories a day. That's not much if you know that, for example, one meal of pasta has 800 calories. That bothers me. It especially bothers me when I have been active for two or three hours and it records only thirty-six minutes because I had been thinking, "Cool, if I was this active, I might reward myself and have a burger for dinner," which I can't according to the data. (Female executive assistant, age 42)*

Stressors related to the transparency of personal data are over-transparency and inflexibility. Users perceived over-transparency when the display of personal data went beyond users' expectations and reflected users' behaviors even at times when users did not wish to see it. Moreover, users perceived the device as inflexible and demanding with regard to the regularity and strictness with which they had to use it to obtain the data they needed to be able to exercise self-control. For example, a user stated how the social comparison features created over-transparency:

> *At the beginning, I used it quite often because it lets you observe, for example, what others did on the weekend, so I could see that my friend had been swimming in the morning and in the afternoon, even though she had already been for a walk. And the next day, she did a half marathon and in the evening, she went out with the dog. That made me think, "Wow! I have to do that as well," so I am constantly comparing myself. You see how other people work out, you see how they become better, and then you automatically compare yourself to them. (Female consultant, age 29)*

These stressors led to strains, which became visible as negative outcomes. Some users who perceived stressors that reduced their sense of self-control felt restricted in pursuing and attaining their goals. Others reported feeling rejected and abandoned by a trusted partner. A user who relied on her wearable for sports stated that she felt insecure about her performance and health-related behavior when the wearable was missing, which lead to emotional strains:

> *I got used to the watch, and it really influences me during the game, so it can be very disappointing if I don't have it with me. It is a reliable partner when I play golf, and if I forget it or forget to charge it for my game, I feel abandoned: Something is missing and I need my partner. It supports me in my game, and I feel a lot safer. (Female project manager, age 53)*

In contrast, users who perceived stressors from excessive levels of control showed obsessive behavior in having an extensive focus on the wearable, which even gave rise in some cases to detrimental habits. A user reported that the over-transparency the wearable enabled resulted in addiction-like checking behaviors and frequencies:

> *Right now I would say it is not that extreme, but there were days or weeks when I got up and the first thing I did was look up how I had slept, whether I had slept better than last night, how much deep sleep I had, and how many REM phases I had. I also looked at it multiple times a day and checked how many steps I had. An important factor may have been that, during the days or weeks when I did competitions with friends, I was really, really addicted to it, and certainly looked at the Fitbit every thirty minutes to see whether my friend or I was in the lead, and I just wanted to win, so I checked it several times a day. I have probably already logged into the app three or four times today to see how well my day is going so far. (Female business student, age 26)*

Users employed three kinds of coping mechanisms to reduce the effects of stressors and strains: *unwillingness to adjust*, *distancing*, and *tolerance*. Some users were unwilling to give in to the wearables' demands and applied coping behaviors to ease technostress. For example, they used other devices to track themselves, or they refrained from engaging in certain activities when the wearable was missing or out of battery. Others chose to distance themselves mentally and physically from the wearable and the data it displayed. Such distancing behavior comprised rethinking their attitude toward the data and even deciding to pause the use of particular features for some time. To avoid technostress, one user described how she repeatedly convinced herself not to rely excessively on the display for calorie expenditure, thus mentally distancing herself from the wearable data:

> *I thought I should lose a little bit of weight and started looking very closely at the calories, but they are not always accurate, so orientating toward them was a negative experience for me. I consciously have to tell myself to ignore it. Even though it is interesting to see that information, I have to remind myself not to take it as a reliable indication. (Female student, age 20)*

Others reacted to the restrictions in using the wearable by tolerating its perceived shortcomings and adapting their expectations and behavioral responses to it. For example, they adapted their use habits to be in line with the wearable (e.g., by adjusting their personal schedules to the battery's life) and accounted for the devices' fallibility (e.g., by mentally calculating missing or faulty data). A user who reported having problems activating the sports-tracking feature established the habit of double-checking its activation, thus finding a way to cope with and tolerate the device's unreliability:

> *Now I am checking whether the wearable is really working twice or even three times. For instance, today I checked at the beginning whether the wearable had started to record my session, and I checked whether the wearable was still recording my parameters, such as my heart rate, again during my exercise session. (Female business student, age 26)*

Validation Stress

Users in the validation stress pattern seek normative approval of their behaviors from their wearables. They use their devices to get recognition for achievements and to corroborate or correct their own feelings, in which users placed less trust than they did the data. Distrusting a subjective feeling and memory, a user described using the wearable's data as a numerical validation:

> *I just have to check with the wearable if something is true or it's just my feeling. Your feeling can deceive you. That's why I like statistics. At some point you will realize how deceptive the impressions about your activity can be, and you can always put a good number behind it to see if your impressions are accurate. Human memory is really not that reliable. (Male self-employed interviewee, age 36)*

Negative effects related to this pattern were associated with wearable's characteristics that support validation. While some users sought validation through the automated collection and display of data, others used self-tracking features to collect validating data. In addition, some users set goals and used the rewards they received for achieving these goals as validation, or they obtained from the wearable social comparison that provided validation. Activity reminders also supported users' need for validation by keeping the users updated about their current performance status. In this context, one user explained that the wearable had become an essential device, as its characteristics enabled validation of her performance, which she perceived as highly motivating:

> *The Fitbit is very important to me because it gives me confirmation. For instance, I can see that "Wow! I really went running," that I ran this and this distance, that I burned this many calories, and that my pulse was that high. So, for me, it is really a bit of a confirmation that I've done a great job because I need a great deal of motivation to get myself out there and go running. I think it's great to go running, but I don't find it easy to motivate myself, which is why it is extremely important and motivating for me to get confirmation from the Fitbit if I've done something great and that maybe I even improved compared to the last time. (Female business student, age 26)*

Even though validation from the wearable generally motivated users, sometimes the exact same affordances that provided validation invoked stressors. The two prevalent stressors in this technostress pattern were excessive transparency and discrepancy between feeling and data. As in the previous pattern, wearables' creating excessive transparency could lead users to feel disapproval if insufficient or undesirable behaviors were made visible. Discrepancy between users' feelings and data was present if users felt a disconnect between their subjective feeling about their performance and the data, in which they usually trusted. A sports user spoke about the discrepancies between her effort and feeling and the performance shown in the data that sometimes arose:

> *In training, sometimes it can happen that I really put in a lot of effort, and then I see that it was just a medium performance, which can be demotivating. I thought it was a good performance and the watch says, "No, you could have been much faster and better!" (Female medical student, age 28)*

These stressors resulted in various strains since users lacked validation or even perceived disapproval from their wearables. Users reported being demotivated because of frustration and disappointment about the reflection of past performances in the data. Other users experienced feelings of guilt and pressure. Moreover, as a consequence of not receiving the validation they had sought, users felt that the device was not recognizing and appreciating their achievements and efforts. For instance, one user reported being frustrated when the device said she was losing shape shortly before a competition, even though she was training hard to be prepared, feedback that negatively influenced her emotionally before the start of a competition:

> *When the watch told me that I was losing shape shortly before a competition, it was extremely frustrating. As I said, when the wearable pretends to be very scientific, I take it seriously, which might be risky. If it tells I am losing shape before a competition, then that negatively influences me mentally, and I go to the start in a completely different way. (Female nurse, age 53)*

The lack of validation also negatively influenced users' evaluation of their behaviors, abilities, and health status. This strain was particularly apparent with sleep-tracking features. Monitoring and evaluating sleep data caused some users to reassess their sleep and their subjective feelings with regard to it. When presented with data representing low sleep quality, users tended to re-evaluate their feelings, even though they had initially felt well-rested and vital. A user of the sleep-tracking feature gave an account of how the sleep data that her wearable collected influenced her:

> *For example, if it tells me that I have slept badly, but actually I slept for eight hours, that's kind of demotivating because I actually went to bed early and it should reflect that I slept well. Then I ask myself why the data is not as good as when I slept for only six hours. It sometimes even influences my feelings in the sense that I feel more tired that I would if I did not have this information. (Female medical student, age 28)*

Based on these stressors and strains, users eventually developed coping behaviors to circumvent or mitigate the negative effects. Our data indicate four types of coping behaviors employed by users in the validation stress pattern: *rationalizing*, *compensation*, *gaming the system*, and *alternative validation*.

Users engaged in rationalizing the disconfirming experiences by finding logical reasons, explanations, or justifications for not getting a "thumbs-up" from the wearable. For instance, some searched for reasons that other people had achieved higher performances, while others just searched for excuses for their own performance to avoid being demotivated and to be able to improve. One interviewee described how she rationalized her watch's underestimating some of her training sessions:

> *From then on I started not taking the watch 100 percent seriously because I realized that it had a large deficit: the Fenix 5 simply does not weigh long, low-intensity training sessions properly. (Female marketing manager, age 43)*

Users also sometimes engaged in compensating behaviors to avoid future adverse effects. For example, they attempted to make up for missing steps from the previous week. In addition, users sought alternative sources of validation, reporting their accomplishments even when the wearable's validation was missing. Other users sought recognition from external parties (e.g., medical doctors) to overcome missing performance validation and related strains. Finally, users found ways to outsmart the device to receive validation when they were either not eligible for a reward or when they should have received a reward but did not. For example, a user reported how she gamed the system by activating the exercise mode even though she was not exercising so the device would recognize her efforts:

> *Sometimes, when I am in a situation in which I haven't reached my workout goal yet, I activate the workout mode even if I am not working out, such as when I am walking to the bus. Normally, I would never switch on the activity mode because it's a maximum of ten minutes and it is not worth the effort, but if I'm already close to the goal, I sometimes do it anyway. Actually, I do not try to trick the watch, but I try to get additional minutes that I really do but that would not normally be tracked. (Female student, age 22)*

Discussion

This study presents two patterns for how users of persuasive technologies experience adverse effects that revolve through a circular process of technostress and mechanisms to cope with them. This section first highlights the most interesting results and discusses how our empirical findings contribute to the literature on persuasive technology and to the literature on technostress. Then it presents implications for practice.

Our results show that persuasive technology users' experiences of adverse effects follow a distinct course that is well represented by the technostress perspective and its elements of technology characteristics, stressors, and strains. We found that users pass through the technostress process multiple times, leading to learning and anticipation of adverse effects, and highlighting the circular nature of experiencing technostress. Following the anticipation of adverse effects, users employ coping behaviors to mitigate adversity in each of the stages of the technostress process. Moreover, we found that the experience of technostress, that is, the manifestations of stressors, strains, and coping behaviors, differed based on two drivers of wearable use. Users who sought to control their behaviors were more likely to perceive stressors related to their wearables' technical properties and over-exercise of control that led to restrictions in goal attainment and obsessive behaviors (i.e., control stress). In contrast, users with the drive to get validation, dissonance between the data and their actual behavior or between the data and their subjective feelings gave rise to negative emotions because of the perception of disapproval.

We make two primary contributions to research. First, we contribute to research on persuasive technology in the health context by providing insights into the under-researched area of adverse effects. In outlining two distinctive technostress patterns that occur with wearable users (i.e., control stress and validation stress), we highlight the stressors and strains experienced and explain the causes of technostress, as well as the coping mechanisms users employ to mitigate stress. Our findings underscore that persuasive technologies that are intended to change users' health-related behaviors generate multifaceted outcomes that go beyond the positive outcomes of using the technologies to include negative outcomes (cf. Benbunan-Fich 2019; de Moya and Pallud 2020). In reaching these findings, we offer an explanation for the contrasting results obtained in experimental studies on the effectiveness of wearable devices in changing users' health-related behaviors. Moreover, since our sample consists of current long-term (> 8 months) users, our results emphasize the importance of users' having adverse effects on the radar, even when they are continuous users. For researchers, this result suggests that they should also consider adverse effects (e.g., obsessive behaviors or destructive patterns) when assessing the success of persuasive health technologies.

Second, we contribute to the technostress literature by highlighting the circular nature of the technostress process and acknowledging the important role of users' learning and anticipation processes in shaping their coping behaviors. While prior studies that have applied the technostress perspective have emphasized describing technology's characteristics, stressors, and strains with organizational (e.g., Tarafdar et al. 2007) and non-persuasive individual IS (e.g., Salo et al. 2019), our study goes a step farther by investigating how users cope with the stress they experience. While some users use beneficial behaviors to cope with technostress from wearable use, such as compensating activities, rationalizations about missing data, and seeking alternative validation, other coping behaviors were detrimental to the users' relationship with the wearable, such as resistance to following the wearable and cheating to obtain the expected rewards. Such harmful coping strategies should be regarded as serious threats to sustainable and effective use, not only to continuance. Therefore, researchers who adopt the technostress perspective should assign a greater role to users' learning and anticipation processes that result in the development of coping strategies.

Our findings also have implications for practice. First, technostress must be anticipated for all wearable users, including continuous, long-term users, so providers should adjust the metrics for successful use to be sensitive to users' experience of negative effects. Such adjustments may include complementing static interaction measures (e.g., app views per day) with more dynamic and feedback-dependent measures (e.g., app views toward the end of the month or app views after receiving negative feedback). Second, the design of persuasive technologies should be based in part on metrics that sense adverse effects and adjust to minimize the threat of negatively affecting users. Such features may be achieved by, for example, providing more advanced personalization of features and a more neutral, non-judgmental representation of behaviors (e.g., hours in the various sleep phases instead of assessing the overall quality of sleep). Providing more transparency in the collection and computation of data and metrics may also help to ease negative experiences. Third, given the importance and potentially detrimental nature of coping behaviors, persuasive technologies should support users in finding and exercising beneficial coping strategies. For example, designers may consider incorporating and promoting the option to adjust inaccurate data manually or establish alerts if tendencies for harmful obsessive behaviors are sensed (e.g., users starving themselves or overtraining).

Limitations and Further Research

Our research is subject to some limitations. First, despite the advantages of the narrative interview technique and leaving the structure of the interview to the interviewee, individuals' memory structures might cause biases in the accounts of their use histories toward, for example, extreme events that are easier to remember. Future research may triangulate other research methods to assess our findings quantitatively. In particular, future research could examine the relationship between experiences of strains and the respective coping responses in an effort to design more effective interventions. Second, the sample used in our study has a number of limitations. Because of the purely Swiss sample, the findings' generalizability is limited, and a follow-up study may consider other geographical and cultural contexts to determine whether the identified patterns hold across other cultures. Our sample's including individuals only up to age fifty-four may miss adverse effects that occur specifically with an older population. Future research may investigate age and population groups with lower technology literacy. Moreover, our focus on continuous users of wearable devices limits our findings' ability to describe and explain phenomena experienced by users who quit using their devices. A separate study may shed light at the role of technostress in users' decisions to discontinue use, which could help explain the extraordinarily high attrition rate. Third, given our study's focus on persuasive technologies in the personal health context, the generalizability of our findings across technologies and use contexts is limited, so future research could investigate the extent to which our findings are transferable to other technologies and contexts.

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