# AFFORDANCES AND BEHAVIORAL OUTCOMES OF WEARABLE ACTIVITY TRACKERS

*Research paper*

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## Abstract

*Wearable Activity Trackers (WATs) are often ascribed the ability to reduce health risks by promoting physical activity and healthful eating habits. However, research has shown that their use does not always lead to behavior changes. Using the affordance lens, this study investigates how WATs' material features facilitate behavioral outcomes, as users interpret WATs in light of their personal health-related goals. Using narrative interviews with twenty-five WAT users, we found two categories of affordances—learning affordances and behavior-focused affordances—leading to three behavioral outcomes: behavior change, compliance change, and remaining with the status quo. Moreover, we identified four types of users (based on their goal configurations) that actualized different affordances and showed different behavioral outcomes. While some types of users fundamentally changed their daily routines as a result of using WATs, others simply complied with technology cues or did not change their behavior at all. Our results have several implications for research on WATs and WATs' design.*

*Keywords: Wearable, affordance, behavior change.*

## 1 Introduction

Physical inactivity is a key cause of an array of noncommunicable diseases, such as cardiovascular disease, diabetes, and cancer, which cause as much as 52 percent of premature deaths worldwide (World Health Organization, 2014). Since engagement in physical activity can alleviate the long-term health risks of raised blood pressure, high blood sugar, and overweight (World Health Organization, 2010), societal interest lies in interventions that can induce positive behavioral changes in physical activity and diet. With the emergence of mobile and sensor-based technologies, an increasing number of health interventions are delivered through mobile and wearable technology. "Wearables" are electronic computing devices worn on the body that use sensor technology so users can track such personal activities and parameters as daily steps, sedentary time, activity, nutrition, and sleep behavior (Sjöklint et al., 2015). This study focuses on wearable activity trackers (WATs), devices that allow users to track of their physical activity and other behaviors. Typically, WATs aim to shape their users' health behaviors by applying persuasive principles and techniques, so such devices are "behavior change support systems" (Oinas-Kukkonen, 2013). Not surprisingly, the health sector has considerable optimism about WATs' potential. The intended behavioral outcomes of WAT use, such as increased activity levels and conscious nutrition, are keys to improving public health and reducing pressure on healthcare providers and insurers (Gimpel et al., 2013).

Naturally, research has emphasized the physical and health-related outcomes of WATs' use. A series of effectiveness-directed trials on WATs' use from medical and nutritional sciences have shared optimistic results (e.g., Barwais et al., 2013; Finkelstein et al., 2016). Brickwood et al.'s (2019) meta-analysis underscored the positive effects of WATs' use on health-related parameters like increased physical activity, reduced sedentary periods, and caloric expenditure. However, several studies have also indicated that WATs are not effective in improving such outcomes (e.g., Slootmaker et al., 2009; West et al., 2016). In addition, the focus of most studies in Information Systems (IS) has lain on investigating WATs' use, which is an inadequate proxy for behavior change and behavioral outcomes in general (e.g., Becker et al., 2017; Kari et al., 2016; Rieder et al., 2019). Therefore, we lack an empirically founded explanation for how these behavioral outcomes are achieved. Such an explanation will complement and contribute to previous research on WATs and help providers of WATs improve their technologies.

As a theoretical foundation, the concept of affordances is particularly well-suited to explaining why users might interact with the same technology in different ways and experience different outcomes (Leidner et al., 2018). The affordance perspective is an appropriate theoretical lens through which to investigate the complex intertwining between users' goal configuration, the possibilities for action provided by WATs' material properties, and the resulting behavioral outcomes (Volkoff and Strong, 2013). Against this background, our research question asks: *How do the affordances provided by WATs enable behavioral outcomes?*

To address this question, we conducted narrative interviews with twenty-five users of WATs, which gave us an in-depth understanding of these users' use history and how WATs helped them identify and realize opportunities for new behaviors.

The present research makes several contributions to theory and practice. First, we contribute to WAT-specific research by being first to link the affordances commercially available WATs provide to behavioral outcomes. Second, we offer an explanation for the actualization of different affordances resulting in different outcomes by identifying user types based on user goals. Third, our research provides practical insights for WAT design. Based on the affordances and behavioral outcomes enabled by certain WAT features identified in our study, WAT providers can assess whether these are in line with those intended by the designers and decide about necessary adaptations.

The paper proceeds as follows. First, we present the theoretical background on wearables, the affordance perspective, and its role in IS as well as in wearable-specific research. Then, we present our method and the results of our analysis, before concluding with a discussion of our results, limitations, and proposals for further research.

# 2 Theoretical Background

## 2.1 Wearables for Behavior Change

"Wearables" is an umbrella term for any electronic computing device worn on the body that is using sensor technology to let users track their personal activities and vital parameters (Sjöklint et al., 2015). The term encompasses a wide range of devices (e.g., wristbands, glasses, clothing); though we focus on wearable devices that allow users to track physical activity and vital parameters: WATs. Wearable devices that exclusively track other health-related parameters, such as fertility, blood pressure, or blood glucose levels, are thus not part of our analysis. WATs, usually taking the form of wristbands and smartwatches, are the most popular category on the wearables market (IDC, 2018).

By providing users with insights into their physical performance through self-tracking of such parameters as steps, sleep, sports activities, and food consumption, WATs allow users to self-optimize (Gimpel et al., 2013, Sjöklint et al., 2015). Users can interact with WATs directly over the device's screen or via mobile applications, which are typically accessible using a smartphone. WATs are usually positioned by their providers as facilitators for changes in health behavior. For this purpose, they incorporate persuasive techniques to target a variety of health-related behaviors and outcomes (Lyons et al., 2014; Mercer et al., 2016). Such persuasive techniques encompass but are not limited to gamified elements, such as badges or challenges (Lyons et al., 2014). A typical persuasive technique is the step counting feature that can help users to form or alter behavioral patterns like introducing daily walks, while the nutrition tracking feature can support the reversal of unhealthy eating habits. WATs can also reinforce existing behavioral patterns, for example, by providing users with workout histories and statistics, making regular exercise more fun and appealing. Thus, WATs can be regarded as behavior change support systems (BCSS), defined as "socio-technical information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception" (Oinas-Kukkonen, 2013, p. 1225). BCSS are persuasive systems or applications designed to alter behavior in a predefined way (Oinas-Kukkonen, 2013; Oinas-Kukkonen and Harjumaa, 2009). BCSS aim to accomplish certain outcomes, i.e., changing users' behaviors, which also includes reinforcing existing behavioral patterns or taking up entirely new ones (Oinas-Kukkonen, 2010), so the magnitude of the change the system aims to induce can vary.

Oinas-Kukkonen (2013) distinguishes between three types of changes: Compliance change, behavior change, and attitude change. The compliance change is lowest in magnitude and easiest to achieve, since it involves simple acts of complying with an external (i.e., technological) cue. In contrast, behavior change includes a more fundamental, intermediate- to long-term change in behavioral patterns or routines. Attitude change, the third type of behavioral change, is a cognitive category, which is regarded as an enhancement of behavior change, yet at the same time as catalyst of behavior change. Oinas-Kukkonen (2013) indicates that behavior change is more likely and more stable if the individual has also changed her attitude.

In medical and nutritional sciences, a large body of literature has investigated the effectiveness of wearables in health interventions. Such studies predominantly ran randomized controlled trials to quantitatively assess the effectiveness of wearable-mediated interventions as compared to non-wearable or non-technology controls. Many studies found support of the effectiveness of wearables to influence health-related outcomes. Prominent outcome measures that were found to be improved by WATs included the number of daily steps, minutes of moderate to vigorous physical activity, sedentary time, calorie expenditure, nutritional intake, body weight, and body fat percentage (Brickwood et al., 2019; see also Barwais et al., 2013; Finkelstein et al., 2016). Other studies however have obtained non-supporting results of WATs' effectiveness to influence health-related outcomes. These results dampen the prospects of WATs as drivers of health behavior change by not finding significant effects of WAT use on parameters like physical activity, aerobic fitness, body weight and composition (e.g., Slootmaker et al., 2009; West et al., 2016) or highlighting that benefits which are indeed achieved are not sustained over time (e.g., Jakicic et al., 2016). Turning towards IS research on wearables, we see that only a small fraction of the literature has looked into the user experiences related to wearable use (e.g., Becker et al., 2017; Kari et al., 2016; Rieder et al., 2019). However, none of these studies are addressing behavior change or the processes that lead to behavior change following wearable use. While providing valuable insights, prior research does not shed light on how exactly the material features of WATs allow for behavior change as the users interpret WATs in light of their individual goals. However, such an understanding is necessary for WAT providers to design WATs and interventions in a more targeted way.

## 2.2 Affordance Perspective

The concept of affordances has its origins in the field of ecological psychology. Gibson (1986) emphasizes that people who look at an object do not initially see its qualities so much as what it will enable them to do. Thus, affordances describe "what is offered, provided, or furnished to someone or something by an object" (Volkoff and Strong, 2013, p. 822). Affordances, which arise from the relationship between an artifact and a goal-oriented actor, refer in IS research to the possibilities for action offered by the material properties of an IT artifact to a user in order to achieve a goal (Volkoff and Strong, 2013). The user's interpretation of affordances depends on the objectives she pursues in using the technology. For example, depending on the goal of an actor – whether a person wishes to eat dinner or to fix a light bulb – a chair may afford an opportunity for sitting or for climbing on. Thus, the same technology or object can afford different possibilities for action to different people. Being regarded as underlying mechanisms, affordances – in contrast to the concrete outcomes of an action – are not observable per se; rather they must be actualized by an actor to lead to outcomes and thereby become empirically observable (Volkoff and Strong, 2013). In order for an affordance to be actualized it must be perceived by an actor who then enacts the afforded potential for action (Volkoff and Strong, 2017). This also implies that the possibility exists that an affordance might never even be actualized or perceived (Volkoff and Strong, 2013). The empirically observable state or condition reached after actualizing an affordance is referred to as outcome (Volkoff and Strong, 2017). Affordances are complex assemblages of technological properties, users, and the relation between them, which is why they can provide or affect other affordances and produce various outcomes in a non-deterministic way (Leidner et al., 2018; Volkoff and Strong, 2017).

Leidner et al. (2018) underline the need to conceptually distinguish between the materiality of an IT artifact, its use, the affordances such use provides and the resulting outcomes. Materiality refers to those properties and features of an IT artifact, encompassing hardware (i.e., physical materiality) and software (i.e., digital materiality), that have some stability across contexts and across time (Lehrer et al., 2018). While technology use describes the direct interaction of the user with IT features, affordances are made possible by technology use. Outcomes, in turn, result from the actualization of an affordance, not from technology use. Leidner et al. (2018) use the example of commuting on a train to illustrate the conceptual differentiation: Since the train is the technology and the goal of the actor is getting to work, riding on the train marks using the technology, while the affordances arising from the relation between the technology and the user goals might include working, sleeping, or conversing with other people. The outcome relates to the affordances actualized and would – in the case of working on the train – for example, involve that the actor got more work done in a day.

The affordance lens has received considerable interest in the IS research community to explain how technologies are involved in shaping user behavior at an individual level (e.g., Mettler and Wulf, 2019) and within organizations (e.g., Lehrer et al., 2018; Strong et al., 2014; Volkoff and Strong, 2013). In this study, we use this theoretical lens to investigate the affordances provided by the material features of WATs and how these affordances result in behavioral outcomes. The relational nature of affordances make the concept particularly well-suited for explaining why users might interact with the same technology in different ways and experience different outcomes (Leidner et al., 2018).

In the context of wearable technology, a handful of authors have taken up the affordance lens. On the one hand, studies taking a design perspective, have tapped into the concept, using affordances as requirements wearable devices have to fulfill (Benbunan-Fich, 2018; Guest et al., 2017; Zhang and Lowry, 2016). Another stream, more closely related to our study, has investigated the perceived affordances of WATs. Affordances of WATs have been investigated in the workplace (e.g., Mettler and Wulf, 2019; Yassaee and Winter, 2017). In addition to identifying affordances, Mettler and Wulf (2019) found that different user types of wearables in the workplace perceived different affordances. Moreover, Rockmann and Gewald (2018) studied the affordances of activity tracking systems, which are however not worn on the body, but sports apps, while Bower and Sturman (2015) identified the pedagogical potential of wearable technology from an educational perspective. Focusing on perceived affordances, none of these papers have covered actualized affordances nor investigated the behavioral outcomes of WAT use. By considering actualized affordances and behavioral outcomes of WATs, our research seeks to take a different stance of affordances, namely, regarding “affordances as a completed action” (cf. Lanamäki, 2016, pp. 132).

# 3 Method

Since empirical evidence of the actualized affordances and behavioral outcomes of wearable use is scarce, we sought to obtain full and rich personal accounts using a qualitative approach. We conducted narrative interviews with WAT users, following established principles (Chatman, 1978; Küsters, 2009) in order to capture individual user experiences and to obtain a chronological picture of the individual use histories. The goal of the narrative interview technique is to obtain an account of a sequence of past events (Küsters, 2009). Thereby, the organization and structuring are entirely left to the interviewee. Since the interviewer does not interrupt the narrative, the interview technique helps to avoid common biases, such as 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). The narrative interview is an especially suitable technique to address our research question for two main reasons: First, the narrative interview offers an approach which dispenses with any interviewer interference that exceeds the necessary amount. This helps discovering the user goals, technology features, related affordances, and behavioral outcomes the interviewees really used or encountered by avoiding answers and topics only triggered by the interview situation that did not have any importance for the individual use history. Second, the technique allowed us to obtain processual, sequential information with story-like character regarding the individual use histories. This was particularly important in order to understand how WAT use, affordance actualization, and behavioral outcomes unfold over time.

## 3.1 Data Collection

We interviewed twenty-five WAT users who were based in Switzerland. With a market penetration of 7.8 percent in 2019, Switzerland is one of the most advanced markets for wearables in Europe (Statista, 2019a). All interviews were conducted between September 2017 and July 2018. We chose to focus our analysis on users of devices by Fitbit and Apple – two of the largest providers of wearable devices worldwide (Statista, 2019b) – which share similarities regarding the activity tracking feature, for example, having a strong focus on everyday use as compared to dedicated sports tracking devices and incorporate a myriad of features related to physical activity.

Using purposive sampling, we included interviewees that met the following inclusion criterion (Miles and Huberman, 1994): all interviewees were actual intermediate to long-term WAT users (i.e., past the trial phase). All of our twenty-five interviewees had used their WATs for more than six months and some even for several years. Within this inclusion criterion, we sought maximum variation in demographics (i.e., gender, age, profession) allowing us to identify shared patterns across diverse individuals. The first interviewees were recruited through the authors' personal networks, and snowball sampling was applied to recruit additional interviewees (Miles and Huberman, 1994).

In line with the narrative interview technique, we did not use an interview guideline (Küsters, 2009) but a pre-formulated stimulus to impel interviewees' storytelling: "Please tell me the story of your activity tracker, from the moment you got it until today." After the interviewees finished their narratives (without interruption), we took up the topics the interviewees mentioned in their narratives to trigger additional accounts. Only after exhausting all narratives did we bring up other potentially important topics or concepts that had not been mentioned, such as goals and behavioral changes. All interviews were held in person, and interviewees were ensured anonymity and confidentiality in the statements they made during the interview. The variation in the duration and elaborateness of the narratives is reflected in the variation in the depth and length of the interviews, which lasted an average of 48 minutes and ranged from 26 to 83 minutes. The recorded interviews were transcribed in the participants' native language (i.e., German, Swiss German dialect, or English). Data were processed by native German and fluent English speakers. The quotations presented in this paper were either given in English or translated into English.

Our sample consists of twelve female and thirteen male students and professional whose ages ranged from twenty-one to sixty-four years. All interviewees used their WATs in their day-to-day lives, not only for specific activities. The rich narratives allowed us to reach considerable depth in the data from our twenty-five participants and to reach saturation to the extent to which the data instantiated previously determined conceptual categories (Saunders et al., 2018). Based on our data, we found a variety of features, uses, actualized affordances, and behavioral outcomes in the interviews. Table 1 presents an overview of the study's participants, including the types of users, into which we delve more deeply later in the manuscript.

| Alias | Age | Gender | Occupation | Months used | Device | User type |
|---|---|---|---|---|---|---|
| INT1 | 57 | M | Managing director | 12-24 | Fitbit | Problem-solver |
| INT2 | 33 | M | Computer scientist | > 24 | Apple | Self-observer |
| INT3 | 36 | F | Software developer | 6-12 | Fitbit | Performer |
| INT4 | 24 | F | Computer scientist | > 24 | Apple | Self-observer |
| INT5 | 40 | M | Controller | > 24 | Apple | Self-observer |
| INT6 | 24 | F | Student | > 24 | Apple | Dataficionado |
| INT7 | 22 | F | Student | 12-24 | Fitbit | Performer |
| INT8 | 22 | M | Student | > 24 | Apple | Self-observer |
| INT9 | 53 | F | Dental assistant | > 24 | Apple | Dataficionado |
| INT10 | 41 | M | Engineer | > 24 | Fitbit | Dataficionado |
| INT11 | 60 | M | Bank employee | > 24 | Apple | Performer |
| INT12 | 49 | F | Administrative employee | > 24 | Fitbit | Performer |
| INT13 | 56 | F | Administrative employee | > 24 | Apple | Problem-solver |
| INT14 | 32 | F | Business engineer | > 24 | Fitbit | Dataficionado |
| INT15 | 46 | M | IT employee | 12-24 | Apple | Self-observer |
| INT16 | 56 | M | Computer scientist | > 24 | Fitbit | Problem-solver |
| INT17 | 64 | M | Computer scientist | > 24 | Fitbit | Problem-solver |
| INT18 | 29 | F | Media planner | 12-24 | Fitbit | Problem-solver |
| INT19 | 27 | M | Auditor | 12-24 | Apple | Performer |
| INT20 | 26 | M | PhD student | 6-12 | Fitbit | Dataficionado |
| INT21 | 27 | F | Legal secretary | 12-24 | Fitbit | Performer |
| INT22 | 32 | M | Engineer | 6-12 | Fitbit | Dataficionado |
| INT23 | 21 | F | Student | 6-12 | Fitbit | Self-observer |
| INT24 | 32 | F | Secretary | > 24 | Fitbit | Performer |
| INT25 | 31 | M | Account manager | > 24 | Apple | Self-observer |

*Table 1. Sample characteristics*

## 3.2 Data Analysis

Our data analysis broadly followed the five-step process suggested by Leidner et al. (2018). This process is of particular help when linking technology uses, affordances, and outcomes and relating them to types of users. Since the aim of our research is to determine how the affordances WATs provide shape behavioral outcomes, we considered this process to be appropriate. The data was coded and analyzed by the first and second authors in an interpretive fashion, involving close interaction and multiple iterations.

In the first iteration, open coding of the transcripts was conducted to extract the main narrative threads and events from the individual use histories, separate them from more minor recounts, we and identify the features of WATs. In the second iteration, we coded the behavioral outcomes of using the WATs that the interviewees described. For this purpose, we used Oinas-Kukkonen's (2013) conceptualization of behavioral changes, so we coded for behavior change, compliance change, and remaining with the status quo—the last for users who did not change their behavioral patterns. While compliance change marks a momentary action performed to comply with system requests, behavior change refers to a sustainable and pervasive shift in behavioral patterns or even routines that exceed the system's requests (Oinas-Kukkonen, 2013). Third, we coded for affordances: We began by extracting the direct uses of WAT features, separating them from the affordances, or action potentials, as Leidner et al. (2018) suggested. Next, we identified the affordances that the interviewees had actualized. For example, while "check level of physical activity (e.g., number of steps)" was a direct use of the WAT's activity-tracking feature, it afforded "working toward short-term behavioral goals." This step was highly iterative, involving close interaction and frequent discussion of individual instances among the authors to demarcate the concepts and arrive at a common interpretation. In the fourth step, we linked the WATs' features, affordances, and outcomes as abstracted representations of the dominant narrative threads found in the interviews, starting from the WATs' features, how the interviewees used them, what action potentials were realized, and which outcomes were brought about. Using one comment from the interviews, we can illustrate how we coded our data. The comment reads: "*The Fitbit gives me a good overview. Usually, when running uphill, my heart rate was skyrocketing, like up to 190 or so. My Fitbit helped me monitor that and to stay in a good range so I am not constantly reaching my peak heart rate. It let me configure a pulse range so I was able to monitor how I was performing when exercising. After some time, I also came to realize that cycling was much better for me than running if I wanted to work on my endurance*" (INT24). The feature the interviewee refers to is the pulse/heart rate tracker, which she used to check her heart rate during training and to set a pulse range she wanted to maintain while exercising. The quotation reveals that she arrived at a compliance change as she adjusted the intensity of her workout based on the moment-to-moment feedback from the WAT. Connecting this outcome with her direct use of the feature, we found that the WAT enabled her to train in a predefined pulse range and to observe her body's functions. In the fifth step, we turned back to the data, coding for the users' characteristics and goals. Based on the primary user goals, we identified four types of users: problem-solvers, performers, dataficionados, and self-observers. The features each of these types used, the affordances they actualized, and the behavioral outcomes they enjoyed differed.

The coding process was first applied to the interviews with Fitbit users and then to Apple users to see whether affordance actualization and behavioral outcomes differed. Since we found no differences, we combined the groups and present the findings together. The similar findings for the two groups may be traced to our analyses' having decomposed the two kinds of WATs to their features, which are similar.

# 4 Results

Our analysis reveals several strands, starting from WATs' features, individuals' uses of these features, and actualized affordances, leading to different behavioral outcomes for different types of users. We found six features, each of which had a distinctive use. Based on how these features were used, users actualized certain affordances, which can be grouped roughly into two categories: learning affordances, which are cognitive in nature, and behavior-focused affordances, which are behavioral in nature. Learning affordances allow users to acquire knowledge about a certain behavior by observing or reviewing one's own activity, developing awareness of one's activity levels, ranking one's performance, observing one's physical functions, increasing one's body-mindedness, understanding one's sleep patterns and quality, and assessing one's nutritional behaviors. On the other hand, behavior-focused affordances, which are more explicit in proposing behavioral actions, are often associated with goal attainment and so are more directly to be linked to the execution of a particular behavior. Behavior-focused affordances include working toward short-term behavioral goals, training in one's optimal pulse range, competing with others, and obtaining awareness of ideal behavior. Proceeding from these affordances, we observed three behavioral outcomes: 1) behavior change, referring to a substantial change in behavioral patterns and routines; 2) compliance change, which is a momentary change in behavior motivated by following a specific cue; and 3) remaining with the status quo, which suggests that existing behavioral patterns remained. These behavioral outcomes differed based on WATs' features, actualized affordances, and the type of user (i.e., problem-solvers, performers, dataficionados, and self-observers).

The following sub-sections detail the results of our analysis and structure them by type of user. Table 2 provides a comprehensive overview of the WATs' features used, the uses of those features, the affordances that users actualized, and the behavioral outcomes. The empty cells under behavioral outcomes by user type indicate that a particular strand was not associated with that type of user at all.

The presentation of our findings is structured along types of users. In addition to illustrating the strands—WATs' features, individual uses of features, actualized affordances, and behavioral outcome—we also detail the individual types of users.

| WATs' features | Direct uses of features | Actualized affordances | Behavioral outcomes by type of user | | | |
|---|---|---|---|---|---|---|
| | | | ***PS*** | ***P*** | ***D*** | ***SO*** |
| Activity tracker | • Check level of physical activity (e.g., number of steps)<br>• Set personal behavioral goals<br>• Check status of goal attainment | • Working toward short-term behavioral goals (B)<br>• Observing one's own activity (L)<br>• Reviewing one's own activity (L)<br>• Developing awareness of one's activity level (L) | BC | BC, R | R | CC |
| Challenge feature | • Invite others<br>• Connect with others<br>• Join challenge<br>• Look at rankings | • Competing with others (B)<br>• Ranking own performance (L) | - | R | - | CC |
| Pulse / heartrate tracker | • Check pulse / heartrate<br>• Set target pulse range | • Observing one's own physical function (L)<br>• Training in one's optimal pulse range (B) | - | CC, R | R | - |
| Sleep tracker | • Record sleep stages<br>• Set smart sleep alarm | • Understanding one's sleep patterns and quality (L) | R | BC | R | R |
| Nutrition tracker | • Enter food / drink intake | • Assessing nutritional behavior (L) | - | - | R | CC |
| Reminders | • Receive reminders | • Obtaining awareness of ideal behavior (B)<br>• Increasing one's body-mindedness (L) | - | CC | CC | CC |

PS = Problem-solvers; P = Performers; D = Dataficionados; SO = Self-observers; BC = Behavior change; CC = Compliance change; R = Remaining with the status quo; (L) = Learning affordances; (B) = Behavior-focused affordances

*Table 2. WAT Features, Use, Actualized Affordances, and Behavioral Outcomes*

## 4.1 Problem-Solvers

The problem-solver is a WAT user whose main characteristic is a health issue or health-related dissatisfaction. These problems vary in severity, ranging from complaints about minor weight issues to diabetes or chronic cardiac disease. Before beginning to use a WAT, problem-solvers have low activity levels and are not prone to engaging in any kind of sports activity. They regard using a WAT as a way to tackle their health problem and regain control. They perceive WATs as a control device that mediates and translates between users and their bodies, offering users insights and ways to resolve issues. Problem-solvers have good reasons to change their existing patterns of action and take up the target behaviors, even though some might not be highly motivated to do so. Problem-solvers' focus lies on the activity-tracking features, including the step-counter and daily or weekly goals that the WAT imposes on them. They rarely use other features in a sustained way. One problem-solver with frequent weight fluctuations describes the WAT as motivator to get the issue under control by observing his or her patterns of activity:

*I was very motivated, I have to admit. I tend to have weight fluctuations at times and, for me, that was a new trigger to pull myself together and control myself more closely: What are you doing where?* –INT13

Against the backdrop of problem-solvers' goals, WATs' material properties allowed these users to use their WATs in such a way that could lead to fundamental changes in behavior. Using WATs afforded gaining awareness and being proposed behavior-focused solutions to problem-solvers. Since they are not initially knowledgeable about their own health, activity levels, or how to approach their health issues, WATs allow them to observe and review their behaviors by, for example, directly comparing their behaviors to an established benchmark. A problem-solver who had suffered a heart attack describes how the WAT allowed him to set daily step goals and afforded progress toward meeting these goals:

*I had a heart attack last year, In rehab, I learned that the only thing you can do to avoid a second one is to be more active. Some tests revealed that my heart was doing better than expected because I had started moving [prior to the heart attack] and I thought I should do even more. I raised my daily [step] goal to 15,000 after I had repeatedly reached 10,000. My way to work was too short, so I started making a detour along the river, so I am on the move for 1.5 hours.* —INT17

Positive effects in the form of improved health parameters, well-being, or positive feedback from others led problem-solvers to be in an upward spiral, becoming even more motivated and willing to throw over old habits and sometimes to alter routines fundamentally. A diabetic problem-solver recounts how improved parameters in a medical examination confirmed the value of the new routines:

*At some point during a visit to the physician–I see my physician every three or four months because of my diabetes–critical values like blood sugar and weight had decreased. I thought, 'Well, then, [pursuing my daily step goals] is probably not wrong after all.' At the bottom of my heart, of course, I had known it for a long time: Move and you will feel better! Actually, that's quite simple, but [the WAT] was the perfect way to remind me of it.* —INT1

## 4.2 Performers

The performers are an active and sporty user group in whose lives physical activity plays a significant role. In sports, but also in other aspects of life, they are driven by performance and high ambitions. Thus, in the context of WAT use, performance improvements and self-optimization with the help of data are central. Their primary motivation to use WATs is to keep track of their personal development and performance improvements. The technology has an array of features for performance-oriented users. Besides intensively using several features of activity tracking, including sports tracking, they are the only group to use heartrate tracking. They also used the challenge feature, sleep tracking, and reminders, although less than they did the other factors. A performer describes reaching and stretching for personal goals enabled by the WAT as critical:

*[I always check] how much I have done, so I always reach my goals or set new goals. I'm that kind of person: I get bored quickly and I always have to have new goals, heavier weights, longer distances, or the same distance at a faster pace. I always try to outdo myself.* —INT21

Given the performers' distinct focus on goals, they also actualized learning affordances, which allowed them to review and assess their behaviors. Such affordances work for some users as a "conscience" that gave them reason to feel either self-confirmation or guilt. These users actualized more behavior-focused affordances where they suspected a potential for optimization, such as when users used heartrate monitoring to optimize training and accelerate personal development:

*The watch is always checking my pulse, and I can check it directly on my wrist, but what is interesting about it is that, if I know exactly in which pulse range I am burning the most fat, then I can configure that on the Apple Watch and during training to check whether I am within the pulse range. That's absolutely brilliant; that's really great. I always use it [for sports activities]. Also, when I am riding my e-bike, it indicates whether I am within the fat-burning range. After training, I can always review whether I was within the range in which I want to train.* —INT11

Behavior change occurred for this group when it was necessary for self-optimizing. However, when these users saw their existing behaviors as desirable and potentially leading to performance improvements, they retained their existing behavioral patterns:

> *It's not that I am going for extra runs because of [the WAT] but that I will walk for one or two stops, when I have to wait for the tram to arrive. Once, I was in Basel in the evening and I would have had to wait for the tram for 25 minutes or so, so I just walked home instead of standing there waiting. But I think I would have done that anyway, not only because of the Fitbit but because I just don't like to stand around waiting—I'd rather walk—but it is helping me to see these things. At the train station, for example, I am now taking the stairs instead of the escalator. I've already got around 2,500 [steps] and around seven flights now and I've only just gotten up.* —INT21

These users actualized affordances related to goal attainment, but they were not in the foreground, as they goals turned out to be easily reached, so they contributed mainly to feelings of self-confirmation. One performer joyfully describes using the WAT's challenge feature, which offers self-confirmation but is not a cue to adjust behavior:

> *I am still syncing the counter, still measuring myself, controlling myself, and I am still happy when I end up top of the list. In the meantime, we are six competitors, and I think we are going to keep that up for a while.* —INT12

Many performers temporarily put the WAT down to circumvent feedback if they anticipate that the feedback will be negative. This behavior supports the conjecture that some performance-oriented users use their WATs as a self-confirmation device, serving as an ego push. A performer describes a pattern of temporary discontinuance in stressful periods to silence the WAT's role as "conscience":

> *When I am stressed and cannot get out, this is frustrating and it is pulling me down because I realize what I have not achieved. If I know in advance that it is going to be a stressful phase, I will put [the WAT] aside because I don't want to be constantly reminded of what I have not achieved.* —INT3

## 4.3 Dataficionados

Dataficionados are enthusiastic about technology and curious, and they take pleasure in trying out new gadgets. They particularly like data, figures, and statistics, so using WATs serves the primary goal of quantifying themselves. Dataficionados are not particularly motivated to perform any kind of target behavior or to change their existing behavioral patterns. Instead, their interaction with WATs is largely restricted to the passive use of the activity- and sleep-tracking features, which serve as self-measurement tools. Dataficionados also use and sometimes react to reminders and track their heart rate and nutrition. One dataficionado describes in a delighted way how generating data and self-quantifying lie at the heart of his or her WAT use:

> *I guess the reason I like things like this is that I am a bit obsessive about quantification of these kind of health things and tracking statistics. I'd say that was the main reason I got it; I like looking at these charts that pop up every day. I've also got one of the scales that syncs up to it.* —INT20

Against the backdrop of dataficionados' self-quantification goal, they predominantly actualize learning affordances by observing their behavior in a neutral way, without drawing inferences regarding ideal behavior. The neutral observation of behaviors, together with not viewing their performance in light of WAT-set goals, make it easy and convenient for dataficionados to retain their behavioral patterns. Two dataficionados describe monitoring their physical activity for the sake of quantification alone, without adjusting their behavior as a result:

> *I am using the training function, which detects movements. I really like that. I am mainly doing interval training and functional training, and that's being recorded. I find it nice that it lets you see how much you have done, when, where, and at what temperature.* —INT6

> *I clearly see it when I am working in my home office. It has a huge impact on my steps, and it eventually gives me a guilty conscience, but it does not motivate me to go outside again if I have only 9,000 steps in the evening. I don't do that.* —INT14

## 4.4 Self-Observers

Self-observers are typically inactive in their work lives, with varying activity levels for their leisure time, ranging from inactive to sporty. They are primarily interested in a variety of smart watch features, not only activity tracking, leading to the purchase of more sophisticated wearable devices. Their motivation to make changes to their behavioral patterns tends to be weak; they prefer to use their WATs to gain insights into their behaviors and functioning. The goal of observing themselves leads to the use of a wide array of WAT features, including activity tracking, the challenge feature, sleep tracking, nutrition tracking, and reminders. An inactive self-observer describes how step-counting and goals help balance his activities:

> *To me, the step goal and checking whether I am generally active enough is very important. As a computer scientist, I also have a bit of a work-related problem, as I am sitting a lot. If I haven't done anything for an entire week, I start to feel sluggish and then I immediately have to change something.* —INT2

Self-observers actualize learning and behavior-focused affordances their WATs provide. While using their WATs, they are confronted with their behavioral insufficiencies, which weakens their motivation to change. A self-observer describes how the WAT could show that he should be more active:

> *In the beginning, it was shocking, I saw that I was only walking 2 km or so, which is quite miserable. This motivated me to walk the stairs instead of using the elevator. It really had a strong influence on me because it showed me in a simple way how badly I was actually doing. I came to realize that I had to be more active.* —INT4

After realizing that their behavior is not necessarily ideal, the behavior-focused affordances, including working toward a WAT-imposed goals, helped the self-observers make behavioral improvements actionable and feasible without having to take up entirely new behavioral patterns or routines. Thus, self-observers show a strong tendency to comply with the behaviors cued by the WAT even though they do not have a preliminary motivation to change. A self-observer describes the small adjustments he made to everyday routines to be compliant with the WAT-imposed goals:

> *I think once an hour you should be moving around. If you don't do that, you'll get a little reminder ten minutes before an hour has passed. It's a little reminder that you should move, which I often get at the office and I use as an occasion to go to the toilet or grab a glass of water or something like that–not always, but every now and then.... In the office, quite often I've been sitting there for two hours and really haven't been doing anything, that is, I haven't been moving.* —INT5

# 5 Discussion and Implications

This study investigates the affordances and behavioral outcomes of WAT use; more specifically, we identify the action potentials several types of WAT users realize that lead to changes in behavior, acts of compliance, or remaining with existing behavioral patterns. Based on narrative interviews with twenty-five long-term users of WATs, we found various affordances provided by WATs that these users had actualized, which fall into two broad categories: learning affordances and behavior-focused affordances. These actualized affordances can lead to substantial changes in behavioral patterns (i.e., behavior change), simple adjustments in behavior to comply with technology cues (i.e., compliance change), or remaining with the (behavioral) status quo. These strands differ depending on the users' goals and characteristics, which we summarized as types of users based on their goals and motivations for use. We contribute to WAT research by presenting the first study to link WATs' material features to behavior change using the affordance concept as a theoretical lens. Our results show that, even when users have established highly sustainable use patterns (i.e., after several years of use), their physical behavior may still be unaffected. Therefore, we posit that the conceptual separation of WAT use and behavior change is central to analyzing and explaining either of them. We also show that whether behavioral change takes place and at what magnitude depend on the set of affordances actualized, which depends on the type of user (i.e., the user's goals).

Based on our analysis, we identify two key sets of propositions that relate to how WATs enable behavioral outcomes. First, our findings suggest that users' goals are one of the key determinants of differences in behavioral outcomes. Previous studies in the context of health and physical activity have highlighted the importance of users' goals and, drawing on the concept of motivational affordances, they have looked into the role of user goal orientation and motivation to explain the use of self-tracking technology's features (e.g., Rockmann and Gewald, 2019; Stragier et al., 2018) and benefits (Rockmann and Maier, 2019). Adopting a similar perspective, James et al. (2019) showed how exercise goals drive the use of features and how such use influences users' well-being. Other studies have focused on the fit between users' characteristics and the design of motivational feedback, showing that users' goals and motivations lead to the appreciation or rejection of various classes of feedback (Hamari et al., 2018; Hassan et al., 2019). While these related works provide substantiation for our notion of users' goal configurations, our study goes farther in showing how the use of features–which are determined by users' goals–allow users to actualize specific affordances and realize behavioral outcomes. Hence, the four types of users identified in our study are characterized by distinct goal configurations, which affect the behavioral outcomes and offer an explanation for why the use of the same feature leads to behavioral outcomes that differ from user to user. Users who have clear behavioral goals tend to change their behaviors more fundamentally, while users without such goals or only vague and malleable goals tend to retain their existing behavioral patterns or just comply with WATs' cues. This finding is in line with goal-setting theory, which posits that goals affect outcomes to the extent to which they shape motivation and effort toward goal attainment (Locke and Latham, 2002).

**Proposition 1a**: Problem-solvers and performers are prone to show a behavior change.

**Proposition 1b**: Dataficionados are prone to remain with the status quo.

**Proposition 1c**: Self-observers are prone to show a compliance change.

Second, we identified two classes of actualized affordances—which identification helps to explain the functioning of the individual affordances users actualize—linking technology use and behavioral outcomes. These classes are learning affordances, which are cognitive in nature in that they create learning experiences for users, and behavior-focused affordances, which are more direct in proposing action potentials on a behavioral level and which often have the attainment of certain goals at their core. Users' behavioral outcomes depend on the class to which the actualized affordances belong, as users who actualize only the learning affordances have a tendency not to change their behaviors, while users who also actualize behavior-focused affordances tend to change their behaviors.

**Proposition 2a**: If only learning affordances are actualized, users are prone to remain with the status quo.

**Proposition 2b**: If behavior-focused affordances are actualized, users are prone to show a compliance or behavior change.

## 5.1 Implications for WAT Research

Our results offer explanations for other studies' varying results regarding WATs' ability to change behavior. For example, Slootmaker et al. (2009) and West et al. (2016) did not find that WATs had significant effects on behavioral outcomes using samples of office workers and undergraduate students, respectively. Knowing that behavior change predominantly occurs with problem-solvers and performers, we might explain the absence of evidence for behavior change in terms of the sample composition (i.e., overrepresentation of dataficionados and self-observers). Conversely, Barwais et al.'s (2013) presented evidence (albeit weak) for WATs' ability to induce behavior change; however, the short intervention period of four weeks allowed for only limited conclusions about behavior change because the change's sustainability was not measured. This problem is also reflected in Jakicic et al. (2016), which found supporting evidence of WATs' effectiveness but also indicated that the behavioral patterns were not sustained over the entire study period of twenty-four months.

Our findings have several implications for WAT research. First, our results suggest that researchers should identify the goals and basic motivations that their study participants pursue by using WATs.

Second, researchers who use WATs devices that are designed for experimental purposes or commercially available WATs should consider which affordances the devices—or, more specifically, which of its features—may be useful to which groups of users. This consideration can be of particular importance in assessments of the affordances that users can actualize to influence their behavioral outcomes. Third, studies have measured the behavioral outcomes of WATs' use in terms of changes in physical activity, sedentary time, nutritional intake, and body weight. However, we suggest a more nuanced view that differentiates between a fundamental change in routine (i.e., behavior change) from simple acts of complying with technology cues (i.e., compliance change), as both outcomes can be valuable in improving health. Fourth, we propose that longer study periods are needed to assess the devices' effectiveness over the long term.

### 5.2 Implications for Designing WATs

Our results have several implications for the design of WATs. First, research that has taken a design perspective has predominantly dealt with technology affordances as requirements and with opportunities in terms of what is feasible from a technical perspective (e.g., Benbunan-Fich, 2018). However, by taking the perspective of affordances, our study shows that, even though most of the devices our participants use offer a bouquet of potential affordances, users actualized only a few of them. Therefore, WAT designers must find a better balance between technically possible affordances and affordances that users actually perceive as useful, understand, and realize. Second, depending on which of the two broad categories of affordances a feature offers, users may be hindered from arriving at particular sets of outcomes. A feature that offers only learning affordances might be less powerful in inducing behavioral outcomes since users have to come up with ideas for concrete actions themselves. This relationship can be observed with the sleep tracker, a purely awareness-creating feature that does not propose remediating suggestions for users. If users seek to change the behaviors the features track, the technology leaves them alone to find ways to realize it. This observation offers an explanation for the number of users who retain the status quo (e.g., do not change their bedtime routine despite using the sleep-tracking feature). Third, our study supports the importance of users' goals in determining which affordances users are actualizing and which outcomes they are reaching (Leidner et al., 2018), which is why users' goals should be considered when designing WATs. Inquiring about users' goals and basic motivations during a WAT's setup process may help WAT providers to tailor intervention content more precisely to the characteristics and interests of the individual users. Fourth, whether the WAT's use was sustained, long-term, or regular is an improper measure of success. All of our interview participants were continuous, long-term users of WATs, and yet we found evidence of differing behavioral outcomes (i.e., compliance change vs. remaining with the status quo vs. behavior change). Therefore, use statistics lack the power to explain WATs' behavioral effects. To assess a WAT's success in terms of inducing behavioral change, WAT providers should interview or observe users in addition to running analytics algorithms on their use data.

## 6 Limitations and Further Research

Despite the careful design of our research approach, our findings are subject to limitations. First, we cannot claim that our account of affordances is exhaustive, since we included only WATs by Apple and Fitbit in our analysis. Considering other devices, especially devices with stronger positioning in sports and more sophisticated sports-tracking features (e.g., training intensity, blood oxygen saturation, lactate threshold) that serve other user goals might yield other sets of affordances. Therefore, future research should study other use cases to obtain a more comprehensive picture of the actualized affordances of WATs. Second, the generalizability of the findings may be limited by the selection of participants in the study, who were all based in Switzerland. A follow-up study that takes other cultural contexts into account could determine whether the findings hold in other countries. Third, factors other than affordance actualization might jointly determine the behavioral outcomes of WAT use, so further research may investigate such factors in detail. Beyond that, future research efforts should test the propositions derived from our analysis empirically.

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