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# Behavior, Change, and Self-Leadership with Wearable Activity Trackers: A Case Study of Ultra Endurance Athletes

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**Työn nimi:** Käyttäytyminen, muutos ja minäjohtajuus puettavien aktiivisuusmittareiden avulla: tapaustutkimus ultrakestävyysurheilijoista
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**Abstract:** Wearable Activity Trackers are built to influence and create change in human behavior. While the actual effectiveness is still a matter of debate, most research has focused on focus groups from a health perspective or individuals with the need to decrease sedentary behavior. This study aims on defining how wearable activity trackers influence the activity and recovery behavior of ultra endurance athletes. The research is a qualitative case study and the data collection method is semi-structured thematic interview. Five ultra endurance athletes highly engaged to wearable activity tracker usage were interviewed. The results suggest that wearable activity trackers do influence the activity and recovery behavior and change initiatives of ultra endurance athletes. The athletes were engaged with the actual metrics rather than the behavior change techniques, yet the trust grew gradually through evidence. They expressed major self-leadership and self-efficacy. Compliance with the wearable was visible when the subjective feeling matched. In other words, the behavior was self, not IT-lead and the individuals were able to transform wearable-driven behavior to self driven, turning external motivation to internal. Arguably, while wearables can support and reinforce change, they are unlikely to be the sole drivers of lasting behavioral modifications. Sustainable behavioral change with wearable activity trackers is a complex combination of self- and wearable-driven techniques and external enablers.
**Suomenkielinen tiivistelmä:** Puettavat aktiivisuusmittarit on suunniteltu vaikuttamaan ja luomaan muutosta ihmisten käyttäytymiseen. Niiden todellisen tehokkuuden ollessa edelleen debatin kohteena, useimmat tutkimukset ovat keskittyneet terveysnäkökulmasta tarkasteltuihin kohderyhmiin tai yksilöihin, joilla on tarve parantaa aktiivisuuttaan ja elintapojaan. Tämä tutkimus tarkastelee, miten puettavat aktiivisuusmittarit vaikuttavat ultrakestävyysurheilijoiden aktiivisuuteen ja palautumiskäyttäytymiseen. Tutkimus on laadullinen tapaustutkimus ja datankeru-

umenetelmänä on puolistrukturoitu teemahaastattelu. Haastateltavana oli viisi puettavien aktiivisuusmittarien käyttöön voimakkaasti sitoutunutta ultrakestävyysurheilijaa. Tutkimuksen tulokset viittaavat siihen, että puettavat aktiivisuusmittarit vaikuttavat ultrakestävyysurheilijoiden aktiivisuus- ja palautumiskäyttäytymiseen sekä käyttäytymismuutosaloitteisiin. Urheilijat keskittyivät enemmän dataan kuin käyttäytymisen muutostekniikoihin, mutta luottamus myös niihin kasvoi ajan myötä näyttöihin perustuen. He osoittivat merkittävää minäjohtamista ja minäpystyvyyttä. Puettavan aktiivisuusmittarin käytössä näkyi mukautuminen sen ohjaukseen silloin, kun subjektiivinen tunne vastasi mittareita. Toisin sanoen käyttäytymistä ohjasi itse henkilö, ei IT, ja yksilöt pystyivät muuttamaan puettavan aktiivisuusmittarin ohjaaman käyttäytymisen minävetoiseksi, muuntaen ulkoisen motivaation sisäiseksi. Vaikka puettavat aktiivisuusmittarit voivat tukea ja vahvistaa muutosta, ne eivät todennäköisesti ole kestävien käyttäytymismuutosten pääajuri. Kestävä käyttäytymisen muutos puettavien aktiivisuusmittarien avulla vaikuttaa olevan kompleksi yhdistelmä minä- ja mittarivetoisia tekniikoita sekä ulkoisia mahdollistajia.
**Keywords:** Behavioral Change, Self-Leadership, IT-Leadership, Self-efficacy, Wearable Activity Trackers, WAT, Behavior Change Techniques, BCT
**Avainsanat:** Käyttäytymisen muutos, minäjohtajuus, IT-johtajuus, minäpystyvyys, puettavat aktiivisuusmittarit, käyttäytymismuutosmekanismit

# Glossary

| | |
|---|---|
| WAT | Wearable Activity Tracker |
| BC | Behavior Change |
| BCT | Behavior Change Technique |
| HR | Heart Rate |
| HRV | Heart Rate Variation |
| AI | Artificial Intelligence |

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Returning to academia after several years to reinforce my technical knowledge turned out to be a very meaningful experience for me. Even though studying on first parental leave and later parallel to full-time work (+ kids) was not easy, I'm proud to say I was able to finish and more importantly, learn. This thesis is in the very interesting intersection of technology and human behavior, bridging them together. I am thankful to have been able to choose a subject that combines many of my key interest areas.

Moreover, thank you to my two beautiful kids who enabled my studies and most of all my husband, who helps me remember that anything is possible with the right mindset, self-leadership and external enablers. Now that this project is finished, I can't wait to see what our next pursuits will be.

# Contents

# 1 Introduction

## 1.1 Background of the Study

> "I have no doubt that in the future, wearable devices like Fitbit will know my blood pressure, hydration levels, and blood sugar levels as well. All of this data has the potential to transform modern medicine and create a whole new era of personalized care." - Michael Dell

The potential of wearable technology has been to some extent visible for years, if not decades. Non-invasive biosensors have evolved significantly in recent years, which has made it more viable to incorporate sensors in smartwatches and other wearables [11]. Wearables are unique in the sense that being attached to an individual's body, the individual can be digitized, leading to a new age of quantified self [32]. The emerging field of smart wearables holds within a large variety of technical systems from smart glasses to blood sugar tracking or fitness trackers. The wearables can be used for instance in easing the user's everyday life, monitoring and measuring health and/or activity, guiding users towards better choices, or reducing sedentary behavior [51]. It is suggested that health-tracking wearables help individuals improve their physical activity, nutrition, and sleep by prompting action and recording different activity variables [42]. Especially the advancements in mobile and sensor technology are seen to affect wearables becoming an increasingly popular method in motivating physical movement [74].

The field of smart health-tracking wearable devices has been a trending and increasingly growing research field in the past decade. For instance, Shina et. al. [80] found that the number of wearable activity tracker (WAT) research papers increased from 10 published in 2013 to 199 published in 2017. This is no wonder, as the adoption of health-tracking wearable devices has also increased over the past years. According to an Accenture [2] research survey, the number of consumers using wearable technology increased in the US market from 9% in 2014 to 33% in 2019. While this survey demonstrated a major drop to 18% in use during the Covid-19 pandemic in 2020, a more recent survey [72] suggests the demand and use have both recovered and potentially increased, leaving it at 35% in early 2023. The largest mo-

tivations for fitness tracker usage were the encouragement to achieve fitness goals (31% of respondents) and general interest in tracking health (24%). On the contrary, the main reasons for no longer using or not engaging with a wearable device were the price (23%) and losing/not having an interest in tracking health data (18%). The price question may unfortunately result in those needing the devices most not being able to acquire them [61].

While the large population is adopting wearables with increasing speed, those more involved in sports are more likely to already be equipped with a device that tracks the activity. For instance, tracking time, speed, location, and distance of runs is typical for runners [10]. Even the dataist perspective is possible, where actions are a series of data flows, and the human experience is secondary. Surveys suggest experienced runners feel wearables are a central part of their workouts [71]. Monitoring heart rate, pace, and other physiological parameters combined with making training-load adjustments are common ways of using the device.

The downside to high adoption rates is controversial results in sustainable behavior change regarding physical activity and lifestyle. This study goes a step deeper than 'those more involved in sports', focusing on ultra endurance athletes. While this group of typically engaged wearable activity tracker users is small and in many ways exceptional, their wearable behavior, change, and self-leadership models may serve as scalable insights for larger populations.

## 1.2 Literature Review

Behavioral change achieved by wearable activity trackers can be described as meaningful changes in behavior that lead to the self-improvement of individuals [80]. It is one of the six main research branches Shina et al. [80] identified by topic modeling the 463 articles conducted in the field of wearable activity tracker research between the years 2013 and 2017. Other defined research branches were Technological Focus, Patient Treatment and Medical Settings, Acceptance and Adoption, Privacy and Self-monitoring Data-Centered.

Oinas-Kukkonen [59] stated that information technology always aims on influencing and altering attitudes and behavior in some way. He presented a Outcome/ Change matrix to build understanding of the impact. Shina et al. [80] discussed how the severity and effectiveness of the influence vary depending on the design and implemented strategies. Behavior change is accomplished through a variety of actions

regarding the tracking and patterns of health and wellbeing. Even though the technology aims to influence positively, according to Sullivan et al. [84] it is still unclear to what extent these devices produce long- or short-term behavior changes that lead to increases in activity levels. While Stephenson et al. [82] found promise in IT-lead change to sedentary behavior, Rieder et al. [73] argue that effective behavior change is still not reached fully effectively by wearables. Furthermore, according to Lehrer et al. [42] there is still little evidence that wearables can produce long-term behavior change. Lasikiewicz and Scudds [41] found in recent research that the potential impact of wearables on improving health and wellbeing is complex and still requires further investigation. Ogbanufe and Gerhart [58] found a link between having the smart watch as part of their identity and usage. Those who held the device as part of identity used more advanced features and actively explored new ways to improve their own performance. Nevertheless, this research was not limited to health but also incorporated other smart watch qualities.

Patel et al. [61] explain that the difficulty with wearables creating sustainable change is to do with motivation. They explain, that either external motivation needs to be turned into internal (i.e. creating new habits) or external motivation needs to be sustained. Neither are simple paths. In the same lines according to Ryan and Deci [76], the individual's motivation in the starting point is a major influencer to methods and outcomes - it may vary from unwillingness to passive compliance to active personal commitment. Moreover, intrinsic interest must be held by the individual in order for them to maintain and create intrinsic motivation. All in all, the question of motivation should not be overlooked - the authors found, that while competence and self-efficacy for an activity could be the same, motivation leads to different results. Precisely put, those with high authentic intrinsic motivation are likely to perform better compared to those with only external motivators.

While research shows ambivalent results towards achieving sustainable change with wearables, Patel et al. [61] found the determinants of successful change are not in technology features but rather in the incorporated engagement strategies. These are such as combinations of effective feedback loops, individual encouragement and social competition and collaboration.

Abraham and Michie [1] created a taxonomy for behavior changes, which has later been reinforced (i.e.[34]). Michie et al. [54] thereafter created the behavior change wheel to combine understanding in behavior, interventions and policies for better intervention design. Carey et al. [12] aimed on pinpointing the mechanisms

of action for behavior change techniques to improve their use. Understanding what kind of behavior change techniques are incorporated in wearable devices has been central in many researches (i.e. [84], [18], [51]). Olander et al. [60] had emphasis on interventions towards obese adults. Lehrer et al. [42] bridged the gap between self-leadership strategies and technology explaining how in fact the strategies may be applied by either the individual or wearables (= as BCTs). This enables a more holistic approach to understanding behavior and change with wearables.

Wearables in the use of athletes have been studied from a broad variety of angles. For instance, Baldassari et al. [6] developed a wearable and set of machine learning models to improve runners' motivation. Moreover, Pobiruchin et al. [62] researched the accuracy and adoption of wearables in a marathon running context. Toner et al. [85] scrutinized the ways distance runners use wearables underlining the importance of own "somatic experience" in the interpretation. Van Hooren et al. [36] researched the impact of real-time feedback in running, to understand impact on reducing injury. Seçkin et al.[79] contributed the field with an extensive review of wearable technology in sports. While behavior change mechanisms with wearable devices has been extensively researched, there are still few studies focusing on cognitive and behavioral outcomes of using wearables [74]. Moreover, the studies do not extend to ultra endurance athletes. While self-leadership has been researched from the ultra endurance athlete perspective (e.g. [81]), as such the combination of behavior change and self-leadership with wearables in the ultra endurance athlete context remains underrepresented in research.

## 1.3 Research Questions and Objectives

While the research results around the true impact of wearables on sustainable health behavior change remain contradictory to date, it seems potentially profitable to scrutinize the concept from a super-user, namely ultra endurance athlete perspective. This group generally possesses a high level of self-leadership strategies and uses wearables in obtaining their goals. In addition to being a fresh addition to the research, the habits of ultra endurance athletes concerning wearable use in managing their activity may spark themes that are integratable to the larger populations also. In other words, if it is better understood how wearables impact ultra endurance athletes and how they lead their excessive training and recovery patterns with the devices, it may be beneficial in understanding the contradictory research results of

wearable adoption. Hence, the key objective of the study is to understand how wearable activity trackers influence and change the behavior of ultra endurance athletes. Moreover, it is central to understand how ultra endurance athletes use wearables and which behavior change mechanisms impact them and how. Another important perspective is how ultra athletes manage their own activity behavior with the help of wearables. Finally, this study aims on producing a contribution to the wearable development by underlining potential techniques that could be emphasized in wearables to increase behavior change.

These main objectives lead to the main research question:

**How do Wearable Activity Trackers influence the activity and recovery behavior of Ultra Endurance Athletes?**

The main research question was further divided into four sub-questions to clarify the main objectives of the thesis:

- Which qualities in WAT are important for Ultra Endurance Athletes?
- What kind of behavioral change do Ultra Endurance Athletes accomplish with WAT?
- Which WAT BC mechanisms are most effective for Ultra Endurance Athletes?
- How could WAT be developed to better support behavioral change?

The research is a qualitative case study, based on five in-depth thematic interviews with ultra endurance athletes. Four of the interviewees are ultra trail runners and one is a triathlonist competing in all distances. Common factors for all interviewees were that they compete and have competed in distances considered ultra. Furthermore, while none of the interviewees are professional athletes, all of them train with a certain intensity and frequency to maintain and develop a fitness level that enables competing. All of the interviewees were engaged wearable users. This means they used wearable devices, more precisely smart activity tracking watches to monitor their workouts and recovery.

## 1.4 Theoretical Framework

The theoretical framework of the study, which is presented in Figure 1.1 combines traditional behavior change theories with concepts built to explain behavior change with IT systems, such as wearable activity trackers. The framework aims on visualizing the relationships between central terminology and concepts. The study builds upon the change process by Prochaska and DiClemente [66]. Furthermore, a central theory is that of Lehrer [42], defining IT-leadership as self-leadership strategies executed by an IT system. This study suggests that IT-leadership strategies and behavior change techniques implemented in wearable devices are in close relation to each other. IT-leadership strategies may be viewed as a broader concept, whilst behavior change techniques are well defined, concrete methods aiming on altering behavior.

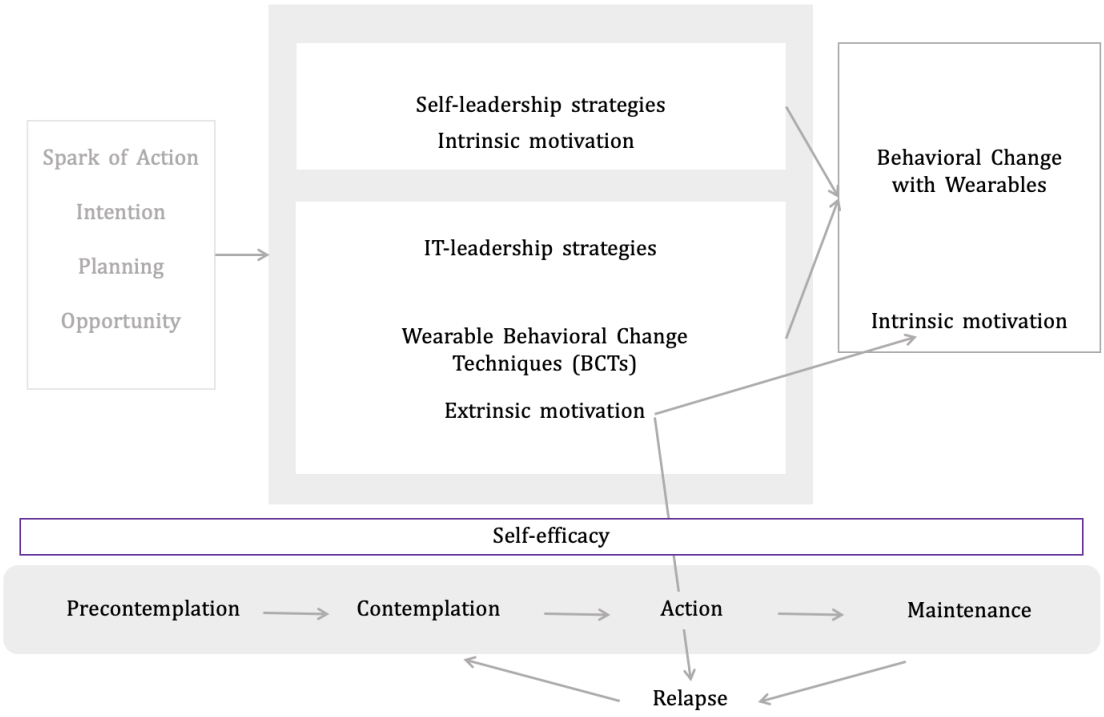


Figure 1.1: Theoretical framework of study

The concepts of intrinsic and extrinsic motivation are moreover central. Behavior change techniques incorporated in wearables are an extrinsic motivation, yet they need to become intrinsic in order for successful behavior change to happen. Self-efficacy, as has been lifted in previous research, is a central concept to explain suc-

cessful behavior change. It can be seen to exist and strengthen throughout the process of changing behavior with each self- or IT-lead behavior change.

Since the variety and use cases of wearables are broad, this study focuses on wearable activity trackers, which particularly aim on increasing activity and guiding towards better health choices.

## 1.5 Key Concept Definitions

This thesis includes terms that might be generally unfamiliar or subject to different interpretations. Therefore, this section briefly defines these concepts to aid the reader's comprehension of their meaning within this context. The terminology will be further explored and discussed in subsequent sections of the study.

- **Wearable Activity Tracker** In this thesis, the wearable activity tracker, WAT, wearable, fitness tracker, watch, and device are all synonyms used to describe a wearable system that collects data of the users singular training activities, physical activity in general and recovery, such as sleep and stress levels. In this study, the wearables are watches, but they could be also e.g. smart rings or wristbands. Notably, this study focuses on devices created for sports, making a distinction between smart watches (e.g. Apple), created primarily from a different foundation. In the literature there is some anomaly within the definitions, e.g. Jin et al. [39] define fitness trackers are devices that do not track sleep, whereas some other literature uses it as a complete synonym to the other terms.

- **Ultra Endurance Athlete** Someone, who systematically engages and typically also competes in ultra length sports. In running the definition is distances past the marathon and in triathlon, it can be considered the full distance triathlon. Notably, in this thesis, the athletes are not professional.

- **Wearable Behavior Change** The change in behavior accomplished with a wearable device.

- **Behavior Change Techniques** Methods used to influence individuals in changing their behavior. In this context, the BCTs are methods incorporated into IT-systems such as wearables with the goal of altering behavior.

- **Self-Leadership** The concept of leading self towards wanted outcomes by using strategic methods, such as natural rewards.
- **IT-Leadership** The concept of having an IT-system, such as a wearable device, use BCTs and e.g. biofeedback to lead the individual towards the wanted outcomes.
- **Internal Motivation** Motivation stemming from the individuals self. Typically these are factors such as purpose, interest, learning, or curiosity.
- **External Motivation** Motivation stemming from external factors. Typically these are factors such as money, praise, rewards, or social status.

## 1.6 Structure of the Thesis

The thesis is divided into theoretical and empirical sections. The theoretical portion is organized into three primary chapters, while the empirical section comprises two. The initial chapter introduces the reader to the thesis by outlining the research background and significant prior literature. It then presents the research problems and theoretical framework, discussing key concepts and the structure of the thesis. The subsequent two chapters elaborate on the main theoretical constructs of the study, acquainting the reader with the concepts of wearable activity trackers and ultra endurance, as well as self-leadership and change. These concepts are analyzed using previous literature, and pertinent models are introduced as a contrast to the empirical elements. The objective here is to provide a comprehensive overview of the topic and contextualize the empirical section. Additionally, the theoretical segments aim to construct a detailed understanding of behavioral change strategies within the context of wearable activity trackers. The fourth chapter synthesizes these concepts and explores how behavioral change is pursued using wearable technology, highlighting the significant role of behavioral change techniques in influencing human behavior through these devices.

The empirical section begins with the fifth chapter, which details the research methodology employed in the study. It provides an in-depth examination of the methodological approach, emphasizing the semi-structured thematic interview. This chapter starts with a brief introduction to qualitative methods, followed by an extensive discussion on data collection and analysis. The sixth chapter presents and evaluates the qualitative research findings through the themes previously discussed

in the theoretical chapters, comparing these insights with the models introduced. It explores both the similarities and differences observed.

The seventh chapter concludes the thesis by summarizing the findings, acknowledging the study's limitations, and suggesting areas for further research. The final chapter eight serves as the conclusion to the study, encapsulating the research's overarching contributions and conclusions.

# 2 Wearable Activity Trackers and Ultra Endurance

This chapter sets the scene of the thesis by familiarizing with the concepts of Wearable Activity Trackers and Ultra Endurance Athletes. Moreover, this chapter bridges the themes together to help build an understanding of how frequently wearables are used in endurance sports. Finally, this chapter dives into flagship watch models of the three brands mentioned by the Interviewees of this study. The functionalities and differences are scrutinized to build a holistic view of these major players in the industry.

## 2.1 Introduction to Wearable Activity Trackers

Wearable technology may be defined as devices that are worn or otherwise carried, which monitor data in real time. Wearables can be much more than perhaps the most common smart fitness watches, smart watches, wristband activity trackers and health tracking rings. It can be smart jewelry, Bluetooth headsets and web-enabled glasses. It may focus on for instance fitness, health or entertainment. By definition, the device connects to the internet which enables the data to be synced with other devices such as mobile phones or laptops. Depending on the use case, some wearables use accelometers or remote smart sensors, while others use optical sensors. [87] This study focuses on wearable activity trackers, which are, as also most represented in the market, also in this case more accurately smart watches.

Wearable Activity Trackers are a combination of the user interface, sensor entity and back-end system. The trackers generally collect a lot of data (e.g. heart rate, HRV, stress, sleep, daily steps, climbed floors). The data is not presented to the user raw, but rather in summaries emphasizing what is important. Often the systems are also able to suggest supporting activities to stay on track towards goals, such as detecting changes in the user's bodily functions. The back-end system can hence be seen as also an influencer to a user's engagement towards the system. [86]

Michaelis et al. [53] found that there are four main themes to describe user experience of wearable devices. They are usability, motivation, technological trust and wearability. Moreover they discovered, that above displaying accurate data, users

found more determinental to the experience factors such as syncing issues, problems with setup, poor battery-life and uncomfort in wearing the device.

Wearables are often used to follow and alter behavior, i.e. physical activity, sleep and readiness. Users may for instance use nutrition tracking in attempt to reverse unhealthy eating habits. For others the main motivator for use may be in reinforcing existing behavior. This could mean using the device to monitor workouts, focusing also on long-term data statistics. [42]

The popularity of wearable activity trackers has increased due to advancements in technology and rising awareness of the significance of health and fitness maintenance. Technological advancements are practically seen in the possibility to integrate evermore accurate technologies, such as Bluetooth, GPS, and a large variety of sensors to measure versatile bodily and external conditions. In addition to the consumer and athlete user segments, there is a growing segment of preventive healthcare for chronic diseases, which include cardiovascular disorders and obesity. From accessibility perspective, online retail channels and e-commerce platforms have made a range of wearables available for a broader range of consumers. Moreover, smartphone adoption and the development of mobile applications that utilize wearable collected data increase desirability of these devices. Due to these main reasons the market size of wearables is projected to grow in a CAGR (Compound Annual Growth Rate) of 19.6 percents between the years 2023 and 2030. [14]

## 2.2 Introduction to Ultra Endurance

Ultra endurance athletes are individuals who participate in physical activities and competitions that go well beyond the typical duration and intensity of endurance races. These events often involve continuous or staged competition over extreme distances and durations. The races may be in challenging environmental conditions, testing the limits of human performance and endurance. The popularity of ultra-running has sky-rocketed in the past ten years, from roughly 140 000 to over 600 000 ultra competition participants globally in 2020 [75]. Roughly 20% of participants are female and the average age for contestants is just over 40 years.The Ironman (full distance) triathlon events had 84 000 participants in the year 2019 globally, with only 65 000 finishing their chosen events [17]. These altogether low rates may reflect the required commitment and heavy training in three sports.

Ultra endurance sports typically involve running, swimming or cycling. If de-

fined in time, ultra-endurance is typically seen as performance durating over 6 hours [89]. In ultra-running this is by common definition distances exceeding the standard marathon, which is 42.195 kilometers. Common distances in ultra-running are from 50 kilometers, 100 kilometers or 100 miles (= approx. 160 kilometers) all the way to multi-day races, which can be hundreds of kilometers in length. Ultra-cycling races range from 200 kilometers up to thousands of kilometers, and ultra-swimming may be tens of kilometers in open water. Triathlon is a race combining all three of these sports. The ultra-distance triathlon is called the Ironman, which consists of a 3.86 kilometer swim typically in open water, 180.25 kilometer bike ride, and a marathon distance run, completed in that order in a continuum.

Ultra endurance athletes require not only exceptional physical fitness, endurance, and strength but also a strong mental fortitude to overcome the challenges of long hours of continuous activity, sleep deprivation, varying environmental conditions, and the psychological stresses associated with such demanding competitions. Their training is comprehensive, incorporating endurance training, strength and conditioning, nutrition strategy, injury prevention, and psychological preparation to ensure both physical and mental resilience. Well planned training enhances an athlete's peak competition condition while preventing the risk of over-training through months of intensive preparation. Effective training plans adhere to fundamental principles: comprehensive development, progressive overload, training specificity, tailored approaches to the athlete's unique needs, regular and systematic training, and building up structural resilience to stress. The capacity for enduring repetitive stress plays a crucial role in training. [89]

## 2.3 Endurance Sports and Wearables

Pobiruchin et al. [62] analyzed a half marathon and marathon running event to understand how wearables are used by active non-professional athletes. They found that out of the almost 900 participants, 26.1 % did not use a wearable in their training or at the event. 8.8 % reported to use more than one device. The most popular device was a GPS-enabled sport watch, which was represented by 44.7% of the participants. Other possible solutions in order of popularity were: mobile phones with an app to track performance, heart rate monitors, smart watches and wristband activity trackers. They found that females and elderly people were more likely to not possess an additional device for exercise. Furthermore, they found a statistically in-

significant connection between higher exercise frequency and use of wearables. The mobile phone tracking app was significantly more represented in the group running a half, not full marathon. The longer the distance, generally the more training and preparation is required. Hence this finding potentially implies that whilst in the half marathon distance the mobile phone tracking app is considered sufficient by many, while the distance grows, the contestants are more likely to be using technology designed especially for the sport.

Looking at the smartwatch market, Apple Inc dominates it with an over 20 % market share [38]. Runners up are Fossil Group Inc, Garmin LT and Google LLC. Nevertheless, looking at the market from the perspective of ultra endurance, according to one survey the best running watches come from Coros, Garmin and Suunto [69]. Apple smartwatches only pair with iOS, lack battery performance and have sport environment usability issues compared to sports dedicated watches in the same price range. This suggests an explanation to why individuals involved in more systematic sports activities are likely to own a device dedicated for sports, not lifestyle.

The Garmin flagship models mentioned (Forerunner 945, Fenix 7, and Enduro 2), COROS Vertix 2, and Polar Grit X2 Pro each excel in durability, with the Garmin Enduro and Polar Grit X2 Pro meeting military standards for toughness. Generally, all of the watches incorporate similar functionalities and sensors, battery lives and GPS-qualities, making any of them a good choice for ultra endurance sports. Whilst the different watches may have small nuance differences in measuring accuracy, strengths, durability and CPU-power, the choice between the manufacturers is mostly a question of brand preferences and image. The following subsections of the study scrutinize the three wearable brands which arose in the interviews of this research.

### 2.3.1 Garmin sport watches

Garmin is an American, Swiss-domiciled producer of wearable technology and GPS navigation for various use cases, from automotive, aviation, marine, to outdoor and fitness markets. Established in 1989, Garmin is a global significant player in the wearable technology industry. Garmin products utilize a wide combination of sensors built in to the wearable and wireless sensors, which enables the user to design their holistic measuring experience to suit their need. [23]

The watches utilize ANT+ and/or Bluetooth and/or WiFi wireless sensor net-

work technology to connect the wireless sensors with the device. The wireless sensors may be for instance golf club trackers, dog trackers, power trackers or sensors measuring biking details. Moreover, commonly used wireless compatibles are heart rate tracking belts and headphones. [30]

Three out of the five Interviewees for this study had Garmin watches. In triathlon circles according to the Interviewee, the Garmin Forerunner -series devices are popular. This is due to the way it is optimized for all the three sports. The more advanced Garmin watches, which all of the interviewees used such as Garmin Fenix 7, promise up to 18 days of battery life [25]. When the GPS and music function are used together, the battery lasts for a significantly shorter amount of time, whilst using only the GPS-tracking increases the time to up to 57 hours. An exceptionally long battery life is promised for the Gamin Enduro -series, which are designed for ultra distances [24]. They promise up to 48 hours of battery life and 150 hours GPS-tracking time. Nevertheless, this battery performance requires optimal conditions for the use of the solar charging implemented in the watch.

The Garmin flagship devices such as those mentioned previously, are equipped with more or less the same sensor technology. For instance, the Forerunner 945 is equipped with 10 built-in sensors [28]:

- GPS
- GLONASS
- Galileo
- Garmin Elevate
- Pulse ox
- Barometer
- Electronic Compass
- Gyroscope
- Accelerometer
- Thermometer

Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS) work hand in hand in producing a better positioning and navigation experience [29]. GLONASS provides an additional 24 satellites which produces an up to 20% speed compared to relying solely on GPS. The Galileo Satellite Network is the global navigation satellite system of Europe. Notably, satellite systems are mostly interoperable, yet they are not available everywhere. Hence, Multi-GNSS satellite systems include systems such as Galileo, GLONASS, GPS, BeiDou, QZSS, and IRNSS (NavIC). [26]

Garmin Elevate is an optical heart rate sensor based on the back of the device, towards the wrist. The functionality is based upon green light reflectivity from the wrist; as oxygen amounts in our blood hemoglobin vary, light reflects differently. The heart rate is calculated based on this reflectivity, taking to account the periodic pattern of contraction (systole) and relaxation (diastole). The Pulse Oximeter works in a similar mechanism: red and infrared light rays are absorbed by blood depending on the level of oxygen in the hemoglobin. Pulse data is detected by emitting light at the two frequencies and algorithmically calculating an estimation of the blood oxygen saturation. [27]

The Barometer, Electronic Compass, Gyroscope and Accelerometer are packed as one multi-sensor circuit chip. This enables both space and energy optimization which is beneficial in wearable devices. The gyroscope measures angular momentum, the accelerometer measures motion and gravitational acceleration, the electronic compass measures magnetic fields, and the barometer measures air pressure. Interestingly, a significant amount of user measurement functionalities are a combination of different sensors. Gyroscopes indicate the direction of movement, whereas accelerometers measure acceleration. When these are used together, they enable the determination of the movement vector. This, coupled with orientation information from an electronic compass and location details from GPS, allows for the calculation of displacement. Incorporating time information into this data enables us to determine our mode of activity. This technology is practically applied in the running dynamics feature of Garmin running watches, which calculates various specialized metrics to provide a deeper understanding of your running performance. [27]

### 2.3.2 Polar sport watches

Established in 1977, Polar is a Finnish designer and manufacturer of wearable sport and fitness devices. One of the interviewees of this study had a Polar Grit -series

watch, which is Polar's flagship series for endurance and tracking sports. The newest addition to the series is Grit X2 Pro, which is advertised to excel in battery life, navigation, measuring accuracy and speed [65].

It features a 1.39-inch AMOLED touchscreen display, known for its brightness and clarity in various lighting conditions, including direct sunlight and nighttime [68]. Given the inherent energy demands of AMOLED display technology, it could be presumed that the battery longevity of the Polar Grit X2 Pro would be adversely affected [63]. However, despite the inclusion of a more luminous display and enhanced processing capabilities, the watch surpasses its predecessor in terms of battery duration, achieving up to 10 days of operation in smartwatch mode. During workout, the device provides up to 43 hours of battery life in performance training mode and extends to up to 140 hours in eco training mode. This duration is sufficient to support the completion of extended endurance events, such as ultramarathons or 100-mile races, without necessitating recharging.

The watch incorporates Polar Elixir, a sensor fusion technology developed by Polar. It is designed to measure a wide array of physiological and mechanical data from the human body, leveraging a combination of different sensors and data points to offer comprehensive insights into an individual's health and fitness. The core components working under the Elixir framework are the optical heart rate measurement, blood oxygen level measurement, skin temperature tracking, and wrist-ECG. The latest addition is the Gen4 optical heart rate sensor, which offers improved accuracy and includes nightly skin temperature tracking and ECG recording capabilities. The device's dual-frequency GPS system and newly optimized antenna design deliver enhanced positional accuracy, vital for navigation in challenging outdoor environments. Furthermore, the Grit X2 Pro introduces a suite of navigation tools, including offline maps and turn-by-turn guidance, ensuring reliability and user confidence during explorations. [64]

### 2.3.3 COROS sport watches

COROS, founded in 2014 and headquartered in California, US, positions itself as a company at the intersection of high-grade hardware and innovative technology, driven by the goal to aid athletes in their training regimes in the most extreme environments. They emphasize an efficient and intuitive user experience, underlining their design philosophy that prioritizes simplicity and user-friendliness. The brand has gained recognition not only for the robustness and technical capabilities of its

products but also for the noteworthy endurance of their battery lives, making them suitable for ultra-runners and extreme athletes. [15]

The COROS Vertix 2, used by one of the interviewees, is a standout model for ultra endurance, designed to meet the demanding needs of trail running and ultra-running, where battery life is a critical feature. The Vertix 2 is noted for its impressive size and weight, accommodating a large 1.4-inch screen and weighing around 80 grams with the silicone band, making it a substantial piece of gear on your wrist. This size supports a need for a large battery and a high-performance processor, as well as providing the advantage of displaying multiple data points simultaneously and navigating maps more comfortably. [70]

The watch includes an extensive array of sensors for comprehensive fitness and health tracking. In line with the competitors' flagship models, COROS Vertix 2 incorporates the following sensors [16]:

- Optical Heart Rate Monitor
- Barometric Altimeter
- Accelerometer
- Gyroscope
- 3D Compass
- Thermometer
- Optical Pulse Oximeter
- Electrocardiogram Sensor

The Vertix 2 boasts one of the longest battery lives seen in a GPS watch. With standard full GPS tracking offering 140 hours and normal use extending up to 60 days. Even in its highest accuracy setting, all systems GPS with Dual Frequency, it promises up to 50 hours of use. This is especially significant when considering endurance events or multi-day expeditions, placing the Vertix 2 at the top of its class for battery performance. [5]

# 3 Self-Leadership and Behavioral Change

This chapter introduces the concepts of self-leadership and behavioral change by diving into their foundation through relevant literature and frameworks. The frameworks help place the concepts of self-leadership, IT-based leadership, self-efficacy and behavioral change in relation to each other. This supports building the understanding of the theoretical foundation of this study. Finally, this chapter introduces literature on the subject of behavioral change with IT systems, such as wearables.

## 3.1 Self-Leadership

Individuals use certain cognitive and behavioral strategies to control their behavior aiming on increased effectiveness. Furthermore these means are used to enhance performance by achieving self-motivation and self-direction. This process is called self-leadership. Self-leadership was introduced by Manz [44], with origins in the research and concept of self-management by Manz and Sims [46]. Self-management can be viewed as more day-to-day deeds to complete stated goals, whereas self-leadership includes a higher meaning and purpose to the completion [33]. The strategies of self-leadership are commonly divided into three categories, which are behavior-focused, natural reward and constructive thought pattern strategies [48]. Behavior-focused strategies are those such as self goal-setting, self-observation, reward and constructive self-criticism. Natural reward strategies create rewarding aspects to the task at hand. Constructive though pattern strategies aim on creating a more constructive thought process for the individual. This may be reached by e.g. positive self-talk, mental imagery, and identifying and replacing dysfunctional assumptions and beliefs.

Goal-setting has been shown to have a dramatic impact on motivating individual performance [43]. Sidwell [81] identified a cycle of challenge and performance in his research of ultra-endurance athletes. When an individual accomplished a goal, self-efficacy, autonomy and competence accrued and they ended up setting more challenging goals. He found the same thematic in the beginning of the running careers; the interviewees started from shorter distance races and gradually expanded

their kilometers with each accomplishment.

The self-leadership framework may allow individuals to develop effective habits for reaching their goals [45]. Neck et al. [57] found that self-leadership strategies focusing on behavior encourage desirable and suppress undesirable behavior. Moreover, feelings of competence and self-determination are enhanced with natural reward strategies. This may boost task-related behavior which enhances performance. Sidwell [81] found, that ultra-endurance athletes did not quit at setbacks, such as not reaching goals. Rather, they engaged in self-assessment, determined whether they have resources to reach the goal, realigned efforts and continued. It seemed in fact, that the challenge of the sport is a large part of the traction. In cases where natural or intrinsic rewards are lacking, external rewards may also be effective [49]. This is especially if the task at hand does not include intrinsically motivating factors. Nevertheless, natural reward strategies are typically preferable and more effective. Sidwell's [81] literature review concludes, that those who find purpose or meaning in tasks they set out to do, most likely perform better. While self-leadership strategies divide in three, they are seen to influence each another.

Self-leadership as a concept is often seen in organizational context research. As is typical to the business field, the concept is a normative model meaning it is prescriptive hence emphasizing on how something should be done. Vice versa, deductive or descriptive theories aim on explaining the means of a phenomena leaving little emphasis on the actual future implications or advice. [57]

Not all researchers see self-leadership should be separated as its own concept, but rather that it is indistinct from self-regulation [57]. Stewart et al. [83] suggest self-leadership is most fundamentally grounded in social cognitive theory [7], which includes triadic reciprocity as a concept. The foundational idea behind the concept is that behavior, cognition and the external environment are reciprocally influenced by each other. This suggests that behavior is influenced by both the external environment and internal mechanisms and vice versa. Furthermore, Neck and Houghton [57] argue self-leadership to be separate from personality trait factors such as extraversion and conscientiousness.

Neck and Houghton [57] aim on defining an operative context for self-leadership (see Figure 3.1). They define the relationship between different contexts, strategies and outcomes linked to the concept. The authors suggest self-leadership can be determined as its own consistency operating within the more descriptive frameworks of social cognitive theory, self-regulation, self-control and intrinsic motivation the-

ories. Moreover, they suggest utilizing self-leadership strategies produces certain predictable outcomes, such as self-efficacy, psychological empowerment, independence, commitment and creativity. These outcomes are suggested to result in better performance of the individual, team and organization.

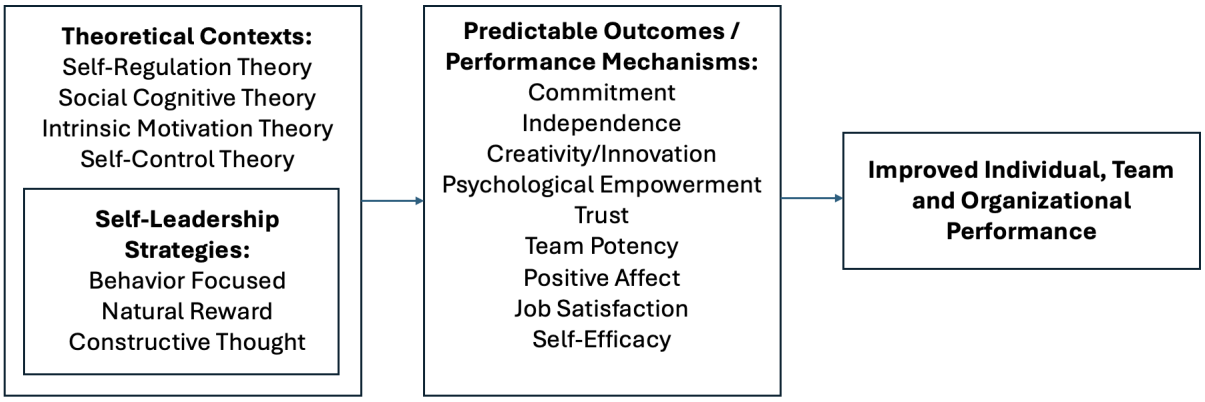


Figure 3.1: Relationships between self-leadership themes [57]

## 3.2 Behavior Influencers

The theory of planned behavior is a continuum to Fishben and Ajzen's [21] theory of reasoned action. The theory of planned behavior was originally published in 1986, after which Ajzen reinforced it in later research [3]. As can be seen from the Figure 3.2, the theory aims to predict and describe the reasons behind human behavior by mapping the relations between attitudes, beliefs, intentions and behavior. Intention is a central factor in the theory. It aims to describe the intention of the person performing the certain behavior and is seen to include the motivational factors behind behavior. Generally speaking it could be determined, that the higher the person's intention to act, the more likely they are to do so. The actual control of the behavior is generally described to be a combination of the person's motivation (intention) and ability (behavioral control), which refers to more external factors such as required opportunities or resources to perform the behavior. Yet in Ajzen's [3] model, this concept is not the 'objective' behavioral control, but rather the perceived control, which can be defined as the individual's "perception of the ease or difficulty of performing the behavior of interest". This view is closest to Bandura's concept of self-efficacy [7], yet this model places it into a more general framework.

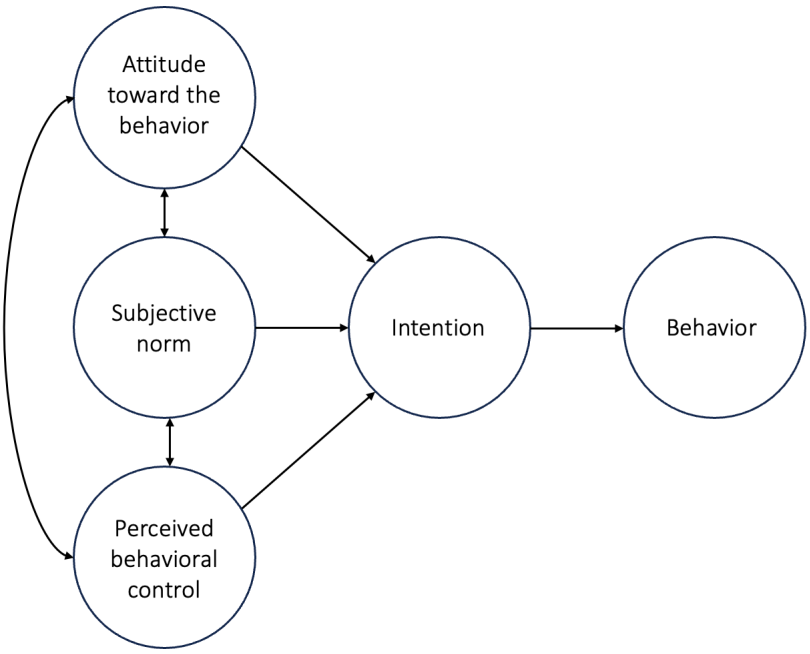


Figure 3.2: Theory of Planned Behavior. [3]

Depending on the situation and behavior, the relative importance of perceived behavioral control and intentions varies. The importance of perceived behavioral control grows as the control over the behavioral performance decreases. In the research, Ajzen [3] aimed to validate the theory by predicting behavior through the interaction of intentions and perceived behavioral control. He analyzed studies which dealt with a great variety of activity and concluded, that while multiple strong correlations that proved the hypothesis correct were found for different activities, one of the weakest predictions was in losing weight. In other words, whilst the intention to lose weight was major, the individuals did not succeed in the action in the same level.

As is visualized in Figure 3.3, Michie et al. [54] map opportunity, capability and motivation to be the three influencers that interact to generate certain behavior. In this context, capability is viewed as holistic capacity of an individual to engage in a certain activity. Necessary knowledge and skills are seen to be a part of this. Motivation is not only conscious decision-making and goals, but also all the meta processes behind the direct behavior. These are those such as avalytical decision-

making, habitual processes and emotional responding. Finally, opportunity may be seen as the external influencers, which prompt or enable behavior. The influencers are all interconnected, and work in both directions. This implies that for instance changes in opportunity may spark different behavior, yet also enacting a certain behavior may alter the three influencers.

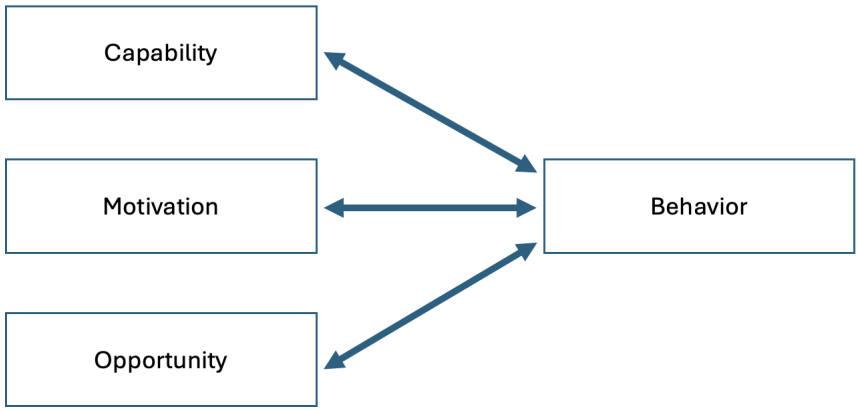


Figure 3.3: Behavior Influencers. [54]

Although this model is a model for explaining behavior, it may be seen to provide a ground for behavior intervention design. Interventions may alter the behavior system by changing one or more components. When addressing intervention planning, it is central to understand the behavioral target and what components of the system need to be altered to accomplish behavioral change. Mapping the wanted change under the components of the system helps in understanding the severity of the needed change; i.e. does it require small change in one component or perhaps major changes in all three? [54]

## 3.3 Comprehensive Model of Change

Prochaska and DiClemente [66] created a Comprehensive Model of Change originally to understand and treat addictive behavior. Later, the theory has been broadly adopted to other research fields and more broadly to explain phases of change. According to the study, successful change is accomplished through four stages, which are precontemplation, contemplation, action and maintenance. The stages cannot be treated linearly however, since most individuals do not progress that way, but rather in a cyclical manner involving relapse and new contemplation. Notably, dif-

ferent change processes are more effective towards individuals depending on the phase of their change journey. Figure 3.4 demonstrates the cyclical nature of the model and states the four stages of change including the main processes of change suggested for each stage.

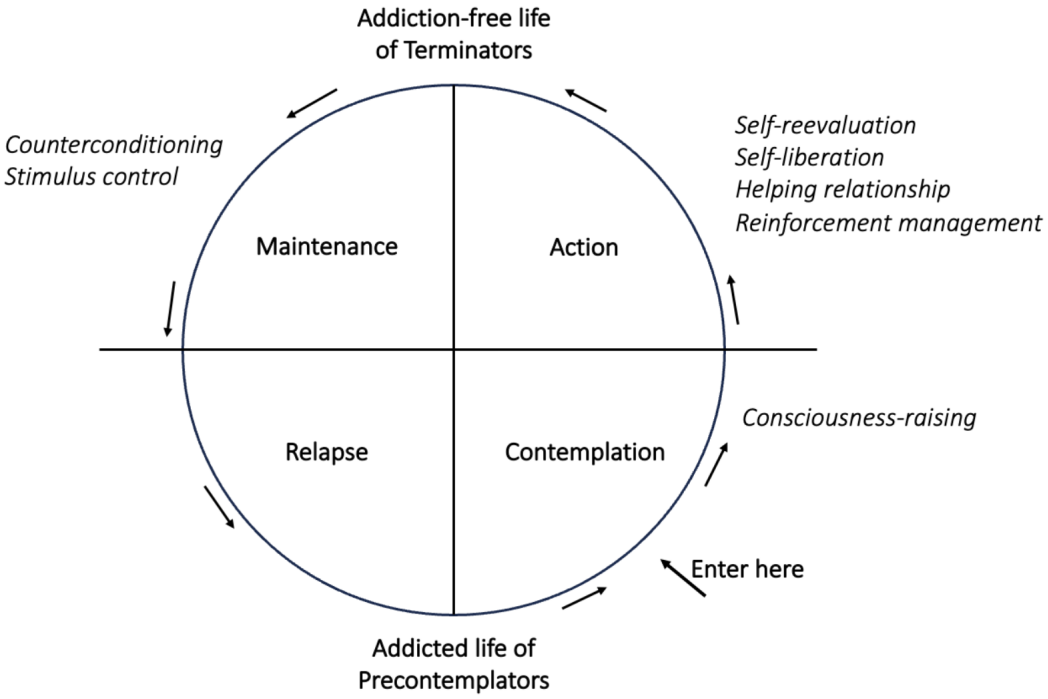


Figure 3.4: Comprehensive Model of Change. Adapted from [66]

In this model, the individual enters the loop when moving from precontemplation to contemplation. The precontemplation phase characterizes a state of mind, where the individual has no intention to change their behavior. This may be due to e.g. lacking confidence in abilities or being uninformed of consequences. Typically, in the contemplation stage, the individual has realized there is a problem and is pondering towards taking action to change the behavior. In this stage, the change process of consciousness-raising interventions including methods such as interpretations, confrontations and observations have been found as best approaches to support and help move the individual to the next stage. The methods can be self-lead or therapeutically lead. Self-reevaluation is the process between contemplation and action, where the individual assesses their values and often re-aligns them. Self-liberation is key to taking action, as it refers to the individual's belief they have

autonomy to change their life. This process has a strong link to self-efficacy with the addition that on top of the self-belief, also behavioral processes such as counter-conditioning and stimulus control are needed to stay in the course from action to maintenance and avoiding relapse. Building lasting change underlines setting a good premise for the maintenance phase, which includes assessment of possible relapse conditions and the continuation of counter-conditioning and stimulus control. The social aspect is critical throughout the stages of change. [66]

# 4 Wearable Activity Trackers in Behavioral Change

This chapter bridges together the concepts introduced in the previous chapters. First, the previous research around the motivation and benefits of using wearables is scrutinized after which the concept of self-efficacy is discussed in the wearable context. Finally, the concept of behavior change techniques is introduced and the implications in wearable context are looked into in detail in respect to the previous literature.

## 4.1 Motivation and Benefits of Usage

Jin et al. [39] identify 19 drivers of fitness tracking technology usage which can be categorized under four main themes. As is shown in Figure 4.1 these are user characteristics, device characteristics, perceived benefits or risks, and external drivers.


Figure 4.1: Outcomes of fitness tracking behavior. [39]

User characteristics are those such as age, personality traits, self-efficacy and current individual status and personal involvement. Device characteristics refers to device and data-related qualities such as attractiveness and functionality. Perceived benefits and risks stand for e.g. the user's experience of usefulness and ease of use. Finally, external drivers underline the social aspects as a driver. Notably, the literature review is narrowed from activity trackers to fitness trackers, as it does not take to account other than physical activities, such as sleeping. They define four main outcomes to fitness tracking, which are respectively task motivation and experience, physical activity level, and well-being or health. Reflecting to the previous literature

on the matter the authors point out that out of the fitness tracking outcomes e.g. health, activity level and motivation are consistently shown as positive variables. On the contrary, task experience and subjective health have more variability in the interpretations. The contradiction in task experience is that while some research shows that fitness tracking actually lifts the enjoyment of the fitness task at hand, some shows that the task may feel more work-like hence less enjoyable. Regarding subjective health, while several researchers have found fitness trackers have a positive effect on perceived well-being by e.g. establishing feelings of accomplishments, there has also been contradictory research that points out negative impact to e.g. happiness and satisfaction. Nevertheless, it should be taken to account that while findings on the positive side were published in many research papers, according to Jin et al.'s [39] study, Etkin [20] was the only one who delivered negative findings on the matters. De Moya and Pollund [56] found that wearables may also be a source of disempowerement in cases, where individuals hand out the power of decision-making regarding their health to the wearable. They argue that often in these cases, the individuals do not possess the motivation or capability to manage themselves. This holds within the risk of becoming a spectator rather than an actor in self-management.

Windasari and Lin [86] found that an individuals' perception of their health affects intention to use a wearable device. Based on the research it seems that interactivity is increasingly value-creating and important to individuals with low health-related self-efficacy. Furthermore they suggested that for individuals with high self-discipline, the wearable is more of a reminder or tracker meaning that implemented features such as interactivity would not have a major influence in decision making. Rieder et al.[74] were on the same lines determining, that positive reactions to the devices' propositions were more frequent by users who are driven by self-determination, self-improvement, and confirmation mechanisms. They found that in these groups, behavioral change happened also without the individual's intention.

It is seen that real-time feedback has the potential to reduce discontinuation of running by both reducing injury risk and improving motivation [36]. Moreover, Giraldo-Pedroza et al. [31] found in their broad literature review that the real-time feedback or in other words biofeedback given by wearables increases running performance. Especially positive peak acceleration was reduced with biofeedback. Furthermore, feedback on stride frequency and contact ground time and

speed helped decrease associated injury. Nevertheless, in their literature review, the authors found major variance in the results of the studies regarding the subject. They suggested this could be due to motor learning skills and the way of feedback delivery. The motor learning process is one main influencer in long-term changes of the running technique. In other words, the individual's capability to apply learning skills to different environments by listening to intrinsic biofeedback signals is crucial to sustaining change in e.g. gait.

Lehrer et al. [42] found a new behavioral self-leadership strategy implemented by both technology and users. This is social comparison, which refers to an individual acting in the context of others and forming a different perception of themselves. At best it works as a motivational factor for the individual to push beyond regular performance. An example of this would be seeing peers perform a certain activity more regularly and being motivated from that to engage in that activity more. It can also be seen that social comparison creates accountability and persistence in sticking with certain new habits. As the influences towards both motivation and accountability seem to be major, implementing social comparison as a behavioral change strategy in wearables seems something worth considering. Also Patel et al. [61] encourage social aspects in planning stickiness of wanted new behavior. They suggest social competition and collaboration as important links between technology and the user.

## 4.2 Self-efficacy in Wearable Behavioral Change

Self-efficacy is one of the perhaps most mentioned outcomes of influential self-leadership [57]. It is arguably of significant importance to self-leadership, since it may be seen to influence effort, thought-patterns, persistence, and aspirations. Prussia et al. [67] suggested that self-efficacy is a moderator for both work performance and self-leadership.

Self-efficacy is often characterized as "an individual's belief on their ability to perform a certain behavior" [7]. It is one of the dominant behavior-change theories [59] with original roots in cognitive psychology [7]. Already Bandura's [7] research finds the connection of self-efficacy and producing desired outcomes in behavior. Self-efficacy was lifted as significant when it comes to succeeding in pursuits. The research showed that high self-efficacy towards physical activity leads to higher likeliness of persevering with physical activity through obstacles. On the

other hand, it was argued that low self-efficacy impacts performance and confidence, since the individual will lack belief in their ability to perform. Moreover, through research, self-efficacy has been associated with the severeness of the effects of BCT's. More precisely, it seems that individuals with high self-efficacy towards the needed action are more likely to accomplish lasting behavior change. [60]

Rieder et al. [73] explore the behavioral and contextual factors behind long-term behavioral change raising self-efficacy as a major influencer on the phenomenon. Furthermore, they research how context influences the perception of self-efficacy and compliance of the wearable user.

In this context, self-efficacy can be divided into two streams: computer (wearable) self-efficacy and general self-efficacy. Computer self-efficacy refers to the user's belief of their capability to use a wearable device easily whereas general self-efficacy stands for the user's trust in their ability to perform tasks prompted by the wearable. Furthermore, self-efficacy has even been linked as a predictor of technology acceptance. [73] Oinas-Kukkonen [59] first proposed that self-efficacy is the link between the wearable-driven behavior change and the intervention component. Moreover, the research was the first to build and secure self-efficacy theory to be a significant theoretical foundation for wearables.

In the research to understand the link between self-efficacy and behavioral change leading to wearable compliance, Rieder et al. [73] separated compliance influencing internal and external context. External context can be defined as the factors in the surroundings (e.g. work, weather, time of the year) which influence the individual yet they typically have little control over. Internal context on the other hand refers to the individual's personal habits, emotions, and attitude. The authors found that while the external context was negative, the influence of the internal context could be either compounding or neutralizing, which was then the main definer to the individual's compliance on the wearable. For instance, if the user is committed to an annual goal (e.g. amount of run kilometers) the wearable is helping them accomplish, they found it easier to push through the negative external factors, such as bad weather. Interestingly, the authors found self-efficacy to be a variable tied to certain situations rather than a constant and stable measure: some context-specific behavior could show very low self-efficacy in one situation while the same individual could present high self-efficacy towards the same behavior in another situation. Sullivan and Lachmann [84] suggested that self-efficacy may also increase without specific targeting, if the user is consistently able to reach their goal. Figure 4.2 visualizes the

theory of Rieder et al. [73] to demonstrate the impact of internal context in neutralizing or compounding the negative external content.

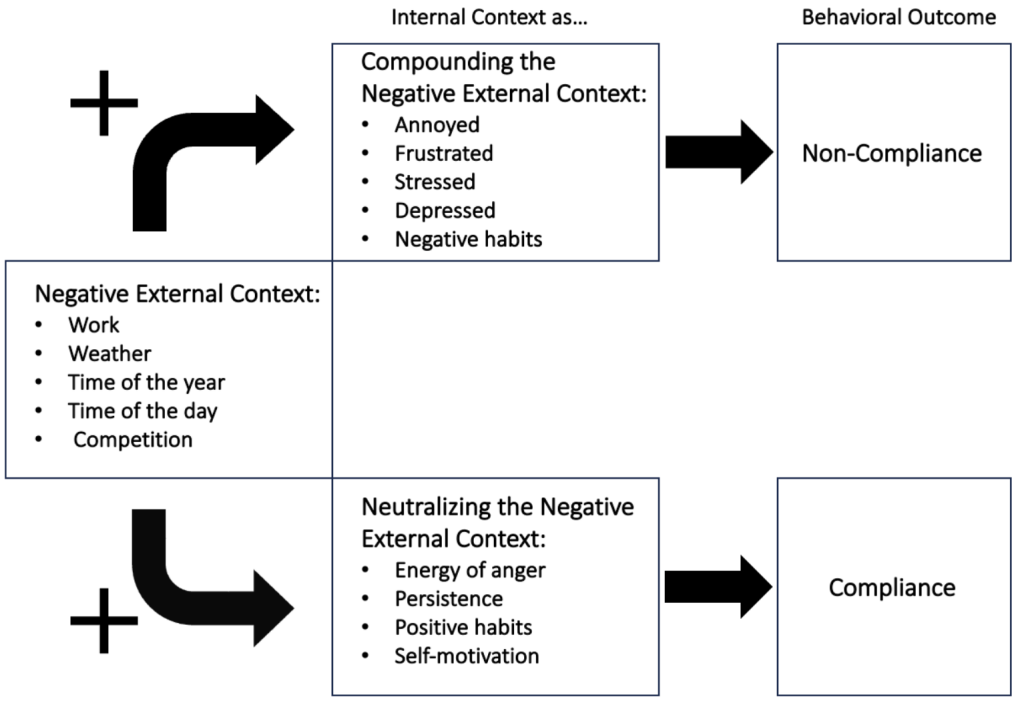


Figure 4.2: Impact of Internal and External Context [73]

Extrinsically sparked behavior is not typically found interesting by individuals, yet they still engage in such activities [76]. This may be due to the action being prompted, valued or modeled by others the individual feels related or attached with. When building lasting behavior change, which is affecting the individual to the deepest level, Ryan and Deci [76] found that supporting autonomy, competence and relatedness drove internalization and integration, which contributed to the wanted outcome. In other words, individuals must experience the wanted behavior as self-determined in addition to having competence and self-efficacy, in order to spark intrinsic motivation. On the contrary, amotivation results from the lack of these features.

## 4.3 IT System Behavioral Change

Wearables can be viewed as supporters of behavioral change which is, after all the goal of the systems. Oinas-Kukkonen [59] defines behavior change support systems as "socio-technical information systems with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception." In the research, two models are defined to better frame relevant research and design.

Table 4.1 demonstrates the Outcome/Change design matrix by Oinas-Kukkonen, which describes the likely outcomes of behavior change based on the influence of three different kind of Outcome and Change types.

Table 4.1: Outcome/Change Design Matrix [59]

| | C-change | B-Change | A-Change |
|---|---|---|---|
| F-Outcome | Forming an act of complying (F/C) | Forming a behavior (F/B) | Forming an attitude (F/A) |
| A-Outcome | Altering an act of complying (A/C) | Altering a behavior (A/B) | Altering an attitude (A/A) |
| R-Outcome | Reinforcing an act of complying (R/C) | Reinforcing a behavior (R/B) | Reinforcing an attitude (R/A) |

The matrix helps to understand the different levels and severity of behavior change that can be accomplished through IT systems. The outcome types are forming, altering, and reinforcing. The forming outcome refers to a situation where a situation is new to the individual and a new pattern of behavior is being built. In the situation of the altering outcome, change is sought to existing behavior. Finally, in the reinforcement outcome, focus is on making existing habits stronger and more resistant to change. Change is categorized A to C, where A refers to changes in attitude hence being most influential and difficult to accomplish. B stands for behavior change and C for complying, which is the lightest form of behavioral change, where the aim is in getting the user to comply to the guiding requests of the application.

Lehrer et al. [42] aim on identifying systematic behavior change accomplished with a wearable device. They define four use patterns stemming from self-leadership theory and their broad interview analysis. As can be seen from Table 4.2, the patterns leading to different outcomes in behavior are: following, ignoring, combining, and self-leading. Different use patterns incorporate different levels of motivation, IT- and self-leadership strategies leading to different behavioral outcomes.

Table 4.2: Wearable Use Patterns [42]

| Wearable Use Patterns | Motivation to change behavior | IT-based leadership strategies | Self-leadership strategies | Behavioral outcomes |
|---|---|---|---|---|
| **Following:** Following leadership strategies provided by the wearable | high | X | | Compliance change |
| **Ignoring:** Ignoring leadership strategies provided by the wearable | low | X | | No behavior change |
| **Combining:** Combining leadership strategies provided by the wearable with self-leadership strategies | high | X | X | Behavior change |
| **Self-leading:** Self-leadership supported by the wearable | medium | | X | No behavior change |

The first group, following, represents individuals highly motivated to change their health behavior, yet not having own ways of doing so. Hence, they comply with the wearable, giving the technology leadership of their behavior change. This group generally found the IT-based leadership strategies motivating and rewarding. The wearable worked as an external motivator from which continuous confirmation towards the actions was also sought. The second group had low motivation for behavior change due to external constraints. They show no change in behavior from using a wearable device. Furthermore, this group did not comply with the IT-leadership strategies, but rather ignored and even got annoyed with the prompts from the device. [42]

The third group had a high motivation for behavior change and acquired own self-leadership strategies to support wearable leadership strategies in the matter. Thus, they combined both leadership strategies succeeding in substantial behavior change. Individuals in this group were able to shift from wearable-dependency to self-leadership with the help of the device. They repeated the same pattern in behavioral change, from first responding to wearable prompts with compliance to initially developing a self-driven pattern of accomplishing the wanted behavior (i.e.

drinking water or walking a certain number of floors). In this use pattern positive reinforcement is underlined as an important influencer in turning IT-based strategies to self-leadership strategies. Users were able to turn the wearable's extrinsic motivation into intrinsic by slowly shifting from need of the immediate feedback from the device. Nevertheless, they relied on the device as a confirmation and objective proof of the accomplishments and additional incentive to perform. [42]

The fourth use pattern, self-leading, consists of individuals with strong self-leadership and no dependance in wearables for behavioral change. In other words, these users had high levels of physical activity or altered it with their own initiative, not based on the wearables' prompts. Nevertheless, the wearable was considered a good supportive tool for monitoring and optimizing sports activities and everyday life. For this group, it seemed that the wearable together with goal setting and self-observation, was one self-leadership reward strategy more. The wearable was even incorporated in the activity as a natural reward for performance. To conclude, the users of this group did not accomplish behavioral change with wearables, but used them actively to support own daily health initiatives. [42]

Lehrer et al. [42] found that wearables were in some cases able to transfer leadership from device to the individual hence, creating sustainable change. They explained how users could first follow the leadership strategy provided by the wearable yet over time internalize the strategy and not depend on the weararble to the same extent regarding the activity. Moreover, the authors found that personal motivation towards the action at hand influenced compliance towards the wearable. Toner et al. [85] suggest that in distance running, the relationship with the wearable is not fully compliant. Rather, being active users of the wearables, the individuals understood the limitations of instant data analytics. It was seen, that wearables cannot take to account external aspects such as weather conditions, the environment, the type of terrain, and the runner's physical state during a run. Hence, rather than blindly following the feedback from these devices, runners used their personal experiences and understanding of their bodies (i.e. somatic knowledge) to interpret the data. They decide based on this deep, intuitive body knowledge, choosing to either challenge or adapt to the information provided by their wearables. This approach highlights how athletes rely on their integrated understanding of the mind, body, and environment to determine the relevance and application of data, emphasizing a more nuanced interaction with technology.

## 4.4 Incorporated Methods for Behavioral Change

Wearable activity trackers incorporate behavior change techniques, which are designed to engage in use and influence the users' actions towards the better. A behavior change technique can be defined as "an observable and replicable component designed to change behaviour" [55]. For BCTs to be effective (= accomplish behavior change), they need to be well specified. Nevertheless, they are descriptors, implying that they vary in regard to the empirical context, situation and severity of possible change. Kim et al. [40] suggest that at best, engagement mechanisms produce total involvement which is a holistic experience enhancing the intention to continue use of the device. This is called the flow theory. Toner et al. [85] argue, that the incorporated algorithms have a major role in how data is presented, indicated, and organised to the user. This gives the algorithms power to influence users, and the participants in the study were able to provide examples of situations where they felt the devices had tried to nudge them towards a certain behavior.

The behavior change techniques commonly used in wearables were first mapped into a 26-item taxonomy by Abraham and Michie [1]. Later, Hagger et al. [34] developed CALO-RE taxonomy stemming from Abraham and Michie's original work. The taxonomy consists of 40 behavior change and is argued to be more comprehensive, less overlapping and to have less conceptual problems. The purpose of the taxonomy is to provide a common vocabulary for the integration of theory and practical implications of the mechanisms. The common ground enables a better comparability to versatile studies, which helps in proving specific links between theory and BCTs.

Behavior change techniques can be lead from IT-leadership strategies, which are self-leadership strategies implemented in wearables or other IT-systems. Lehrer et al. [42] found that leadership strategies may be and often are incorporated by both the users and the wearables. Looking from that angle, their comprehensive reasearch identified self-leadership strategies such as "goal setting", "observation", "punishment", "reward", "cueing", "positive talk", and "making activity more appealing" as mechanisms for changing the user's behavior with wearables. Furthermore, they identified social comparison as a behavioral strategy used in wearables. They found that all of these, excluding punishment and making activity more appealing were techniques applied in the wearable. Also Stephenson et al. [82] suggest that certain BCTs are better applicable to the IT-context. They found in their comprehensive literature analysis, when looking at only computer, mobile and wearable

components the most common BCTs were "prompts and cues", "self-monitoring of behavior", "social support", and "goal setting". Looking at BCTs to influence sedentary behavior as a whole, the most used were "instruction on performing behavior", "social support", "prompts and cues", and "adding objects to the environment".

Sullivan and Lachman [84] found that the most common methods used in wearables to drive behavior change towards increased activity and health are "goal setting", "self-monitoring", "feedback", "rewards", "social support", and "coaching". However, they suggest taking to account also other methods, such as "restructuring negative attitudes", "identifying obstacles", and "modifying environmental factors". Duking et al. [18] were in the same lines with their research reviewing five wearables to determine BCT's incorporated in the devices. They found that the wearables mostly incorporate the same techniques in line with the taxonomy, yet there was some variation in the amount of techniques applied. The most common techniques were respectively:

- "goal setting"
- "review behavior goal(s)"
- "feedback on behavior"
- "action planning"
- "self-monitoring of behavior"
- "discrepancy between current behavior and goal"
- "social support (unspecified)"
- "biofeedback"
- "prompts/cues"
- "social reward"
- "social comparison"
- "adding objects to the environment"

Mercer et al. [51] found nine mutual behavior change techniques in all the devices in the study. These were tied to own performance (e.g. "prompting focus on

past success" and "providing feedback") and social aspects, such as "providing information about others' approval or behavior" or "facilitating social comparison". It is important to note, that the behavior change techniques commonly found in wearables are more likely to appeal more to younger and middle-aged adults, whereas older adults may need more focus on techniques such as "overcoming barriers to physical activity". Notably, individuals may apply self-leadership strategies to fill in for situations, where the wearable does not provide behavior change features [42] Windasari and Lin [86] found that a high level of gamification and interactivity are more likely to engage to the continuous use of wearable devices. However, the authors suggest gamification and interactivity to be mutually exclusive, as they did not find signs of interaction between the two affecting enhanced use of wearables. In other words, it seems the two mechanisms work also individually.

Friel et al. [22] searched for correlations between sustained wearable engagement and device use characteristics. They found that those who reported running as their preferred exercise were more likely to keep using the device. Interestingly more so than e.g. hikers. Furthermore, those who had acquired a tracker to be able to monitor health variables were also more likely to keep using it. Another interesting finding was, that those who shared their data to social media, were more likely to sustain use, whereas sharing data in other ways did not have such a correlation.

Olander et al. [60] found that interventions towards obese adults slightly increased both self-efficacy towards physical activity and the activity behavior as such. Two techniques previously associated with self-efficacy effect were found to also increase physical activity behavior. These were "prompt self-monitoring of behavioral outcome" and "plan social support / social change". On the contrary, they found one technique, prompting generalization of a target behavior, to associate with both lower self-efficacy and lower physical activity behavior.

# 5 Research Methodology

The empirical part of this research was carried out through interviews with five ultra endurance athletes. The subsequent chapter describes and rationalizes the choices made regarding the research methodology and the selection of Interviewees. Additionally, it thoroughly examines the issues of reliability and validity within the context of this study.

## 5.1 Qualitative Case Study

Empirical research is typically categorized into two main approaches: quantitative and qualitative methods. Quantitative methods focus primarily on identifying how outcomes are determined with indicators or variables, which makes them a good fit for deductive approaches [8]. More accurately those approaches are of the nature where a theory or hypothesis justify the variables, purpose and direction of narrow research questions. Quantitative studies aim on using an objective process in projecting research findings on the larger population. Qualitative methods aim to describe, comprehend, and elucidate various phenomena in reality. Eskola and Suoranta [19] highlight key features of qualitative analysis, including the researcher's stance, adopting the viewpoint of those being studied, and the application of theoretical or judgmental sampling. Rather than verifying theories or hypotheses, qualitative research seeks to deeply examine specific events [35]. Common data collection techniques in qualitative research include interviews, observations, text analysis, and transcription [52]. Yin [88] defines qualitative case study as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context, especially when the boundaries between phenomenon and context are not clearly evident". This study is framed towards deeply understanding and clarifying the technology-related behavior of ultra endurance athletes, which implies qualitative case study is an appropriate choice. It focuses on exploring the hows and whys of the individual's actions rather than their frequency. Specifically, it seeks to identify particular behavioral attributes of the individual ultra athlete, rather than quantifying the action points. Qualitative analysis, which aims to por-

tray real life, treats subjects and phenomena holistically [4]. Although sometimes criticized for its reliance on small, potentially subjective sample sizes and the interpretive latitude it grants researchers, qualitative research uniquely allows for an in-depth exploration of participants' motivations and emotions, serving a distinct objective from quantitative research [50].

Fundamental in the qualitative research paradigm is the rejection of the notion that there exists a single, universally correct form of reality or truth. Rather, it adopts the viewpoint that reality is multifaceted and can vary for an individual depending on the context. This paradigm stresses that our understanding of knowledge is deeply rooted in the specific circumstances in which it is discovered or discussed. In other words, considering the environment in which data is collected, like during interviews, as well as acknowledging the influence of wider sociocultural and political factors is central in the research. Essentially, qualitative researchers maintain that it is crucial to interpret knowledge within the context of its origin, highlighting the interconnectedness between knowledge, context, and reality. [13] Considering the size and detail-orientedness of the material [35], case study as a research strategy is well suited for this study. It allows complex and difficult-to-measure phenomena to be explored in depth.

## 5.2 Data Collection

In qualitative research, interviews are a primary method for collecting data. They systematically compile information and typically fall into one of four categories: structured, semi-structured, thematic, and open. Structured interviews have predefined questions and answers, leaving little room for spontaneous dialogue. Semi-structured interviews allow for open-ended responses, providing some flexibility. Thematic interviews outline discussion topics but do not specify exact questions, enabling varied and in-depth conversations. Open interviews resemble casual conversations, with discussions flowing freely without covering all predetermined themes [19].

This study employs a semi-structured thematic approach to interviews. Such formats are particularly useful when the objective is to explore the 'what,' 'how,' and 'why' behind a topic, utilizing non-structured methods like semi-structured or in-depth interviews to uncover deeper insights [78]. The interview framework was built around four main themes, supplemented by additional questions. As noted

by Hirsjärvi & Hurme [35], the hallmark of thematic interviews is their open-ended questions. Flexibility was maintained during the interviews, with some questions being adapted, omitted, or reordered based on the interaction. A deliberate choice was made to allow conversations to flow more naturally, recognizing that not every interviewee needed to be asked the exact same questions due to varying company contexts. Adjusting the phrasing of questions enabled more relevant outcomes, thus embodying the characteristics of a semi-structured thematic interview.

Hirsjärvi and Hurme [35] state that there is no fixed rule for the number of interviews required in qualitative research. The adequacy of the number of interviews is reached when additional interviews cease to provide new, critical insights. In this study, the decision on the number of participants was thus based on an estimation of how many would provide a comprehensive understanding of the topic.

The empirical part of this study consists of five half-structured theme interviews. The Interviewees were chosen with consideration towards the subject, with the aim of building a holistic perspective to ultra endurance athletes (See Table 5.1).

Table 5.1: Interviewees

| Name | Age | Sport | Watch |
|---|---|---|---|
| Interviewee 1 | 28 years | Ultra running (trail) | Garmin Enduro 2 |
| Interviewee 2 | 39 years | Ultra running (trail) | Garmin Fenix 7 |
| Interviewee 3 | 52 years | Ultra running (trail) | Polar Grid |
| Interviewee 4 | 47 years | Ultra running (trail) | Coros Vertix 2 |
| Interviewee 5 | 34 years | Triathlon (all distances) | Garmin Forerunner 945 |

The approach is deductive, meaning there were set themes based on theory and existing knowledge, which were expected to find reflected in the interviews. All of the interviews followed the interview structure presented in Appendix A. The

interviews were conducted via Google Meets due to geographical distances and schedules. Each interviewee was reserved an estimated 45 minute time slot, yet some interviews durated to an hour.

To ensure a holistic representation, there were no further prerequisites towards the Interviewees besides being actively engaged in ultra endurance sports and using a wearable device. Whilst the sampling of five Interviewees is not broad, it should be recalled that the ultra endurance athlete field in Finland is not broad either. This range was seen adequate at the point when the interviews reached a saturation point where certain themes replicated in discussions. Hence, this sampling size was determined as a good starting point to develop a profound sense of how these athletes change their behavior with wearables.

## 5.3 Data Analysis

The primary data for the empirical section of this study was obtained from interviews, amounting to over 50 pages of transcribed speech formatted in Arial font size 12 with 1.5 line spacing. These interviews were carried out during the winter of 2024 and were transcribed with consideration - given that the focus of the research is on context rather than the characteristics of the interviewees and their speech, irrelevant filler words were omitted from the transcription. The interviews were originally conducted in Finnish, and only the direct quotations were subsequently translated into English.

The analysis of the data respectively followed the step-by-step framework introduced by Braun and Clarke [9]. The phases are:

- 'Familiarizing with the data'
- 'Generating initial codes'
- 'Searching for themes'
- 'Reviewing themes'
- 'Defining and naming themes'
- 'Producing the report'

Familiarizing with the data includes in this context the transcribing of the data. This transcription is not merely mechanical but an interpretive act that begins the

familiarization with the data. The second phase starts once the data has been familiarized, creating an initial list of noteworthy observations. It then proceeds to the generation of initial codes from the data. These codes highlight a specific aspect of the data (whether it is the explicit content or underlying ideas) that catches the analyst's interest, representing the simplest unit of data that can be meaningfully evaluated in relation to the studied phenomenon. Phase 3 is initiated once all data have been initially coded and collated, culminating in a comprehensive list of various codes identified throughout the dataset. At this stage, the focus of the analysis shifts from individual codes to the broader concept of themes. It entails the organization of various codes into potential themes and the gathering of all relevant coded data extracts under these identified themes. Phase 4 is initiated once a set of candidate themes has been established, involving the refinement of these themes. During this phase, it will be revealed that some candidate themes do not qualify as themes due to insufficient supporting data or excessive diversity within the data, while others may merge together (for instance, two seemingly distinct themes might actually constitute a single theme). In the fifth phase the essence of the themes is captured and named. Finally, the report is written in a sense that captures the nature of the data. [9]

## 5.4 Reliability and validity

While researchers aim to produce precise and error-free work, the reliability and validity of a study can differ, depending on the empirical approach. Reliability concerns the objectivity of the results, defining whether they stand independent of the researcher. Validity, meanwhile, pertains to how well the research method captures the intended factors. However, these concepts are more clearly applicable to quantitative research, as it is often argued that qualitative research may only partially meet these criteria. Due to its reliance on the subjective perspectives of individuals, qualitative research results are context-specific and could change if the study were repeated. In other words, reliability in qualitative studies can be compromised by factors like the interviewee's dishonesty, misunderstandings, or the researcher's potential bias in shaping the answers to fit a certain narrative, excluding anomalies. [35], [77]

To improve this research's reliability, efforts have been made to shape the process as transparent and straightforward as possible. However, generalizing the findings

beyond the scope of the studied field should be approached with caution, as broad applicability is not this study's goal. Arguably, with any study with such a small sampling size, the results require a larger sampling in order to be considered scalable. Hence, the focus of this study is on generating precise, in-depth insights and conclusions from a limited number of cases regarding the phenomena in question. The degree to which the findings can be generalized is, therefore, most likely small. Yet this is something readers must determine themselves.

Furthermore, it is important to note that the Interviewee group consists of only one triathlon athlete. Whilst this sampling provides results that imply this group may be viewed as one ultra endurance athlete group when it comes to behavior change with wearables, it is only a preliminary result. In other words making this kind of generalization would require a significantly larger sampling ranging from all different sports under the ultra endurance umbrella.

# 6 Empirical Results: WAT Behavior of Ultra Endurance Athletes

This section of the study presents the findings from the empirical research and integrates them with existing literature. The topics are examined in accordance with the primary research question and sub-questions to establish a cohesive perspective and make the structure clear to the reader. Ultimately, a theoretical model, which is derived from both prior literature and the results of this study, is introduced.

## 6.1 Relationship with the Wearable

Research shows that runners are more likely to use wearable devices in the long term (e.g. [22]). As can be expected, this seems to apply also to ultra sports, as each of the interviewees described that they always use their wearable activity tracker, which in this case was a watch (later on referred to as wearable or device). They recognized benefits in gathering the data without interruptions. In other words, they found it important they wore the device all the time, in order to get better data. When asked about the significance of the wearable, the answer was unanimous. Every interviewee felt it would be very hard to be without it.

> "Hard to be without it. I probably never will give it up. And don't see myself suddenly changing brand either."
> - Interviewee 2

> "When I've learned to live and be with it, it's just almost a part of me. Feel very naked without or if it doesn't for example work."
> - Interviewee 4

The interviewees had all used wearables for years and grown accustomed to them. While some interviewees characterized themselves as more traditional and not so data native, a group of data enthusiasts was also visible:

> "I remember when I started the workouts in high school, I used to write down my heart rate and times on a sheet of paper. So data has always been central. It's still fun to look at the old data to see how much I worked out before."
> - Interviewee 3

In line with Michaelis et al.'s [53] four main themes of user experience, the valued qualities fall under usability (including tech features and user interface), wearability and technological trust. For the majority of the group, Garmin was the go-to brand. The most important quality when choosing the wearable was the battery life-time between loadings, as the singular trainings and races may range from hours to over a hundred hours. One interviewee, whose device did not reach that battery life prioritized brand loyalty and familiarity over it. He described how he now always has a spare device with him in case the battery runs out of the main one. Other influencing technological qualities were GPS and use of maps, size and weight, music playing (= music playlists on device), and experience of reliability in metrics. Surprisingly, none of the interviewees mentioned having based their decision on the need or quality of specific metrics outside the listed, such as certain device specific indexes. This could imply, that the interviewees mainly use core metrics, which are pretty much standard to all devices.

The process of choosing a wearable did not seem to be a constant, large comparison of different devices. It rather seemed, that the previous device was abandoned when the battery life weakened or the technology otherwise felt outdated. Several interviewees mentioned, that once they had found a device that fills their requirements, it is easy to stay with the brand also in the future. This was mainly due to being familiar with the user interface and user experience, namely how the device works. This is in line with this study's device introduction, which showcased how similar the mentioned flagship models were in regard to functionalities, sensors, GPS-tracking qualities and battery life. In other words, as the devices in certain price ranges are relatively close to each other, there is not such an urge to switch devices in hope of better functionality. Hence, it may be expected that users are more brand loyal and familiar with a certain brand, having that add up to higher switching costs. Moreover, the experience of accuracy in data collection could be viewed as an influencer in brand loyalty.

Social context played a significant role in determining the choice of device. Importantly, recommendations were meaningful when they came from friends or ac-

quaintances involved in the same sport. In triathlon, it seemed common knowledge that a certain device series fit requirements best. One interviewee who was set on a less common brand in the Finnish market, stressed the friend's experience in the sport in building confidence towards the purchase decision.

> "My friend, an ultra-running guru, uses this watch and praised it. That's how I dared buy it. Friends' recommendations through the sport have influenced."
> - Interviewee 4

## 6.2 Functionalities and BCTs

The Interviewees followed a large amount of different metrics. On a daily level the most followed measures acquainted with recovery were sleep data, heart rate, and heart rate variation. In training data most interesting metrics depending on the workout were: distance, duration, climbed meters, and heart rate.

Data is a central factor in building the understanding of the fitness level and current condition. The Interviewees put in a lot of consistent training and many described how they compared previous data to understand their condition. For example, they could compare previous hill workouts to see the previous pace and heart rate. They could also run a certain route to see how their time and heart rate compared to that. It was also common to compare kilometers from a certain time period (e.g. weekly, monthly or yearly). The process seemed almost surprisingly straightforward and demystified; by putting in a certain amount of hours and well-planned training, the interviewees were sure of their capability to finish.

Moreover, the Interviewees mentioned several behavior change techniques they followed from their devices to at least some extent in their daily routines. Mostly in line with the literature (e.g. [84], [82]) the main BCTs mentioned were:

- Recovery index, Body Battery or other wearable specific indicator that gives a daily score and description on how well the user is ready to perform. The wearable bases the calculation on e.g. the activity levels of the previous day, sleep data and heart rate. [Self-Monitoring, Biofeedback, Providing Feedback]

- Recovery time or other calculation to indicate the amount of recovery time needed right after a certain physical activity. The recovery hour estimation

given after workouts is based on e.g. previous workouts, sleep and the intensity of the workout. [Self-Monitoring, Biofeedback, Providing Feedback]

- Goal setting lead by the user or the device. This may be incorporated in many places in the wearable. The user can set a goal time for a workout (and the wearable counts down to it during the activity), or they can have a daily target of e.g. floors to climb, or active minutes, set by the device or by themselves. [Goal-Setting]
- Training status or other measure indicating the balance between recovery and workouts to show if the fitness level is increasing or decreasing. [Discrepancy between current behavior and goal]
- Workout levels or other structure to indicate the toughness of the workout. This technique typically shows how many minutes the user have stayed in a certain heart rate zone to indicate the impact of the workout. [Biofeedback, Providing Feedback]
- Endurance score or other to indicate overall physical condition. This measure is more stable, describing long-term changes in condition. [Providing Feedback]
- Prompting workouts or other action to advise the user on what activity is recommended for the day.

Differing from the larger crowds, all interviewees stated that having a goal of steps per day was in no means interesting. Furthermore none of the interviewees followed daily steps and did not find any significance in that piece of data. This could be due to the activity levels being so high regardless.

## 6.3 Wearable Compliance and Behavior Change

The interviewees' interest towards the collected data varied to some extent. Some interviewees were interested in every bit of data, yet it seemed more like a habit than active compliance and action. De Moya and Pollund [56] discussed the risks of getting too acquainted with the device, hence giving the act of decision-making to the wearable. In line with this, most interviewees described a time in their past, when they had been too fixed on the device and reaching set goals; so much they

were only looking at the data and pushing past subjective signals of recovery in hopes of reaching better results. In practise this could mean complying with the devices prompts to complete a certain kind of training when the experienced readiness is not on that level. Interviewee two described how focusing on fixed metric goals could end up being harmful:

> "At some point it felt like Garmin was my best friend. Now I go more with my own feeling."

> "I now know better what I'm doing, so I don't need to view everything from the watch. Before I was too focused on collecting kilometers; it destroys motivation if you're too fixated on that. Then you start working out too hard when you should rest. It did more harm for me than good."
> - Interviewee 2

Manz and Sims [47] described that often, a person new to a task needs to build own confidence and constructive thought patterns by building upon positive comments from a superior. In other words, the support works as a surrogate to the person's own constructive thought patterns. When they develop experience, self-efficacy and self-leadership increase. Although this was in the workplace context, the similar pattern was visible in the experience with the wearable. Most interviewees described how the wearable had previously played a more central role in guiding action. As they gained experience, the interviewees trusted their subjective feeling and treated the wearable as one indicator.

Moreover, it generally seemed that BCTs in the wearable were at first followed with caution. Several Interviewees explained how compliance toward the certain BCT formed and grew when they noticed benefit from following it. This finding is supported by the finding that the main reason for not following the BCTs was lack of trust in the accuracy of the measure. One interviewee explained how he was very sceptical about the sleeping data, since there were times when he knew he had been awake yet the device showed sleep. Moreover, Interviewee 3 explained how his trust towards the device had lessened because of the large contradiction to the subjective feeling.

> "About the intensity level. I somewhat look at it, but I don't trust the device. There are periods that show overtraining. But if I've had a break from workouts for a month and after that continue with my regular system, the watch interprets that I'm overtrained. If I'd show the data to a friend they'd probably fall of the chair. My body and mind say other than the app (in those situations). (That is why) I look at it indicatively, but it won't change my plan."
> - Interviewee 3

These findings suggest that when the individual has enough experience and knowledge about their performance and recovery, the absolute measures such as heart rate, HRV, kilometers and climbed meters are more reliable than incorporated indexes that are calculated by the wearable. In other words, the person has taken self-leadership of the activity, and complies to the wearable behavior change techniques when they at least to some extent match the subjective feeling.

Compliance and dependence towards the wearable also during the workout seems to decrease as one becomes more routinized in the certain activity. A beginning runner may for instance look at the heart rate very frequently to ensure they are staying in the right performance level. This study however showed that these experienced athletes were more self-assured and trusted their own feeling of the heart rate in training. Nevertheless, when something changes in the internal context, e.g. having been in a flu or had a longer break for some other pressing reason, it may lead to watching the wearable more closely during the workouts. This was because experience showed that e.g. heart rates could jump in untypical ways after being ill.

> "I follow it all the time. More then I recognize. I scroll the morning data. Then when HRV starts to be off for longer, usually something is wrong. Usually I recognize what it's about. I'll take a day off if it's off for longer. After Covid I followed my heart rate a lot."
> - Interviewee 2

Certain compliance towards the devices was visible, especially when it came to measures such as heart rate, heart rate variation (HRV) and BCTs calculating recovery times. As Interviewee 2 in the previous comment, several interviewees mentioned how they follow their heart rate and HRV in the sense that changes in them will indicate a need for more rest. In a sense those metrics work as BCTs for this group.

Moreover, the BCT recovery time was an indicator Interviewee 4 said she was following now.

> "The watch suggests for example how many rest days should come after a tough workout. I might be for a long time in a situation where the watch says I should take it more easy. If I'd better fulfil the recovery times (the watch suggests), I would feel readier. When I know I don't need to be running the basic distance, I have felt more compassionate (towards myself). When the recovery times have been filled, I have felt more recovered in general."
> - Interviewee 4

Many of the interviewees reported they follow sleep data making sure they get enough sleep. Moreover they had noticed the quality of the sleep also implies suboptimal sleep. Interviewee 5 for instance explained how he consciously altered his behavior in workout timings, drinking alcohol and going to bed at a good time to perform better:

> "If I'd workout too late in the evening, it might impact my sleep quality. My body will be on overdrive, when it should be relaxing and falling to sleep. Alcohol impacts sleep, but so does staying up too late even without alcohol. The data guides me to better decisions in this."
> - Interviewee 5

It seems the behavior change built with the wearable is a combination of wanting to build good data and get better scores in the BCTs and knowing the good BCTs are what will enable one to perform at their best. Nevertheless the data did feel important to the Interviewees; several mentioned if there was a case, when they knew they were going to have a drink or two and stay out late, they would rather leave the watch home so they did not have the "bad data" in their statistics.

> "I might just leave the watch off my wrist now that I'm going to celebrate my friend's birthday, so it doesn't ruin my data."
> - Interviewee 2

Ultra endurance sports are generally viewed as something unreachable and almost absurd for the commoner. First reactions may be close to "I could never" and mental images of an ultra endurance athlete are most likely close to a super-disciplined,

goal-oriented, strict accomplisher. One interesting finding in this research group was that rather than being overly disciplined and strict to themselves, the interviewees seemed to have a certain flexibility and level of rationality in their training. This feature was also noticeable in the collaboration with the wearable; while the wearable may prompt certain workouts for the day, if the subjective feeling of readiness contradicted with the prompt, it was easy to not comply. This could be a result of experience and understanding of the long term.

> "If another day a fast run doesn't happen, it's that's it tättärää"
> - Interviewee 4

## 6.4 Self-leadership with wearables

All of the interviewees displayed a high level of both self-leadership and self-efficacy in their descriptions of their activities around their hobby. Self-efficacy was most present when discussing goals and readiness. The feeling seemed to build gradually through time, experience and accomplishments.

> "Confidence on the level a**hole. Even now I know that I'm ready for a 100 mile (race). I know by running a fast ten (km)".
> - Interviewee 2

Besides providing data, the wearable was able to provide a confidence and self-efficacy boost with a BCT, if it showed the best training status before the competition. Interviewee five described how normally the training status index never shows top levels for him, but after optimal training and lightening workouts before the race, his condition peaks and also the device knows it.

> "Often my coach knows how to do my training plan. When we lighten the training before a race, in the race week the training status (BCT in watch) is "Peaking" (the best status). This lifts my confidence before the race."
> - Interviewee 5

It seems ultra sports are a masterclass to self-leadership, as all three strategies of self-leadership were present in the interviewees' narrative. Out of behavior-focused strategies, self-observation and self-assessment were strongly present in most interaction with the wearable. One could even argue that collecting data from training and recovery is all about self-observation. Goal-setting was perhaps the most mentioned strategy. It was present as self-driven, wearable driven and wearable enabled. One most mentioned wearable enabled technique was placing a goal time in the device and counting towards it. Often in long races the goal time was to the next break spot. It could also represent the maximum finishing time to make sure the individual made it on time to continue.

> "In a race I can set the goal time in the watch. I set the goal time to be a few minutes under my own record. It was all the time as the pace setter. Ahead or behind, I ran according to that."
> - Interviewee 3

Goal-setting was present short and long term. In line with Sidwell's [81] findings of ultra endurance training behavior, also in this research many interviewees described how the desire to pursue longer distances grows at each accomplished distance.

> "When you get some distance (=finish a race) it feeds the need to add kilometers. When you fulfil a dream you start pursuing the next."
> - Interviewee 4

Other strategies that arose in the interviews were positive self talk and self-criticism. The latter was visible in the way interviewees described a time they had quit a race due to subjectively inadequate reasons. This was characterized as "quitting because of the head". One interviewee described how the amount of self hate and disappointment is something one does not want to face again. The other stated that at the point when he once quit and later realized the reasons did not feel adequate, he swore it was the last time. Perhaps representative of the common state of mind and on the other hand the toughness of ultra distance races is how several interviewees stated with a half-humoristic touch that quitting is acceptable only if one has an open fracture in a limb. Although this may sound rough, on the contrary positive self talk was a foundation in the race situation. Even so that Interviewees explained how they were able to block the pain from their mind and keep moving, as Interviewee 1 explains in the following comment.

> "You have to talk to yourself right internally. When the tone changes, you've lost the game. For example in a road race my feet hurt for twenty hours but my brains blocked it out. You learn to be with the pain."
> - Interviewee 1

Arguably self-leadership is best visible when the individual faces challenges with what they are trying to accomplish. All interviewees mentioned some disappointment in their ultra training or competing; having to postpone a set goal, quitting a race or getting injured and having to start rehabilitation. Also in this factor there seemed to be a sense of rationality and understanding that it is the "name of the game". A mutual factor for all was that the setback did not discourage them for a long time, but rather they almost used it as a motivation and turned it into an opportunity. In other words, the Interviewees used constructive thought patterns, positive self talk and self observation to restructure their mind and recover from the setback.

> "I had a time goal of 90 min for the half marathon but the end of the race didn't work out because my calf cramped. Had to slow down and stop, finishing a minute or two over (the goal). I felt so disappointed. That's what it is. The goals are possible but you can't always reach them. I was really disappointed with having to move attendance to the full Ironman. Started training a year in advance for that but broke my collarbone a few months before. In a way it strengthens willpower if something is left undone or you face an obstacle. "Here I come in even better shape at some point". It gives motivation. It (success) could be dependant on to the smallest detail."
> - Interviewee 5

Natural reward strategies are described in literature as internal methods that make the task at hand rewarding as such. In the lines of Sidwell [81], also results from this study imply races and tough workouts are a natural reward for the Interviewees as such. As Interviewee 1 explains, the race works as a reward and motivator for the workouts:

> "My biggest motivation comes from the races. It's a lifestyle. I get so much from training. I don't want to just accomplish. Finishing the 100 mile was the accomplishment, now I seek adventure. In order to get to

the race, I have to have the physical condition and those feet."
- Interviewee 1

Interestingly, the hunger for new goals did not seem to extend infinitely. Rather at some point, when many race distances had been accomplished, several Interviewees mentioned it was more of a lifestyle and habit to train and race. This could imply the significance of the performance-set goals is larger when the individual has not yet truly absorbed the activity as a routine or habit.

"When you've accomplished the goals you've set, when it becomes a lifestyle it isn't a "must do". It's a part of you, not something you go towards. When some habit is formed it is easy to upkeep. If I now decided to run a marathon, I would need to change my workouts, run faster."
- Interviewee 4

## 6.5 Social mechanisms with wearables

Lehrer et al. [42] defined social comparison as a new self-leadership strategy applied by both individuals and wearables. The social context was also emphasised in many other researches as a central influencer to successful behavior change (e.g. [39], [66], [61]). Also in this research, the significance of social was central in building motivation for training, persevering in races sticking to workout routines. Although both triathlon and running are individual efforts, one interviewee explained how although she might begin the race alone, most times during the event she will notice the pace is the same with someone else and they end up running together. Other interviewees mentioned they have a certain group they run races in. Interviewee 1 described preparation as follows:

"Social context is also a source of motivation. I don't want to do it to the team that I haven't prepared properly. If I see (from the Strava data) that others train but I don't, it motivates me to get moving."
- Interviewee 1

One Interviewee explained how the company in the race helps tackle internal voices that start to emerge at some point in ultra distances. Another described how at some points in long races there comes a time when one will just persevere through the

tough patch by staring at the back of the friend running in front and deciding to keep moving forward.

Having workouts visible to the friend group or coach were a motivator to some. All Interviewees used the online social platform Strava, where all of their workouts were automatically visible. There they could choose who to follow. Several Interviewees mentioned how it was helpful to collect training tips and understanding from others targeting same goals. One interviewee recognized motivating others as a driver for her to share the data to Strava. She wanted to showcase the beautiful nature she ran in, take photos and add them on the routes and share the trails she is running on so others could also run them. Another motivation for sharing the data was to show that although she runs races that are several hundred kilometers, her workouts are not always excessive.

> "It feels so good when someone says "you have been my idol in this". I want to show you don't need to be a super human; just decide what you start heading towards"
> - Interviewee 4

## 6.6 Future development

Most Interviewees had a hard time imagining what further functionalities they could wish from wearables. Rather, they wished for development of existing qualities, such as better accuracy in estimating readiness for workouts and training impact. One Interviewee stated the device could generally be more intelligent, while another discussed how it could be interesting to have the watch as a more holistic health device, integrating qualities such as blood values to the calculations. Since technologically many things are already possible, it is arguably more the question of which features truly provide added value and to which customer groups. On the other hand, the findings of this study imply most of the Interviewees are not severe tech enthusiasts who treat wearable features and updates with passion. Therefore, it is not surprising that asking from the Interviewees was not a source of innovative development directions for the wearable technologies. As in design methodology based user interviews, a more fruitful strategy is to understand the user, their actions and technology. Based on that, it is possible to define areas where the future directions lie.

Looking from the self- and IT-leadership perspective, in consideration with this

research it does seem there would be room for generally more intelligent and also more wearable-facilitated behavior change techniques. The BCTs seemed to focus most on the behavioral strategies, while they could also emphasize natural reward and constructive self talk. For instance, Houghton and Neck [37] explain how changing scenery or focusing most on certain, most pleasant areas of the task could help in increasing performance. The device could for example learn from the users routes and collected metrics, which routes the individual performs best on and what are their strengths compared to others. It could then give suggestions and nudge the individual toward these surroundings, where natural reward may exist.

Also generative and conversational artificial intelligence advancements provide opportunities for wearable devices. Looking at how the Interviewees used the devices, there could be opportunity in incorporating conversational aspects to the user interface. This could mean for instance conversational voice commands, i.e. asking the device to retrieve some data and voice it. Moreover, this could be taken to the level where the device is mainly used via speech and the AI is then the coach or training partner, guiding in the daily activities and workouts. The AI could during the workouts voice details of the workout compared to the set targets or previous workouts. The social aspect cannot be undermined, as it was central also in this study. The generative and conversational AI is in fact a way to create a feeling of social interaction with technology. While a lot of the social aspect on this ultra level of training is on Strava, especially for those who are not as engaged in sports, it could be worth reviewing social opportunities in the devices' applications. There could be opportunity in e.g. developing friendly competition opportunities, or in forming groups of individuals with certain commonalities to discuss, comment and like eachothers activity behavior. Moreover, looking at the accessibility of the devices for those who do not yet use them, the conversational AI could create an easily accessible interface. In other words, the AI could feel like a coach, which can bring a new level of accountability and commitment to using the device and complying.

# 7 Discussion and Future Work

This chapter bridges together the theoretical and empirical parts of the study by reflecting the major themes that arose in the empirical part to relevant theory. Furthermore, this chapter introduces potential future research areas.

## 7.1 Discussion and Findings

The understanding of how wearables affect the behavior of ultra endurance athletes remains a topic of little research. Whilst the wearable behavior change of larger populations and certain groups (e.g. obese adults, diabeticians and other therapy groups) have been researched with contradictory evidence of sustainable change, the results of this study imply that ultra endurance athletes are a group that differs from the mentioned in habits and motivators of use. Moreover, this group exhibits high levels of self-leadership and seem to successfully turn IT-driven leadership to self-leadership. This is why this segment of elite athletes is highly interesting in understanding mechanisms behind how wearables can develop positive and lasting change to health-related behavior.

All of the interviewees displayed a high level of both self-leadership and self-efficacy in their descriptions of their activities around their hobby. Self-efficacy was most present when discussing goals and readiness. Nevertheless, the performance-set goals did not exceed indefinitely but rather a pattern was noticeable. The individuals felt the sport was a lifestyle rather than an endless "from goal to next" set of achievements. Overall it seemed, that rather than being overly disciplined and strict to themselves, the interviewees seemed to have flexibility and rationality in their training. Reflecting against Oinas-Kukkonen [59] matrix of outcome/change, this could be an indicator of the highest form of change: change in mindset and attitude. In other words the interviewees described sustainable behavior change in their commitment towards the sport as such. Moreover, the evidence implies the wearable has been in a major role in supporting the engagement growth towards the sport. This implies that the interviewees have been able to use the wearable in altering habits, leading to the outcome of the sport becoming a way of living.

From the ultra endurance perspective, it seems the watches play a major role, not just in the fitness tracking, but in the holistic data gathering and feedback for the individuals. Based on e.g. the marathon running event research of Pobiruchin et al.[62], demonstrating that over 70% of the over 900 participants used wearables at the event and listening to the Interviewees of the study, it seems that the likeliness to be very engaged with wearable technology grows when the severity of the sport engagement grows. This suggests, that ultra endurance athletes can be viewed as an elite user group for wearables, as they are often heavy and engaged users of the devices. All of the brands used by the interviewees have flagship devices similar to each other, which can be seen to strengthen brand loyalty, as users are not urged to switch in hopes of better functionalities. Contradicting from Obganufe and Gerhart's research [58], whilst being very advanced wearable users, the Interviewees did not report to actively exploring new ways of use. Also considering the acquisition of the device, none of the Interviewees seemed to be wearable enthusiasts in the sense they would always be upgrading to the newest device when it is aired in the market. Nevertheless, the wearable was viewed as something very central, even a part of self and identity. Hence, a key finding is that the wearable may be a part of identity and central in everyday life, yet it does not require technology enthusiasm and interest in owning the newest devices.

Another key finding is that ultra endurance athletes seem to use and rely on different features than the large audiences. The behavior change mechanisms utilized by the research group were categorizable behind feedback, goal-setting and to some extent prompts. Methods identified by Duking et al [18], such as cueing, reward and social comparison or reward were not mentioned. Furthermore, the literature raised importance of overcoming barriers to physical activity [51], making activity more appealing [84], and using gamification and interaction [86]. Moreover, Patel et al. [61] found the incorporated engagement strategies such as social competition and collaboration, rather than technology features to be key in determining successful change. This could imply that whilst the previous research on the mechanisms focuses on the larger population, ultra endurance athletes are less driven by external reward and motivation. In other words it seems, that individuals with high internal motivation and capability toward the activity they are using the wearable for are most interested in monitoring self-set goals and understanding the performance data. This is in line with the research of Windasari and Lin [86] suggesting that features such as interactivity do not have such a major influence in decision making

when the individual possesses high self-discipline.

As a central finding, this research suggests that wearables do influence behavior in this target group. Most visible behavior change in this group was mentioned in sleep behavior, alcohol consumption and changing fitness behavior when wearable shows signs of illness. They were small alterations to gradually improve the data and BCTs found important. While in the larger populations the goal is often in decreasing sedentary behavior (as explained by e.g. Stephenson et al. [82]), for ultra endurance athletes the device works more in restraining excessive training and building motivation for resting and recovery. This is in line with the finding of Windasari and Lin [86] indicating individuals with high self-discipline would use wearables more as reminders or trackers. Previous literature underlines as downsides to constant wearable use feelings of disempowerment from experience of constant judgement and surveillance [56] and activities becoming more work-like hence less enjoyable [39]. The Interviewees seemed to experience the similar effect to some extent. It seemed central to keep the BCTs important to self as good as possible. Nevertheless, it seems the Interviewees kept their balance by leaving the wearable home in the rare occasions of a night out that would cause a discrepancy in the data. This could imply that the healthy relationship with the wearable is best sustained when leadership is behind the individual, not the wearable.

Lehrer et al.[42] observed how leadership strategies can be transferred from technology to users. They explained how technology may be an effective way to develop personal self-leadership strategies through time, when the users depend less on the device when the strategy is familiarized. In line with these findings, the Interviewees demonstrated having adopted certain wearable-driven behavior into self-driven. Central examples of this were following the heart rate while training, looking at sleep patterns and observing training readiness. While growing more accustomed to the activity at hand, the reliance on the device decreased. While it was still significantly important in distributing the training data as a whole, during the training session the interviewees were able to rely more on their subjective experience. This finding implies that the wearable is most crucial in the beginning of changing a behavior. Moreover, sustaining the change requires learning and being able to lead the activity.

Looking at Prochanska's [66] theory of change phases, deferring from the large populations it seems ultra endurance athletes are less likely to relapse due to external reasons. This research suggests that in this context, the athletes are likely to

relapse from their wanted goals (= and the mapped change actions it would require) only in cases where it is dangerous or otherwise absolutely out of their hands to continue. In other words, strong internal motivation, habit and self-leadership support the maintenance of a certain action. As Ajzen [3] found, strong intention does not always result in strong results regarding change. Moreover, taking to account Rieder et al.'s [73] research on how internal context neutralizes external context leading to compliance, this research shows in the same lines that the Interviewees saw external challenges as irrelevant. The research showed that not complying was most to do with absolutely not having time, facing injury, or knowing better based on own experience than the device at hand. This would suggest, that ultra endurance athletes are better than average in leading their behavior and avoiding negative external context with the help of the wearable. Hence, this suggests a strong connection between self-leadership, wearable use and behavior change.

Based on the theoretical foundation and empirical findings of this study, Figure 7.1 is suggested to define the relationship between the themes related to behavior change in the context of ultra endurance athletes.

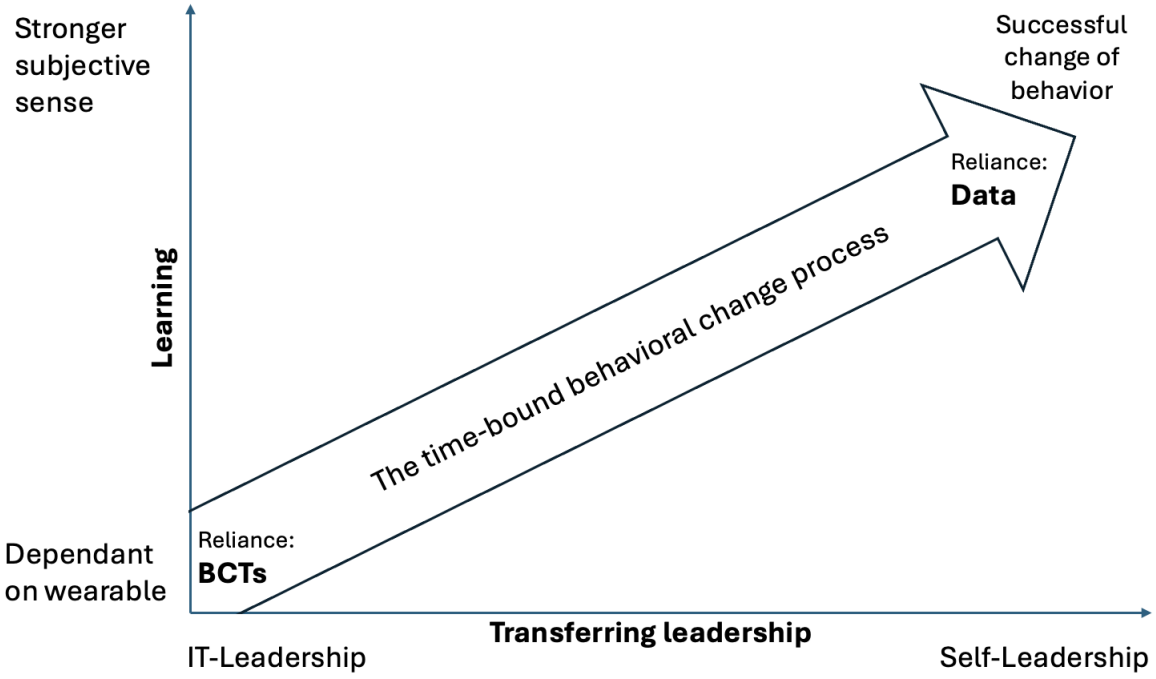


Figure 7.1: The Change Process with Wearables

The Figure concludes the findings of this study suggesting that sustainable change

with wearables is achieved through learning with the wearable and being able to transfer leadership of action from the wearable to self. Moreover, in the beginning of the change initiative, the individual is more dependant on the wearable (e.g. checking often what the heart rate is). When they have adopted the new behavior, they are more likely to be able to trust their subjective feeling more (e.g. not needing to check the heart rate because they feel they know they are in the right zone). What is more, reflecting from the literature to the interviews of this study, it seems the BCTs in the device are most important in the beginning of the behavior change initiative. When the individual becomes routinised with the wanted action (= achieves behavior change), the results suggest they are more interested in the data as such. It is important to note that this model is repetitive, implying the athlete goes through this path with each behavior change initiative with the wearable. Arguably, the smaller changes may add up to support one larger change, for instance in this context the building of ultra endurance sports as a lifestyle.

Finally, this research underlines, in the same lines as several BCT (e.g.[82]) and behavior change studies (e.g.[42]), the importance of social context in creating change. Virtually and in real life, it seems to be a crucial motivation builder. In this research group it seemed there was not major significance in whether the social was actually live or through virtual channels. Hence, it seems to be a major opportunity to increase the amount of social features in the wearables.

## 7.2 Future Directions

This research was pioneering in investigating how wearables act in creating sustainable behavior change for ultra endurance athletes. Whilst behavior change with wearables for versatile subject groups has been researched to date, the results of sustainable change still remain contradictory in the academia. The results of this study give promise, that the ultra endurance viewpoint could bring an interesting angle of further research also. This group of ultra endurance athletes provides an interesting perspective to how wearables are used at best, when the user is very engaged to the device.

As this research was limited to a relatively small group of Interviewees, one logical direction would be to extend the research to a larger sampling size. This could provide interesting insights to how the results scale into a larger audience. Additionally, it would be important to extend the group of triathlonists to validate

whether ultra endurance athletes may in fact be generalised to one group in this context. It would also be interesting to investigate taking to account other type of ultra endurance athletes, such as ultra cyclists. Moreover, in addition to qualitative research, a quantitative research with a large sampling size could be fruitful in validating initial findings from this research.

Looking at the ultra endurance athletes as a user group, it could be interesting to extend research to how they actually use the wearables on a user interaction level. This could help in creating evermore intuitive and usable wearables. Moreover, looking at the opportunity generative and conversational AI brings, it would be interesting to investigate the opportunity via research towards the ultra endurance athletes.

# 8 Conclusions

This research aimed on understanding how ultra endurance athletes accomplish change with wearables. Finding a holistic viewpoint to this question required certain subquestions. It was crucial to understand which qualities in wearables are important to the ultra endurance athletes and what kind of behavioral change do they accomplish with wearables. Moreover, the research set out to discover which wearable behavior change mechanisms were most effective and how could wearables be developed in the future. This is a qualitative case study, where five athletes were interviewed in a half-structured thematic interview.

Mirroring the results of this research it is evident that wearables impact, alter and change the behavior of ultra endurance athletes. The behavior change techniques most important for the Interviewees were categorizable to feedback, goal-setting and prompts. Yet, while for the larger population behavior change techniques may pay a more significant role, for the ultra endurance athletes it seems the data itself is the most important value of the device.

Most clearly, change was created and sustained with wearables in areas such as sleep behavior, alcohol consumption and exercising when the data implied illness. Moreover, it could be said the wearables had been helping these athletes in turning the sport to a lifestyle. Hence, referring to the larger discussion around whether wearables are able to create change, based on this preliminary research the answer would be that in the ultra endurance athlete context, yes. This research shows that the change initiative begins from the user's own spark and intention. When the individual is novel to the activity they want to enhance, the wearable may function as an extended, external motivation bringing objective data and insights to the user. Nevertheless, unless the user is able to turn the external motivation into internal, transferring IT-lead to self-lead leadership, it is highly unlikely that behavior changes. In the context of this research the task seemed easier, as none of the Interviewees were reaching for a goal they would have found profoundly difficult.

The wearable is an external motivator that can significantly support the act of changing behavior. Nevertheless, depending on how large the wanted behavior change is, sustainable change arguably requires internal motivators, self-leadership,

self-efficacy, and supporting external factors to happen.

Ultra endurance athletes are a fascinating group of individuals when it comes to self-leadership, mental toughness, discipline and tolerance. They are very likely to own a wearable activity tracker and use it in a disciplined manner day and night to record all their physical activities, sleep and other biofeedback. Yet this research shows that the relationship with the device is more complex and interesting than that. On the one hand, the wearable is an extension of self, a large part of identity and something that almost ruins a workout if it runs out of battery. On the other hand, the device, data, and behavior change techniques are treated with precaution and filtering. This is visible as certain caution and almost distrust if the personal feeling is at all contradicting from the data. Nevertheless, collecting as good data as possible is important; even to the extent where knowing own actions will lead to bad data, it is better to just leave the device off the wrist. Interestingly, the Interviewees were rather laid back with the whole sport as such. It was a way of life, as was the wearable also.

In other words, the main questions behind successful and lasting behavioral change are "Why do I want to change?", "Do I believe I have the capability to change?" and "Do I have the knowledge and tools to change?". Most likely, the wearable activity tracker will not be the main creator or at least sustainer of change, but it can be an important tool and knowledge provider. It can help enforce and support change if the individual has the mindset and favorable external circumstances and features to create it.

# References


[1] ABRAHAM, C., AND MICHIE, S. A Taxonomy of Behavior Change Techniques Used in Interventions. *Health Psychology 27*, 3 (2008), 379–387.

[2] ACCENTURE. How can leaders make recent digital health gains last? URL `https://www.accenture.com/us-en/insights/health/leaders-make-recent-digital-health-gains-last`, referred 13.6.2023.

[3] AJZEN, I. Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes 50* (1991), 179–211.

[4] ALASUUTARI, P. *Laadullinen tutkimus 2.0. NeljÃ¤s, uudistettu painos.* Vastapaino, Tampere, 2011.

[5] ALGER, K. Coros Vertix 2 review: The biggest battery in town. URL `https://www.wareable.com/sport/coros-vertix-2-review-8570`, referred 29.3.2024.

[6] BALDASSARRI, S., DE QUIROS, J. G., BELTRAN, J. R., AND ALVAREZ, P. Wearables and Machine Learning for Improving Runnersâ Motivation from an Affective Perspective. *Sensors 23*, 1608 (2023).

[7] BANDURA, A. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review 84*, 2 (1977), 191–215.

[8] BORREGO, M., DOUGLAS, E. P., AND CATHERINE T. AMELINK, TITLE = QUANTITATIVE, QUALITATIVE, AND MIXEDRESEARCH METHODS IN ENGINEERING EDUCATION, J. . J. Y. . . V. . . N. . . P. . .

[9] BRAUN, V., AND CLARKE, V. Using thematic analysis in psychology. *Qualitative Research In Psychology 3*, 2 (2006), 77 – 101.

[10] BROPHY, K., DAVIES, S., OLENIK, S., COTUR, Y., MING, D., NEJRA VAN ZALK, DANNY O'HARE, F. G., AND YETISEN, A. K. Blurring Boundaries Between Humans and Technology: Postdigital, Postphenomenology and

Actor-Network Theory in Qualitative Research. *Qualitative Research in Sport, Exercise Health 13*, 1 (2021), 26–40.

[11] BROPHY, K., DAVIES, S., OLENIK, S., COTUR, Y., MING, D., NEJRA VAN ZALK, DANNY O'HARE, F. G., AND YETISEN, A. K. The future of wearable technologies. *Imperial College London 6* (2021).

[12] CAREY, R. N., CONNELL, L. E., JOHNSTON, M., ROTHMAN, A. J., DE BRUIN, M., KELLY, M. P., AND MICHIE, S. Behavior Change Techniques and Their Mechanisms of Action: A Synthesis of Links Described in Published Intervention Literature. *Annual Behavioral Medicine. 53* (2019), 693 – 707.

[13] CLARKE, V., AND BRAUN, V. *Successful Qualitative Research: A Practical Guide for Beginners*. Sage, Thousand Oaks, CA, 2013.

[14] COHERENT MARKET INSIGHTS. Major players - Fitness Tracking Industry. URL https://www.coherentmarketinsights.com/blog/insights/major-players-fitness-trackers-industry-2152, referred 3.3.2024.

[15] COROS. Coros - About Us. URL https://coros.com/about, referred 29.3.2024.

[16] COROS. Coros Vertix 2. URL https://coros.com/vertix2#spec-detail, referred 29.3.2024.

[17] COX, R. Ironman Demographics: Overall Competitors. URL https://www.coachcox.co.uk/ironman-demographics-overall-competitors/#:~:text=Although%20there%20were%2084%2C000%20Ironman,course%20of%20racing%20in%202019., referred 3.4.2024.

[18] DUKING, P., TAFLER, M., WALLMANN-SPERLICH, B., SPERLICH, B., AND KLEIH, S. Behavior Change Techniques in Wrist-Worn Wearables to Promote Physical Activity: Content Analysis. *JMIR MHealth and UHealth 8*, 11 (2020).

[19] ESKOLA, J., AND SUORANTA, J. *Johdatus laadulliseen tutkimukseen. 6. painos.* Gummerus Kirjapaino Oy, Jyvaskyla, 2003.

[20] ETKIN, J. The Hidden Cost of Personal Quantification. *Journal of Consumer Research 42*, 6 (2008), 967–984.

[21] FISHBEIN, M., AND AJZEN, I. *Belief, attitude, intention, and behavior: An introduction to theory and research.* Addison-Wesley, Reading, MA, 1975.

[22] FRIEL, C., CORNELIUS, T., AND DIAZ, K. Factors associated with long-term wearable physical activity monitor user engagement. *Transl. Behav. Med. 11*, 11 (2021), 262 – 269.

[23] GARMIN. Company - About Us. URL https://www.garmin.sa/company/about-garmin/, referred 15.3.2024.

[24] GARMIN. Enduro 2. URL https://www.garmin.com/fi-FI/p/854515/pn/010-02754-01, referred 18.3.2024.

[25] GARMIN. Fenix 7. URL https://www.garmin.com/en-US/p/735611/pn/010-02540-00, referred 18.3.2024.

[26] GARMIN. Galileo Satellite Network for Automotive Devices. URL https://support.garmin.com/en-US/?faq=YXd153clB76LEPOaWA2799, referred 15.3.2024.

[27] GARMIN. Garmin Technology - Wearable Science. URL https://www.garmin.com.sg/minisite/garmin-technology/wearable-science/heart-rate/, referred 15.3.2024.

[28] GARMIN. Running - Forerunner 945. URL https://www.garmin.com/fi-FI/p/621922#specs, referred 15.3.2024.

[29] GARMIN. What is GLONASS? URL https://support.garmin.com/en-US/?faq=GvYAvElyJN1XErPJevmbJ7, referred 15.3.2024.

[30] GARMIN. Wireless Sensors. URL https://www8.garmin.com/manuals/webhelp/GUID-C001C335-A8EC-4A41-AB0E-BAC434259F92/EN-US/GUID-1E3CECCF-0343-431C-95F0-5716E0341C75.html, referred 15.3.2024.

[31] GIRALDO-PEDROZA, A., LEE, W. C.-C., LAM, W.-K., COMAN, R., AND ALICI, G. Effects of Wearable Devices with Biofeedback on Biomechanical Performance of RunningâA Systematic Review. *Sensors 20*, 22 (2020).

[32] GOES, P. G. Editor's comments: Information systems research and behavioral economics. *MIS Quarterly 37*, 3 (2013), 3–8.

[33] GOLDSBY, M. G., GOLDSBY, E. A., NECK, C. B., NECK, C. P., AND MATHEWS, R. Self-Leadership: A Four Decade Review of the Literature and Trainings. *Administrative Sciences 11*, 25 (2021).

[34] HAGGER, M., KEATLEY, D., AND CHAN, D. K. C. *CALO-RE Taxonomy of Behavior Change Techniques.* Sage, Thousand Oaks, CA, 2014.

[35] HIRSJARVI, S., REMES, P., AND SAJAVAARA, P. *Tutki ja kirjoita.* Tammi, Helsinki, 2009.

[36] HOOREN, B. V., GOUDSMIT, J., RESTREPO, J., AND VOS, S. Real-time feedback by wearables in running: Current approaches, challenges and suggestions for improvements. *J Sports Sci. 38*, 2 (2020), 214 – 230.

[37] HOUGHTON, J. D., AND NECK, C. P. The revised self-leadership questionnaire Testing a hierarchical factor structure for self-leadership. *Journal of Managerial Psychology. 17*, 8 (2019), 672 – 691.

[38] INSIGHTS, G. Smartwatch Market. URL `https://www.gminsights.com/industry-analysis/smartwatch-market#:~:text=Smartwatch%20Market%20size%20was%20valued,compelling%20factor%20driving%20their%20popularity`, referred 15.3.2024.

[39] JIN, D., HALVARI, H., MAEHLE, N., AND OLAFSEN, A. H. Self-tracking behaviour in physical activity: a systematic review of drivers and outcomes of fitness tracking. *Behaviour and Information Technology* (2020).

[40] KIM, Y. H., KIM, D. J., AND WACHTER, K. A study of mobile user engagement (MoEN): Engagement motivations, perceived value, satisfaction, and continued engagement intention.. *Decision Support Systems 56* (2013), 361 – 370.

[41] LASIKIEWICZ, N., AND SCUDDS, A. I Wear a Fitbit; Therefore, I Am a Bitfit: Exploring the Impact of a Fitbit Device on Exercise and Work-Related Wellbeing. *Journal of Technology in Behavioral Science. 8* (2023), 411 – 421.

[42] LEHRER, C., ESERYEL, U. Y., RIEDER, A., AND JUNG, R. Behavior change through wearables: the interplay between self-leadership and IT-based leadership. *Electronic Markets 31* (2021), 747–764.

[43] LOCKE, E., AND LATHAM, G. *A Theory of Goal Setting and Task Performance*. PrenticeHall, Englewood Cliffs, NJ, 1990.

[44] MANZ, C. C. *The Art of Self-Leadership: Strategies for Personal Effectiveness in your Life and Work.* Prentice-Hall,, Englewood Cliffs, NJ, 1983.

[45] MANZ, C. C. Taking the Self-Leadership High Road: Smooth Surface or Potholes Ahead? *Academy of Management Perspectives 29*, 1 (2015), 132 – 151.

[46] MANZ, C. C., AND SIMS, H. P. Self-management as a substitute for leadership: a social learning perspective. *Academy of Management Review 5* (1980), 361 – 367.

[47] MANZ, C. C., AND SIMS, H. P. SuperLeadership: Beyond the myth of heroic leadership. *Organizational Dynamics 19*, 4 (1991), 18 – 35.

[48] MANZ, C. C., AND SIMS, H. P. *New Superleadership: Leading Others to Lead Themselves*. Berrett-Koehler, San Francisco, CA, 2001.

[49] MANZ, C. C., AND SIMS, H. P. *Mastering Self-Leadership: Empowering Yourself for Personal Excellence*. Pearson Prentice-Hall, Upper Saddle River, NJ, 2004.

[50] MCDANIEL, C., AND GATES, R. *Marketing Research Essentials. 8th ed.* John Wiley Sons, Hobokey, New Jersey, 2013.

[51] MERCER, K., LI1, M., GIANGREGORIO, L., BURNS, C., AND GRINDROD, K. Behavior Change Techniques Present in Wearable Activity Trackers: A Critical Analysis. *JMIR mHealth uHealth 4*, 2 (2016).

[52] METSAMUURONEN, J. *Tutkimuksen tekemisen perusteet ihmistieteessÃ¤*. Gummerus Kirjapaino Oy, Jyvaskyla, 2003.

[53] MICHAELIS, J. R., RUPP, M. A., KOZACHUK, J., HO, B., ZAPATA-OCAMPO, D., MCCONNELL, D. S., AND SMITHER, J. A. Describing the User Experience of Wearable Fitness Technology through Online Product Reviews. In *Proceedings of the Human Factors and Ergonomics Society* (2016), Conference paper.

[54] MICHIE, S., VAN STRALEN, M. M., AND WEST, R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science 6*, 42 (2011).

[55] MICHIE, S., WOOD, C. E., JOHNSTON, M., ABRAHAM, C., FRANCIS, J. J., AND HARDEMAN, W. Behaviour change techniques: the development and evaluation of a taxonomic method for reporting and describing behaviour change interventions (a suite of five studies involving consensus methods, randomised

controlled trials and analysis of qualitative data). *Health Technology Assessment 19*, 99 (2015).

[56] MOYA, J.-F. D., AND PALLUD, J. From panopticon to heautopticon: A new form of surveillance introduced by quantified-self practices. *Information Systems Journal 30* (2020), 940–976.

[57] NECK, C. P., AND HOUGHTON, J. D. Two decades of selfâleadership theory and research: Past developments, present trends, and future possibilities. *Journal of Managerial Psychology 21*, 4 (2006), 270–295.

[58] OGBANUFE, O., AND GERHART, N. The mediating influence of smartwatch identity on deep use and innovative individual performance. *Information Systems Journal 30*, 2 (2020).

[59] OINAS-KUKKONEN, H. A foundation for the study of behavior change support systems. *Personal and Ubiquitous Computing 17* (2013), 1223–1235.

[60] OLANDER, E. K., FLETCHER, H., WILLIAMS, S., ATKINSON, L., TURNER, A., AND FRENCH, D. P. What are the most effective techniques in changing obese individualsâ physical activity self-efficacy and behaviour: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity 10*, 29 (2013).

[61] PATEL, S., ASCH, A., AND VOLPP, G. Wearable devices as facilitators, not drivers, of health behavior change. *Jama 313*, 5 (2015), 459–460.

[62] POBIRUCHIN, M., SULEDER, J., ZOWALLA, R., AND WIESNER, M. Accuracy and Adoption of Wearable Technology Used by Active Citizens: A Marathon Event Field Study. *Jmir Health and Unhealth 5*, 2 (2017).

[63] POLAR. Introducing Polar Grit X2 Pro. URL `https://www.dcrainmaker.com/2024/03/polar-grit-x2-pro-details-hands-everything.html`, referred 29.3.2024.

[64] POLAR. Polar Elixir - Biosensing Technologies. URL `https://www.polar.com/en/explore/elixir/`, referred 29.3.2024.

[65] POLAR. Polar Grit X2 Pro. URL `https://www.polar.com/en/grit-x2-pro/explore`, referred 25.3.2024.

[66] PROCHASKA, J., AND DICLEMENTE, C. *Towards a Comprehensive Model of Change. Treating Addictive Behaviors: Processes of Change.* Plenum Press, New York and London, 1986.

[67] PRUSSIA, G. E., ANDERSON, J. S., AND MANZ, C. C. Self-leadership and performance outcomes: The mediating influence of self-efficacy. *Journal of Organizational Behavior 19* (1998), 523–538.

[68] RAINMAKER, D. Polar Grit X2 Pro Hands-On: Hereâs Everything New! URL `https://www.dcrainmaker.com/2024/03/polar-grit-x2-pro-details-hands-everything.html`, referred 29.3.2024.

[69] RANDALL, C. Best GPS Running watches 2024. URL `https://www.irunfar.com/best-gps-running-watch`, referred 15.3.2024.

[70] RANDALL, C., AND HICKS, M. I Run Far - Coros Vertix 2 Review. URL `https://www.irunfar.com/coros-vertix-2-review`, referred 29.3.2024.

[71] RAPP, A., AND TIRABENI, L. Personal Informatics for Sport: Meaning, Body, and Social Relations in Amateur and Elite Athletes. *ACM Transactions on Computer-Human Interaction 25*, 3 (2018), 1–30.

[72] RICKY ZIPP, MORNING GLORY. The Public's Use of Health Apps and Wearables Has Increased in Recent Years. But Digital Health Still Has Room to Grow. URL `https://pro.morningconsult.com/trend-setters/use-of-digital-health-apps-wearables-growing`, referred 13.6.2023.

[73] RIEDER, A., ESERYEL, Y., LEHRER, C., AND JUNG, R. Why Users Comply with Wearables: The Role of Contextual Self-Efficacy in Behavioral Change. *International Journal of HumanâComputer Interaction 37*, 3 (2021), 281–294.

[74] RIEDER, A., LEHRER, C., ESERYEL, U. Y., AND JUNG, R. The Generative Mechanisms Behind Technology-Enabled Changes in Health Behavior. In *Twenty-Ninth European Conference on Information Systems* (2021), ECIS.

[75] RONTO, P. The State of Ultra Running 2020. URL `https://runrepeat.com/state-of-ultra-running`, referred 3.4.2024.

[76] RYAN, M., AND DECI, L. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist 55*, 1 (2000), 68–78.

[77] SARAJARVI, A., AND TUOMI, J. *Laadullinen tutkimus ja sisallonanalyysi: Uudistettu laitos*. Tammi, Helsinki, 2017.

[78] SAUNDERS, M., LEWIS, P., AND THORNHILL, A. *Research Methods for Business Students. 4th ed.* Pearson Education Limited, Harlow.

[79] SEÇKIN, A. C., ATES, B., AND SEÇKIN, M. Review on Wearable Technology in Sports: Concepts, Challenges and Opportunities. *Applied Science 13*, 10399 (2023).

[80] SHINA, G., JARRAHIA, M. H., FEIA, Y., KARAMIB, A., GAFINOWITZA, N., BYUNC, A., AND LUA, X. Wearable activity trackers, accuracy, adoption, acceptance and health impact: A systematic literature review. *Elsevier, Journal of Biomedical Informatics 93* (2019).

[81] SIDWELL, A. J. The Self Leadership Habits of Ultra-endurance, Executive Leaders: An Exploratory Case Study. In *Beckley ProQuest Dissertations Publishing,* (2018), University of Charleston.

[82] STEPHENSON, A., MCDONOUGH, S. M., MURPHY, M. H., NUGENT, C. D., AND MAIR, J. L. Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity. 14*, 105 (2017).

[83] STEWART, G. L., COURTRIGHT, S. R., AND MANZ, C. C. Self-Leadership: A Paradoxical Core of Organizational Behavior. *Annual Review of Organizational Psychology and Organizational Behavior. 6*, 1 (2019).

[84] SULLIVAN, A., AND LACHMAN, M. Behavior Change with Fitness Technology in Sedentary Adults: A Review of the Evidence for Increasing Physical Activity. *Front. Public Health 4*, 289 (2021).

[85] TONER, J., ALLEN-COLLINSON, J., JACKMANB, P. C., JONESC, L., AND ADDRISON, J. 'I like to run to feel': embodiment and wearable mobile tracking devices in distance running. *Qualitative Research in Sport, Exercise and Health. 15*, 105 (2023), 805 – 818.

[86] WINDASARI, N. A., AND REN LIN, F. Why Do People Continue Using Fitness Wearables? The Effect of Interactivity and Gamification. *Sage Open Oct - Nov* (2021), 1 – 18.

[87] YAZAAR, K. Definition, Wearable Technology. URL `https://www.techtarget.com/searchmobilecomputing/definition/wearable-technology`, referred 5.3.2024.

[88] YIN, R. K. *Case Study Research: Design and Methods (5th ed.)*. Sage Publications, Thousand Oaks, CA, 2014.

[89] ZARYSKI, C., AND SMITH, D. J. Training Principles and Issues for Ultra-endurance Athletes. *Current Sports Medicine Reports 4*, 3 (2005), 165–170.

# A Interview Structure

SEMI-STRUCTURED THEME INTERVIEW

PROFILE

- Age
- Sport and background in it
- WAT, which one and why?
- WAT; background

MONITORING, GOALS, AND MOTIVATION

- What was your biggest motivation for acquiring the device?
- How often do you use the device?
- Which metrics/data do you follow?
- The significance of the device in training and daily life
- Do you set goals with WAT? How? (how do you set goals?)
- How do you track your goals along the way?
- How do you react if you don't reach your goal?
- How do you motivate yourself?
- How does the device (=data) support the building of motivation?

BEHAVIOR AND CHANGE

- How does the sports watch/data affect sports/life?
- How does the watch support sports and life around it/recovery?
- When has the watch/data influenced your behavior and how?

- Do you recognize changes in your behavior patterns through data? Describe the process.
- Do you utilize the collected data in your preparation for a competition? How?
- How does the watch/data help you in your preparation?
- What kinds of behavior patterns has the watch affected?

WAT FEATURES AND WISHES

- How do the built-in features of the watch affect your training and everyday life? E.g. daily activity recommendations, social features (friends, etc.), gamification, and watch goals etc.
- What would you like more from data and sports watches?
- Which features would you hope to have?