# THE GENERATIVE MECHANISMS BEHIND TECHNOLOGY-ENABLED CHANGES IN HEALTH BEHAVIOR

*Research Paper*

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## Abstract

*Wearables are used to help motivate individuals to trade their unhealthful behaviors for beneficial ones, thereby preventing the diseases of affluence, which are caused by a sedentary lifestyle. However, inconclusive study results regarding the effectiveness of wearables raise questions about the outcomes of using wearables. Research on the topic paints an ambiguous picture regarding the support wearables offer users in performing beneficial health-related behaviors, leaving the underlying mechanisms of wearable use and its outcomes unexplained. We seek to fill this gap in the literature by means of a critical realist study based on thirty narrative interviews with long-term users of wearables. By identifying seven generative mechanisms that drive users' interactions with wearables and the subsequent cognitive and behavioral outcomes of that use, we answer the research question concerning how and why users' interactions with wearables can facilitate positive behavioral and cognitive outcomes. The study makes several contributions to theory and practice.*

*Keywords: Wearable, Health, Behavior Change, Generative Mechanism, Critical Realism.*

## 1 Introduction

According to the World Health Organization (WHO, 2019), physical inactivity has become one of the most important factors in mortality worldwide, so supporting individuals in adopting a healthful lifestyle and preventing the diseases that are due to sedentary lifestyles is of vital societal importance. With the advancement of mobile and sensor technology, wearables have become a popular way to motivate physical movement. Wearables are electronic computing devices that are worn on the body and use sensor technology to collect and transmit data on the user's vital statistics and activities (Fox and Connolly, 2018; Mettler and Wulf, 2019). Using data analytics, wearables can identify potentially unhealthful behaviors and provide triggers to change them. Moreover, they can motivate users by setting goals or providing opportunities to compare their activities with those of peers. Because of their ready availability and ease of use, wearables have been ascribed the potential to alter human behavior in a predetermined way (Oinas-Kukkonen and Harjumaa, 2009), thereby fostering a more healthful lifestyle (Khalil and Abdallah, 2013).

However, wearables seem to be lagging behind that potential. High abandonment rates (Ledger and McCaffrey, 2014) and unclear effects on health outcomes (e.g., Jakicic et al., 2016; West et al. 2016) raise the question concerning whether and how wearables help users change health-related behaviors. Although information systems (IS) researchers have generated rich insights into the adoption (e.g., Fox and Connolly, 2018) and continuous use of wearables (e.g., Prasopoulou, 2017; Mettler and Wulf, 2019), studies that have investigated the cognitive and behavioral outcomes of using wearables remain scarce, and those that do address this topic have painted an ambiguous picture. Multiple scholars have suggested that wearables can support and empower users in performing beneficial behaviors, but they can also exert negative influences on users' affective-cognitive and behavioral responses (e.g., feelings of surveillance and guilt, detrimental effects to psychological well-being, decreased self-efficacy, and non-adherence to cues) (cf. James et al., 2019; de Moya and Pallud, 2020; Rieder et al., 2021). In other words, little is known about the processes and underlying mechanisms that are active in wearable use that generate observable responses.

We investigate the underlying mechanisms that explain *how* and *why* cognitive and behavioral outcomes emerge over time. Developing an empirically grounded understanding of what drives the outcomes of wearable use will complement and extend previous scholarly work on the use and effectiveness of wearables. Therefore, we pose the research question: *How and why does wearable use enable behavioral and cognitive outcomes?*

Adopting a critical realist ontology, we address our research question by identifying the generative mechanisms—referring to causal power—that generate use behaviors, as well as the consequent cognitive and behavioral outcomes. To derive the generative mechanisms, we conducted narrative interviews with thirty long-term users of wearables who provided in-depth insights into their use histories and their behavioral and cognitive outcomes.

Our research makes several contributions to research and practice. First, it extends the literature on persuasive health technology by presenting a nuanced picture regarding wearables' potential to improve health-related behaviors. Second, by identifying the generative mechanisms that result in behavioral or cognitive outcomes, we provide a possible explanation for why previous research has led to ambiguous findings on the outcomes of wearable use. Third, our study provides scholars with a step-by-step approach to identifying generative mechanisms at an individual level. Finally, Wearable providers and application developers can also benefit from such knowledge in their efforts to improve their devices and applications.

# 2 Background

## 2.1 Wearables for Health Behavior Change

Advances in mobile and sensor technologies have given rise to wearable IS—or simply "wearables" (Prasopoulou, 2017). A popular area of application is that of promoting healthful behaviors. Wearables are often designed with the goal of altering users' health-related behaviors by means of behavior-change techniques like self-monitoring, rewards, and social comparison (cf. Fogg, 2003; Oinas-Kukkonen and Harjumaa, 2009). Wearables are composed of physical and digital artifacts (Benbunan-Fich, 2019). In the physical sphere, sensors are interwoven into objects (e.g., wristbands, clothing) that are worn on the body, as opposed to being carried around, thereby allowing body functions like heart rate, acceleration, and sleep to be monitored and measured (Mettler and Wulf, 2019). In the digital sphere, the sensor data is paired with data analytics and machine learning applications, which create aggregations and display information to the user, either directly via wearable interfaces or using accompanying software programs on smartphones or computers (Benbunan-Fich, 2019). Given their ready availability and ease of use, wearables are ideal means to deliver persuasive content to improve health outcomes like increased physical activity and healthful diets (de Moya and Pallud, 2020).

However, research that has investigated the outcomes and health effects of using wearables remains scarce. While much of IS research on wearables has covered issues like adoption (e.g., Fox and Connolly, 2018), use, and continuous engagement (e.g., Prasopoulou, 2017; Mettler and Wulf, 2019), only a handful of studies have sought to capture the outcomes. A notable exception is Ogbanufe and Gerhart's (2020) study of smart watches, which has highlighted both cognitive and behavioral outcomes. They found that the degree to which the smart watch was part of the user's identity was associated with more advanced ways of using it and that such a strong position in relations to the user's identity was associated with exploring new ways to employ devices to improve individual performance. However, their study focused on smart watches and their broad range of features (e.g., text messages, calendar), so the use of health-related features and the effect on health behaviors were not at the center of the study.

Focusing on the cognitive and emotional effects of wearable use, de Moya and Pallud (2020) found that wearables can leave users feeling both empowered by enabling them to improve themselves, and disempowered because of the feeling of constant surveillance and judgment. Similarly, Rieder et al.'s (2021) qualitative study found a dual influence of wearables such that contextual factors determine the effects wearables have on users' perceptions of self-efficacy and on their subsequent performance of health behaviors, creating inconsistent response patterns. Inconsistency in behavioral outcomes has been emphasized in a number of experimental studies from the medical and nutritional sciences. (For a comprehensive review, see Brickwood et al. (2019).) Even with the optimism about technologies' capacity to increase physical activity, reduce sedentary periods, and increase caloric expenditure, skepticism appears with regard to how well the effects can be sustained over time (e.g., Jakicic et al., 2016). Focusing on fitness technology, including mobile and wearable devices, James et al. (2019) found complex relationships between users' type of motivation (i.e., regulation) and users' psychological well-being. While users with a tendency toward more autonomous motivation types as well as amotivation obtained well-being outcomes, a negative relationship with wellness outcomes was observed with less self-determined users (ibid.).

Given these ambiguous, and highly complex relationships between wearable use and its outcomes, we seek to shed light on the underlying mechanisms that drive users' interactions with wearables and the subsequent behavioral and cognitive outcomes. Thus, we expect to provide explanations for the individual patterns in using wearables and the reason that some users have desirable behavioral outcomes while others do not.

## 2.2 Generative Mechanisms in the Critical Realist Ontology

Our goal of determining why some wearable users achieve positive behavioral changes and others do not requires that we take an approach that will help us identify the underlying mechanisms by which wearable use and the consequent behavioral and cognitive changes take place. With the concept of generative mechanisms—a form of causal power—at hand, we employ a critical realist ontology (Bhaskar, 2008) to look beyond the surface for the mechanisms that drive individual outcomes and patterns of use.

The value of the critical realist philosophy for IS research has gained increasing attention (e.g., Dobson et al., 2013; Henfridsson and Bygstad, 2013; McGrath, 2013; Mingers, 2004; Smith, 2006; Volkoff et al., 2007; Smith, 2010; Zachariadis et al., 2013). Critical realism, a philosophical paradigm developed by British philosopher Roy Bhaskar, offers an alternative to empiricism and idealism. Central to critical realism is the *stratified ontology*: The critical realist presupposes a real world beyond human experience and influence that consists of events that have empirically manifested at the surface (i.e., the empirical) stratum. The stratum subjacent to the surface stratum encompasses events that may have happened, although they have not been or cannot be experienced by human senses. Below that is the stratum of the real, which consists of the deep structures of the world (i.e., generative mechanisms) that may only become actual or empirical through the events they cause at the surface (Bhaskar, 2008). While human agents may well interfere with events at the surface, the generative mechanisms of the domain of the real lie beyond human influence. Generative mechanisms, which are the causal power in the critical realist philosophy, refer to the way of acting of things; they hold the potential to cause changes and phenomena that may become manifest at the empirical level. In regarding the real world as an open system, where no constant conjunctions prevail, critical realism rejects determinism and the possibility of deducing consequent events, thus emphasizing multicausality (i.e., an event may be caused by multiple factors) and multifinality (i.e., a factor may cause multiple outcomes). Hence, in pursuit of explanations, the critical realist seeks to identify the one explanation that best explains the mechanism that generate the events X, Y. For example, Big Bang theories hypothesize various mechanisms that have operated since the Big Bang event. One such mechanism is a constant rate of expansion of the universe.

IS research has published two types of articles that use the critical realist paradigm: methods articles and empirical articles. Wynn and Williams' (2012) guidance for researchers in conducting critical realist case studies in IS highlighted the importance of using *judgmental rationality*—that is, comparing the explanatory power of alternative theories—in critical realism, while Bygstad et al.'s (2016) framework introduced how generative mechanism could be identified through affordances. Empirical articles have used the critical realist ontology in several ways. For example, Bygstad (2010) conducted a critical realist case study of Norwegian airlines to explain how an information infrastructure provides generative mechanisms for innovation, Henfridsson and Bygstad (2013) used critical realism in infrastructure research and identified three generative mechanisms for explaining how digital infrastructures evolve, and Williams and Karahanna (2013) identified two generative mechanisms of coordination processes. Our study employs a critical realist perspective to explain an IS phenomenon, so it falls into the category of empirical articles. While previous empirical articles have focused on organizational IS and so have revealed macro-level mechanisms, we seek to identify the generative mechanisms that are present in individual users of individual IS.

# 3 Methodology

## 3.1 Epistemological Stance

Applying the critical realist philosophy of science has several implications for our epistemological stance and methodological approach. Given the premise of a stratified ontology, capturing the world's stratification is the purpose of science. Science is regarded as both the social activity of producing knowledge and the resulting knowledge that is constructed by human agents (Bhaskar, 2008). In this regard, critical realism employs an epistemology similar to the interpretivist. Another implication is that, since the deep structure level of the world cannot be observed per se—that is, it reveals itself to human senses only through the empirical patterns it generates—imaginative steps must be employed, thus justifying induction (Bhaskar, 2008). Bhaskar referred to this process as "retrodiction" (2008, p. 118), which describes making conjectures about the causal explanation that drives the emergence of a pattern of events. Finally, to be able to find abstract generative mechanisms from empirical patterns inductively, we need data that can produce insights into the sequential patterns in which events occur along the process of wearable use, into the behavioral outcomes, and into users' emotional and cognitive processes. Given these requirements, we follow Klein and Myers (1999) in using narrative data to address our research question.

## 3.2 Data Collection

We interviewed thirty long-term wearable users based in Switzerland, whose market penetration of 7.8 percent in 2019 makes it one of the most advanced markets for wearables in Europe (Statista, 2019). Since our focus is on the use of wearable devices' health-promoting features, we included users of wearables that were dedicated to health and/or sports (e.g., Fitbit, Polar) and users of general-purpose devices that were employed for health purposes (e.g., Apple, Huawei). Despite slight differences in the features of different brands, all devices' feature sets included goal-setting, monitoring and evaluating physical activity, and sending reminders. Because behavior change unfolds over time (Prochaska and Velicer, 1997), we needed to capture a longer use period. After six months, users were likely to have passed the initial trial period, a period that is often not representative of long-term technology use. Using purposive sampling (Miles and Huberman, 1994), we included only long-term users of wearables who had used their devices for at least six months. Given this criterion, we sought maximum variation in demographics (age, gender, occupation), purposes of use (e.g., addressing medical conditions, optimizing sports performance, gathering data), and types of devices (lifestyle and sports). We used the narrative interview technique as our method of inquiry, following Küsters' (2009) guidelines. Since this technique dispenses with an interview guideline, we used a pre-formulated stimulus to kindle the interviewees' storytelling: "Please tell me the story of your wearable, from the moment you got it until today." Questions were asked only once the interviewees had finished their narratives, when we took up topics that the interviewees had mentioned in their initial narratives to impel additional accounts.

The interviews were held in person or via Skype video call. The data were collected by multiple researchers to ensure that differences in the data arose from the interviewees and their individual contexts rather than from interviewer bias (Wallendorf and Belk, 1989). The interviewees were assured anonymity, and the interviews ranged from nineteen to eighty-seven minutes (excluding preliminary talk and instructions). The interviews were held in the interviewees' native languages of German or Swiss German dialect and were transcribed verbatim. Native German speakers processed the interviews so we could use the original transcripts and quotations for data analysis, but the quotations presented in this paper are translated into English.

Our sample (Table 1) consists of twelve women and eighteen men from twenty-one to sixty-three years of age, including students, professionals, and one retiree. The slight overrepresentation of men is in line with the wearable adoption statistics (Statista, 2019). More than half of the interviewees had used their wearables for more than two years, while the remainder had used their wearables for six months to two years. The interviewees used devices of multiple brands but predominantly Fitbit, Garmin, Polar, and Apple. While most interviewees used their devices every day and even at night, some wore them only when they engaged in sports. Our interviewees described various motivations for adopting and using their wearables, including pursuing specific health-related or sports goals (e.g., running a marathon, losing weight); getting an overview of their levels of physical activity, sleep or other vital parameters; or using its smart features for reasons unrelated to health. Our sample included a diverse range of activity levels and health conditions, from users who were chronically ill (e.g., diabetes, coronary diseases, overweight) to inactive to highly active users, some of whom regularly participated in sports competitions as amateur athletes (e.g., middle-distance runner, triathlete, ultramarathoner). Rich, in-depth narratives from thirty interviewees was considered sufficient for data-gathering, as by the time we completed these interviews, we had observed thematic saturation (Faulkner and Trotter, 2017).

| **Full sample** | **#** | **Gender** | **#** | **Devices used[1]** | **#** |
|---|---|---|---|---|---|
| N | 30 | Women | 12 | Fitbit | 12 |
| **Occupation** | **#** | Men | 18 | Garmin | 12 |
| Student | 5 | **Use duration** | **#** | Polar | 8 |
| Professional | 24 | 6-12 months | 5 | Apple | 6 |
| Retired | 1 | 13-24 months | 8 | Other[2] | 5 |
| | | > 24 months | 17 | | |

[1] Some interviewees had used multiple devices.
[2] Other brands included devices by Jawbone (2), Misit (1), Suunto (1), and Huawei (1).

*Table 1. Characteristics of Interviewees*

## 3.3 Data Analysis

Since our research seeks the generative mechanisms that drive *individual's* use processes and outcomes related to wearables, a category of individual IS (Baskerville, 2011), we followed Bhaskar's (2008) original four-step process of "explanation formation" (p. 125): decomposition, redescription, retrodiction, and elimination. We describe each step of our data analysis and illustrate it with the example from interviewee #3, a 40-year-old male project manager and Garmin-user whom we chose at random for use in presenting our approach.

**1. Decomposition:** The purpose of decomposition is to resolve a complex event into its components so causal analysis is possible. For this step, we resolved the interviewees' individual narratives into their components: events, agents, conditions, and outcomes (Table 2).

| | | |
|---|---|---|
| *Events and Outcomes* | • Consistently monitors day-to-day activities<br>• Feels enabled to pursue and reach goals<br>• Reviews training data and tracks progress<br>• Adjusts training intensity based on heart rate feedback<br>• Makes small adjustments to daily activities to be in line with the wearable's guidelines<br>• Gains awareness of daily activity patterns | • Takes up training for a half marathon<br>• Has no knowledge about how to train<br>• Buys a wearable to support his training<br>• Gets a training schedule from Garmin<br>• Follows schedule<br>• Tracks runs<br>• Monitors heart rate<br>• Explores day-to-day features |
| *Agents* | • User (e.g., male, age 40)<br>• Wearable (several, including Suunto watch) | • Friends<br>• Work colleagues |
| *Conditions* | • Office job (sedentary)<br>• Engages in sports multiple times per week<br>• No training expertise, especially not in running | • Different wearable devices with different feature sets<br>• Marathon is on his "bucket list" |

*Table 2. Exemplary Decomposition of a Narrative (based on Interviewee #3)*

*Events* in a narrative refer to changes in the domain of the empirical (and actual) and result either from the actions of agents or what happens to things. We extracted the kernel events related to wearable use from our data. *Outcomes* are events that show, in our case, behavioral and cognitive consequences like change and impact. Outcomes are events, too, so we coded them as events, but we also coded them separately as outcomes for later use. *Agents* in critical realism are entities that have the power to interfere with empirical phenomena, that is, to induce changes. For our research, we operationalized agents as entities who interfere with events or sequences of events. While some interviews featured multiple agents (e.g., friends, medical doctors), in others only the users themselves acted as agents. Even wearables themselves may become agents when individuals perceive them as mentors or leaders. Finally, *conditions* refer to the structures of systems that shape the actions of generative mechanisms and the empirical patterns they produce. We operationalized conditions as structures that affect wearable use, which was often users' personal or professional contexts. Table 2 provides an overview of the elements of the components to illustrate our approach.

**2. Redescription:** The redescription step redescribes the complex event (i.e., wearable use history) at the individual level to facilitate theorizing about the mechanisms at work. For this step, we reassembled the component events into the sequence of events, which involved reconstructing the chronological and causal sequence because the narrative structure of the interviews did not necessarily reflect the causal sequence (interviewees skipping back and forth between themes, adding more detailed accounts, etc.). To obtain a holistic picture of the causal links inherent in the data, we drew the causal sequence of events for each interviewee as a visual pattern (Figure 1).

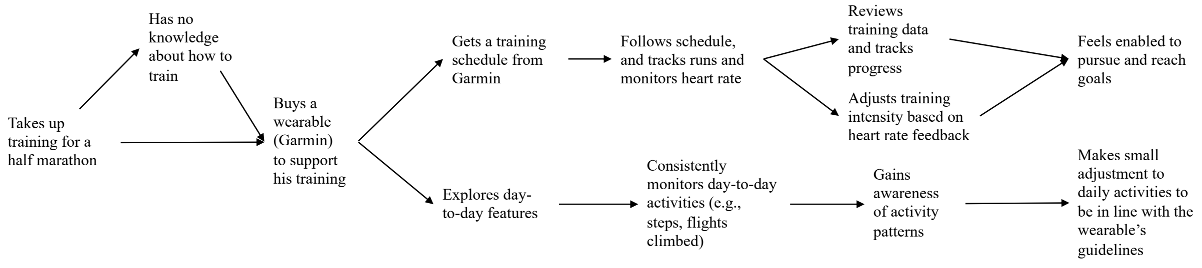


*Figure 1. Exemplary Sequence of Events (based on Interviewee #3)*

**3. Retrodiction:** The retrodiction step involves backward chaining from consequent to antecedent events and inductively and creatively making conjectures about causal explanations that may have produced the events. In line with Bhaskar (2008), we sought a plurality of possible explanations, so this step involved frequent discussion and several iterations with the co-authors for plausibility checks (Wallendorf and Belk, 1989). Table 3 illustrates the process for Interviewee 3.

| | |
|---|---|
| Candidate Mechanism 1: ***Confirmation*** | • The user seeks the wearable's confirmation during his running training. The heart rate feedback is one of the features that provides confirmation, and he adjusts his training intensity to get that confirmation.<br>• Following a training schedule can be regarded as seeking confirmation. This is supported by his lacking training expertise, giving him a reason to seek approval to see if he is training correctly.<br>• He makes adjustments to his activities based on awareness that constant monitoring of day-to-day activity raises to his behaviors, so he seeks confirmation from the wearable. He adjusts his behavior to be in line with the benchmark and to avoid disconfirmation. |
| Candidate Mechanism 2: ***Self-Improvement*** | • The user has ambitious, self-set sports goals and uses several features to achieve them (e.g., heart rate feedback, reviewing training, purchasing and following a training schedule).<br>• He initially buys the wearable to pursue their goal of running a half marathon to tick it off of his bucket list, which indicates the his self-motivation.<br>• As he explores other uses the wearable affords, he takes up monitoring his day-to-day activities, which makes him aware that his activity is not always ideal. Wanting to be a better version of himself, not only in the area of sports, he makes small adjustments to his activities. |

*Table 3. Exemplary Candidate Mechanisms (based on Interviewee #3)*

**4. Elimination:** The elimination step involves extracting from a set of candidate mechanisms the generative mechanism(s) that caused a complex event. We conducted the elimination on two levels: within and across individual interviews. To ensure plausibility, we systematically reviewed and discussed the elimination process among the co-authors (Wallendorf and Belk, 1989). For the within-check, we turned back to the component events and the data and found disconfirming instances that did not match the candidate mechanisms. In the example of Interviewee #3, we found three disconfirming instances for the confirmation mechanism, while there was no difficulty explaining the reasons for emergence of the self-improvement mechanism: 1) constantly increasing his goals, 2) using day-to-day features without initially intending to, and 3) using the wearable to track his training progress retrospectively. Consequently, we eliminated the confirmation mechanism.

For the across-interviewee check, we compared interviews to see whether the same mechanism was really at work. This step was needed especially when similar empirical patterns were traced back to the working of different generative mechanisms or where the same generative mechanism caused varying empirical patterns. For example, after the first few instances, the self-documentation and self-knowledge mechanisms were difficult to tell apart because the empirical patterns they caused were similar at first sight. Only after adding more data were we able to differentiate the patterns the generative mechanisms caused (i.e., a detached way of collecting and viewing the data for entertainment vs. observing and processing information about oneself). Hence, this iterative step of jumping back and forth between interviewees and between generative mechanisms helped to identify how the mechanisms were acting. Following this inductive process, we identified seven generative mechanisms that allowed us to explain the phenomena related to wearable use as our interviewees experienced it.

# 4 Results

Our data analysis revealed seven generative mechanisms that drove wearable use and users' cognitive and behavioral outcomes. The generative mechanisms that tend to change behaviors are self-improvement, self-determination, and confirmation. These three mechanisms not only have the power to impel the continuous use of wearables but also foster users' alteration of their offline health behaviors related to wearable use. The mechanisms that tend to generate purely cognitive outcomes are self-documentation, self-knowledge, exploration, and social relatedness. While individual use patterns driven by these four generative mechanisms are continuous, the mechanisms do not cause changes in users' physical behaviors. Instead, we found an array of cognitive outcomes related to these generative mechanisms, such as learning, entertainment, and feelings of social belonging.

## 4.1 Generative Mechanisms Related to Behavior Change

**Self-Improvement Mechanism:** The self-improvement mechanism describes an internal drive to be better. The activity of the mechanism entails a strong behavior change tendency on the empirical level since individuals must make adjustments to their behaviors to get better. The self-improvement mechanism is closely related to users' intrinsic motivation and to achievements that create intrinsic rewards, so external motivators (e.g., seeking social recognition) play only a minor part, if any. On the empirical level, users in whom the self-improvement mechanism is active tend to set challenging goals and gradually increase them to become better versions of themselves. To them, objectively measured performance and achievement are central indicators of success. While wearables do not play a central role in goal-setting itself, users extensively employ them as guides, commitment devices, and reward machines.

For example, in providing users with training schedules and specific guiding cues during training, wearables supported users in working toward attaining self-set goals. Users also reported that, by creating transparency through social features and historical data, their wearables provided additional areas in which to strive for self-optimization. When using social features (e.g., leaderboard), users could work on improving their performance relative to that of others, whereas using historical data helped them improve relative to their past selves. While these features were not at the center of users' reasons for using wearables, they helped them stay committed to their goals and provided them with rewards that gave them a sense of achievement. One interviewee described how she used wearables to pursue her ever-increasing goals and used the wearables' monitoring features to guide her training and review her progress toward attaining her goals:

*When I started running a year ago, it was important to have a GPS tracker so I wouldn't have to carry my phone, so I got one that tracked my routes and also monitored my heart rate and rotations. Then, last summer, I took up training for triathlon and realized there was even better stuff for that purpose, especially for swimming, and that's how I got the [Garmin] Fenix 5S. It can do a lot more. For example, I can get these performance parameters like VO2-Max or navigation for mountaineering, and I can connect it to my training plan for the Ironman. Since I am training for seven hours of physical performance, I need to monitor my performance and view my development and how I improve. It might be that sometimes I feel like a slave to the watch: Today, I had planned on a slow jog, 21 kilometers, below 158 bpm, but then at 11 kilometers, the watch was at 5 percent [battery], so I had to speed up to get it recorded. (Female nurse, age 33, Garmin-user)*

**Self-determination Mechanism:** The self-determination mechanism relates to the drive for intentional and effective action. With wearable users, we found that the activity of this mechanism is related to a strong change tendency involving users' autonomous steering of health behaviors and attitudinal shifts. On the empirical level, the self-determination mechanism is reflected in users' desire to take matters into their own hands and exercise influence and control to shape certain aspects of their lives. This mechanism was typically found with wearables users who faced some sort of subjective pain point that they either knew about before (e.g., certain health issues) or were made aware of by the wearable (e.g., low activity levels, weight gain). Wearables provided them with the ability to tackle their issues. Typically, we saw users shifting from the position of a patient who is passively receiving information about her condition from the environment to a proactive agent who co-creates her environment as a consequence of intensified self-determination. One interviewee spoke of incidents that created a pivot point for him to change unhealthful behaviors and routines. In response, he started to wear his wearable consistently and to monitor and assess all his activities. He described how the wearable helped him recognize how behaviors and well-being were linked. In working to overcome detrimental habits, he built awareness about the consequences of his behaviors, took up a more mindful lifestyle, and fostered new routines:

*I've been wearing [the wearable] day and night for half a year now, mainly because I gained a lot of weight over a short period. There were two moments last year that made me think. First, I was at a wedding where the groom's father was sick with lung cancer; that's when I thought "you can't keep smoking like a chimney." Second, there was this soccer game that I played last summer when I suddenly felt dizzy and fainted. Of course, I could have said, "It was hot, you didn't drink enough," but I'd also gained a lot of weight. I think it's the combination of causes that made me change. … And since then, I've been tracking how active I am and how much sleep I get. I try to reach the 10k steps per day by going for walks right after lunch. I also registered at a gym. Once a month or so, I enter what I ate during the day so I can see whether I am below or above my calorie expenditure, so every once in a while, I do say no to a beer or a dinner that I've been invited to. This is also reflected in my sleep quality; when I've been drinking, I feel less recovered. I don't think that I fundamentally changed my behavior, but I am definitely trying to be more mindful of myself and my body and be more aware of my behaviors. (Male financial analyst, age 35, Garmin-user)*

**Confirmation Mechanism:** The confirmation mechanism describes the drive to obtain approval of one's own actions and behaviors from external points of reference. Since only behaviors that are in line with the reference get approval, wearable users tend to change their behaviors, but only to the extent that will help them avoid disconfirmation. Users with whom the confirmation mechanism was dominant reported seeking approval about whether their condition or behaviors were adhering to reference points that were considered acceptable standards on the empirical level. For example, they wanted to assess whether their activity levels were in accordance with the prescriptions issued by the WHO or whether their resting heart rate was in an acceptable range for their age. Wearable devices acted as a mediator between users and external reference points, facilitating and allowing for more granular variance analyses and proactively notifying users about the actions that were necessary to adhere to the standards. Thus, wearables had especially strong agency.

Closely related to the action of the confirmation mechanism was users' response by seeking strict compliance with the wearables' goals, cues, and requests, rather than constant improvement and attaining above-average statistics. Interviewees who reported having difficulty in self-assessing their physical activity found a wearable that would support them in evaluating their behaviors relative to the wearable (i.e., steps per day). Seeking adherence to and approval by the device, they adjusted behaviors in their everyday lives and reacted to explicit cues from the wearable. A few users, driven by this mechanism, reported feeling pressure to adhere to the wearable's cues and experiencing negative emotions like frustration and guilt when they did not comply with the wearable. As a consequence, users sought to adhere to the cues to avoid these negative experiences. One interviewee stated that she experienced disconfirmation and intense negative emotions when she did not or could not comply with the wearable's requests, which was then reflected in her activity data:

*I liked the idea of counting steps because I think people tend to have a distorted idea of their activities. I sometimes thought that I'd been very active even though I just spent the entire day at the office, so I wanted transparency about what is happening, transparency about my health—not necessarily the result, but where I stand. That was the main motivator. It was important to me, when I was on the road and doing sports, to learn what I had really done. I have my step goal at 10k and I really try to achieve it. There are times when I purposely go for a walk, mainly on weekends. If I get to choose between walking around the block or sitting in front of the TV, I will always choose the walk. I was surprised how important the data became to me and how strongly it encouraged me in what I was doing, though there was a time when I didn't reach it and that really annoyed me. I was going through a stressful period and didn't have the time to go out, and that frustrated me and got me down because the device always showed me what I had not achieved. I don't want to have to view the goals I did not reach because I couldn't change it. (Female developer, age 36, Fitbit-user)*

## 4.2 Generative Mechanisms Related to Cognitive Outcomes

**Self-documentation Mechanism:** The self-documentation mechanism refers to the drive to capture one's own actions. The objective of the behaviors related to this mechanism is to produce and view the documentation itself for the purpose of entertainment and personally leaving a trace, so pursuing offline health behaviors was not associated with this mechanism. On the empirical level, users with whom the self-documentation mechanism was active sought to record their actions comprehensively over longer periods of time to produce a diary of their activities. By providing many tracking features and connectivity with other applications, wearables facilitate the process of documentation and make viewing the recordings appealing to users. Accordingly, the outcomes caused by the self-documentation mechanism resemble entertainment in viewing one's collection, rather than cognitive processing of the information obtained. In wearable use, self-documentation was often related to meticulous monitoring of various activities and was comparatively little related to (re-)viewing the data in a detached manner. One interviewee talked about his use of exercise-tracking to be able to obtain a representation of his runs in the form of an entry to a map. Despite the importance he assigned to being monitored and to viewing the recordings frequently, he was detached from the data. Instead of relating the metrics to himself and his exercise-related behavior, he used the recordings to browse through the places in the world he had been to and the marathons and trainings he had completed:

*I got a Polar watch for my birthday in 2009. Technologically, it was very limited, but I liked it because I could download my running data and project my routes onto Google Earth. Sometimes they disintegrated Google Earth, so I bought a Garmin because they use a better map. I use it only for running. I am often abroad for business, and whenever I go running, I take my watch with me. That's so cool when you can trace where you've been and the places you've passed by, and also the kilometers, pace, and altitude. That's, well, informative, though certainly not vitally important. … So since 2009, the coolest thing for me is the map, seeing the route and getting data about distance, altitude, and calorie burn. The device does not influence my training. I don't need the device to tell me what to do; I set my goals myself. (Male medical doctor, age 63, Garmin-user)*

**Self-knowledge Mechanism:** The self-knowledge mechanism relates to the drive to obtain knowledge, particularly knowledge about oneself. It predominantly gives rise to cognitive outcomes like awareness and learning, leaving behavioral patterns unaffected. On the empirical level, users in whom the self-knowledge mechanism is active want to observe and learn about their own behaviors and functioning, so they employ the wearable as a magnifier that makes visible behavior patterns and conditions that they had not been able to observe otherwise. They observe themselves by monitoring and reviewing their activities with the help of the wearable. Then they use the new knowledge about themselves to adjust their convictions and even the formation of normative judgment regarding their behaviors. One interviewee, who bought an Apple Watch without intending to self-track any health parameters, provided a good example of the self-knowledge mechanism in reporting how he took up using self-tracking features when he decided to lose weight. Wanting to learn about his own activity patterns, he started tracking all of his activities and appreciating the data for helping him gain awareness and becoming more mindful about his behaviors:

*When I decided that I had to lose some weight, I felt that I needed to get a feeling for how active I was, so I started counting my steps. After some time, I started monitoring any activity when I went for a walk, went hiking, or rode a bicycle. The positive effect was that it helped me get interested in how active I was; it started to matter to me. I don't actively follow the activity goals because I automatically reach 80 to 90 percent on weekdays. Of course, I try to be mindful of it, but I don't follow it very strictly, so it is more about observing and compensating on weekends to meet the goals on average. But I wouldn't rule out that the watch indirectly influences me just by being on my wrist and that I probably stand and move more often than before. … To me, it is an unobtrusive, easy-to-handle companion that adds some sort of systematic awareness. It's not that I wouldn't go for walks if*

*I didn't have a wearable, but it makes me more aware of whether it was 4, 5, or 12 kilometers. (Male IT employee, age 46, Apple-user)*

**Exploration Mechanism:** The exploration mechanism describes the drive to scout and play around with unfamiliar things. Even though exploring an unfamiliar thing may yield the discovery of new or unexpected potential for actions, no tendency to change behavior is associated with this mechanism since users explore for exploration's sake. Instead, this playful form of technology interaction has entertainment outcomes. With wearables, the exploration mechanism is manifested on the empirical level in users' curious and enthusiastic interactions with the technology and engagement with the data output. The exploration mechanism gave rise to diverse use behaviors, depending on the object users wanted to explore. Users who explored what the wearable enabled them to do in general had comparatively fuzzy use patterns that involved periodic, on-and-off use of a wide range of features. Others' explorations were directed to a specific activity and the related data output, which led to a more in-depth use of a reduced set of features. One interviewee, who had been using his wearable to record his mountain bike tours for more than two years, spoke about his excitement and enjoyment in reviewing his tour data, and his disappointment once when he forgot to monitor the tour. Not being interested in exploring anything but the tours, he did not engage with any other features. It was clear that exploring was followed by entertainment (i.e., viewing the tour video) but not by conclusions about behaviors or behavioral change:

*I've been looking for a device to record my mountain bike tours. ... There are several features, and I could easily record my entire life, but I just don't care; I don't know what to do with most of the data. It is fantastic for sports though; you can record your entire tour and make a video of it, complete with images and music—just a little compilation. It is interesting to see that here is where I climbed a hill—12 percent incline, pulse at 180 beats per minute—and to realize that this is where I was breathing heavily. Sometimes I forget to activate the tracking mode. That was the most annoying thing, if I've been taking a break and paused the watch and then forgot to reactivate it. After getting home and uploading my data, I would see that half of the tour was not recorded, and the data was missing. That really upset me. (Male engineer, age 41, Polar-user)*

**Social-relatedness Mechanism:** The social relatedness mechanism describes the drive to feel connected with and accepted by social groups. The mechanism gives rise to predominantly cognitive outcome of feeling related. On the empirical level, users seek contact with social groups, along with their acceptance and approval so they do not feel isolated. For this purpose, users may employ wearables to signal their belonging to a certain social group or even to contact members of the group by using the wearable's social features. For example, users may get a running watch to signal that they belong to the group of runners or may use social features to underscore their status as the "sporty" person in a social group. While the use of social features was also present with other generative mechanisms, the social relatedness mechanism's pattern of use for realizing social belonging outcomes by connecting with others, such as through competitions, was unique. One interviewee, who was highly oriented toward others' reception of her behaviors, talked about her extensive use of social features. Using competitions against her real-life friends over the app, she sought to be at the top of the ranking, frequently checking her status and gearing her physical activity level to win. Her own performance in light of the (lower) performance of others strengthened her status within the group and nurtured her motivation:

*When my friend told me about the characteristics of her activity tracker, I was on fire and ordered one the same day. I connected with a lot of friends. Three times a day or so, I checked what the others were doing, where I was in the ranking, and whether I had reached 10k steps. I have to admit that I like competing against others; I always have. I participated in a few competitions in the past. We're six competitors now, and I am still really joyful if I am at the top, though maybe I've been checking with lower frequency lately. ... But comparing myself to others and realizing that only 30 minutes of* *training would win me a rank motivates me to do it. There's some sort of obligation toward myself. (Female administrative employee, age 49, Fitbit-user)*

# 5 Discussion

This research set out to investigate how and why wearable use gives rise to certain behavioral and cognitive outcomes and adopted Bhaskar's (2008) critical realist perspective to investigate this socio-technical phenomenon (Wynn and Williams, 2012). The concept of generative mechanisms as they relate to critical realism gave us a way to explain how individuals reach certain behavioral and cognitive outcomes. In contrast to prior research, our study captures wearable-enabled change by scrutinizing the sequence of events that unfold over time and identifying their underlying generative mechanisms. Using this approach, we found multiple empirical patterns that connect wearable use with its outcomes and revealed seven generative mechanisms that drive wearable use and its outcomes. We divided these causal mechanisms into two categories related to their outcomes: mechanisms that cause a change in users' offline behaviors (i.e., self-improvement, self-determination, confirmation) and mechanisms that give rise to cognitive outcomes but cause no change in physical behaviors (i.e., self-documentation, self-knowledge, exploration, social relatedness). Through these mechanisms, we can explain how and why wearable use enables some individuals to change their behavior, but not others.

Our study makes several contributions to the literature on wearables and to IS research that addresses phenomena at the individual level. First, our study presents a nuanced picture of wearables' potential to change individuals' health-related behavior. Our findings from users who were driven by the self-improvement, self-determination, and confirmation mechanisms confirm the persuasive potential of wearables, as users who were driven by these generative mechanisms reacted positively to suggestions from their devices and engaged in the proposed activities. However, users who were driven by self-improvement and self-determination were empowered by the wearable to gain knowledge and take control of their own health and/or performance (de Moya and Pallud, 2020). Consequently, these users had a tendency to fundamentally change their routines, while users who were driven by confirmation merely complied with the device's suggestions (Oinas-Kukkonen, 2013). We found that behavioral changes occurred even when users had no intention of changing their behavior. The device triggered their motivation by showing them a discrepancy between their actual behaviors and the behaviors the wearable suggested (Bhattacharya et al., 2018). On the other hand, users who were driven by the self-documentation, self-knowledge, exploration, and social relatedness mechanisms refused the wearable's persuasive potential, as they were not interested in or responsive to its persuasive features. For example, users who were driven by the exploration and social relatedness mechanisms did not use their wearables to improve their fitness but to explore its technical capabilities or reach a feeling of social belonging. However, rather than changing their behavior, these users achieved cognitive outcomes like learning and entertainment, which they perceived as valuable and which drove their long-term wearable use. This outcome is in some ways similar to the concept of semiotic-aesthetic wearable use that Pols et al. (2019) identified. This finding highlights that behavior change should not be seen as the only desirable outcome of wearable use.

Second, our findings enrich the understanding of the nature of the generative mechanisms that shape wearable use and these mechanisms' behavioral and cognitive outcomes. While IS research on wearables has gained traction in recent years, little attention has been paid to the outcomes. Medical and nutritional research that has found inconsistent results regarding the health effects of wearables, have not provided insights into how and why such outcomes occur (cf. Brickwood et al., 2019). By finding that several generative mechanisms are active in wearable use, we provide a possible explanation for previous research's having observed varying outcomes and results (James et al., 2019b). Previous studies have conducted sampling based on cross-sectional characteristics like age and medical conditions (e.g., Naslund et al., 2016), but these characteristics say little about the generative mechanisms that generate outcomes and drive individuals' use of wearables. In particular, we found that such cross-sectional criteria as users' activity levels, health condition, age, and use periods, along with the type of device they use were distributed across generative mechanisms and outcomes. For example, the self-improvement mechanism was present with semi-professional athletes but also with inactive individuals who sought to optimize their general activity levels by using a wearable. In addition, the level of the devices' sophistication varied: Sophisticated sports watches were not only found with the self-improvement mechanism but also with the self-documentation and exploration mechanisms. Even rubber bands have been used by individuals driven by several mechanisms, including self-improvement and self-documentation. Therefore, researchers who seek to assess wearables' effectiveness are advised to take into consideration the mechanisms that are active with study participants in shaping their use behavior.

Third, our study has an implication for IS research that seeks to apply a critical realist perspective at the individual level. Previous IS studies have employed a critical realist stance to examine technology-enabled changes in organizations and have adapted the methodology to identify generative mechanisms on the macro level (e.g., Wynn and Williams, 2012). To the best of our knowledge, no IS study has used the critical realistic ontology to investigate the causal powers behind the use of individual IS (cf. Baskerville, 2011). Against this backdrop, our study makes a methodological contribution by providing a practical, step-by-step approach to deriving generative mechanisms based on Bhaskar's (2008) abstract guideline. This contribution enables other scholars to apply our approach to their own endeavors.

Fourth, practitioners gain valuable insights for the design of wearables. As our results demonstrate, not all users seek behavior change despite using the devices over long periods of time. For example, some users use the devices only to track their activities and interact with the data or to learn something new about themselves. Such users tend to perceive persuasive messages as interruptions, causing them to disable features or put the device away. This finding indicates that wearable design that focuses solely on behavior change is not always optimal. Instead, the devices should be designed in a way that cater to a wider variety of uses. Wearables should not impose goals (e.g., frequent movement) for but assist users in achieving their individual goals. To fulfill the promise of highly personalized computing (Rapp and Cena, 2016), wearables must offer individualized options.

# 6 Limitations and Further Research

The present research is subject to limitations that pave the way for future studies. First, while narrative interviews allowed us to gain in-depth insights into individuals' use histories, the presence of memory bias should be considered. Because we interviewed long-term users of wearables, the insights our study may provide with respect to short-term use and abandonment are limited. Future research may include individuals who have used wearables for shorter periods or discontinuous users to examine the generative mechanisms and outcomes of such use patterns. In addition, we identified generative mechanisms that explain the outcome tendencies in the context of our study (i.e., wearables), so, to expand our findings, future research could examine whether these mechanisms are also present during the use of other persuasive health technologies and the outcomes they tend to cause since the same generative mechanisms in open systems may lead to different outcomes, depending on the context (Bhaskar, 2008). Our study could also be replicated in other cultures to determine whether our results are sensitive to cultural contexts or can be generalized across countries.

A second limitation is that our study identified seven mechanisms that give rise to various behavioral and cognitive outcomes for wearable users. However, we did not focus on the patterns of interaction between generative mechanisms or the triggering conditions and events that cause the mechanisms to become actualized as empirical. Future research on the mechanism's activity patterns, including identifying any counteracting mechanisms and their interplay with the mechanisms revealed in this study, could be worthwhile.

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