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WEARABLES: COMPASSIONATE TECHNOLOGY OR STRESS TRIGGER?

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Dear Dean, Dear colleagues and students, Dear family and friends, Dear distinguished guests.

I stand before you today, adorned with two distinct wearables. The first is my daily companion, diligently tracking my steps, monitoring my resting heart rate, and observing my sleep patterns. This wearable has become an integral part of my daily routine, providing insights into my physical well-being. On the other hand, I have my research wearable running the Sense-it software. This unique software offers a bio-cue whenever there's a sudden spike in my heart rate, especially when I'm not moving too much. One might argue that this device, would be expected to cue me right now at this somewhat exciting moment in my life. Thus, given all these wearables on me, it should come as no surprise when I declare: wearables are good for you!

Imagine setting a daily goal, perhaps aiming for 10,000 steps. Throughout the day, you strive for a varied heart rate, occasionally pushing it above 120 for at least 20 minutes. Such practices not only promote a healthier lifestyle but also pave the way for achieving personal health milestones. The ultimate reward? A longer, and arguably, a happier life.

There's empirical evidence to support these claims. Consider a compelling experiment conducted by Etkin in 2016. Three distinct groups were each given a step counter. However, there was a twist. The control group, represented by a white bar (see Figure 1A), had their display taped off, rendering them oblivious to their step count. In contrast, the other two groups had full visibility of their feedback throughout the day. The "measurement" group was explicitly instructed to frequently check their step count, while the "optional measurement" group was left to their own devices. The results were clear. The group with step feedback clearly surpassed the control group in number of steps! But there's a caveat. Etkin also gauged the participants' enjoyment levels during their walks. Alarmingly, those with access to feedback reported a significant 1-point dip in walking enjoyment (see Figure 1B).

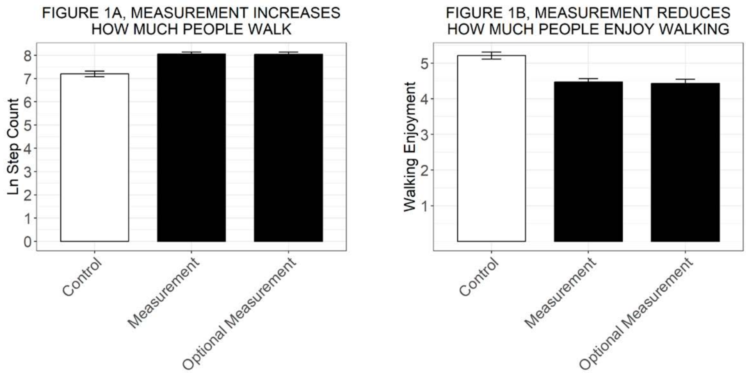

Figure 1A & 1B. Measurement increases steps, but diminishes enjoyment in walking.

This brings me to the challenges often reported when discussing wearable technology. They have the potential to reduce our lives to mere numbers on a screen, detracting from the genuine joy of activities like walking or exercising. The essence of these activities risks being overshadowed by quantifiable metrics, transforming leisurely pursuits into tasks. Some might thrive in this environment, while others may find it stifling. Moreover, there's the looming concern of data privacy. Handing over intimate details, ranging from our whereabouts to our physiological responses, to corporations might not always align with our best interests.

And so, with this backdrop, I invite you to delve deeper into today's discourse on wearables as compassionate technology or stress trigger.

OUTLINE

Today's lecture will unfold as follows: I'll begin by introducing the core theme of my chair, which is the intersection of health psychology and persuasive technology. Our focus will then shift to wearable technology, examining its role as a persuasive tool. We'll deep dive into the essence of wearables, their accuracy, user experience and the insights they offer about health psychology, behavior, and long-term outcomes.

A critical reflection will follow, questioning if our current wearable technologies, and the associated algorithms and feedback mechanisms, truly cater to everyone, especially the more vulnerable in our society. This will lead us to the concept of compassionate technology, which can be viewed as both an extension and an alternative to persuasive technology. I'll present an in-depth example of a bio-cueing technology, a collaborative effort spanning a decade with various university and healthcare partners, showcasing compassionate co-design with patients and care professionals. We'll conclude with insights and future directions for my chair.

INTRODUCTION

Health psychology is defined as 'the study of health, well-being, illness, and healthcare practices. Its goal is to understand, explain, and predict health behaviour so that effective interventions can be developed or designed. This aims to reduce both the physical and emotional costs of risky behaviour and illness' (Morrison & Bennet, 2016). When we look at the second part of this definition, the aspect of developing effective interventions, then this ties directly into the second part of my chair: persuasive technology. Persuasive technology refers to 'interactive systems designed to aid and motivate people to adopt behaviours beneficial to them and the community, while avoiding harmful ones' (Orjii & Moffat, 2018). In relation to this field I would like to mention the groundbreaking and exceptional contributions of my predecessors, Professor Lisette Van Gemert-Pijnen and Professor Robbert Sanderman. Their dedication and expertise have laid a rich foundation for the work in the field of health psychology and persuasive technology we continue today at the University of Twente.

Given this field of health psychology and persuasive technology, what then would you think is the most prototypical persuasive technology? Well, nowadays, of course, when you have such a question, you turn to artificial intelligence. So, I asked this question to ChatGPT, the interface to the Large Language Model of OpenAI: "What is the most prototypical example of a persuasive technology in the field of health psychology? If you could choose only one, what would it be?"

This is what the large language model had to say about this issue: "The most prototypical example of a persuasive technology in the field of health psychology is probably the fitness tracker or activity tracker. These devices, such as the Fitbit, Garmin, and wearables like the Apple Watch, are designed to monitor and record physical activity. They often come with features like step counting to motivate users to achieve a certain number of steps daily, heart rate monitoring to track cardiovascular health and exercise intensity, and sleep tracking to monitor sleep patterns and quality. (ChatGPT 4.0, OpenAI)"

And although this answer is insightful and clearly points out very important behavioral and physiological markers for health, such as the number of steps taken, heart rate, and the intensity of exercise, I believe it misses a crucial point. In the face of an aging population and looming healthcare personnel shortages, the healthcare system is at a pivotal juncture. Wearables, as highlighted already by for example Marzano et al. (2015), offer a blend of research, monitoring, and clinical intervention capabilities. They have the potential to significantly alleviate the strain on our healthcare infrastructure. By tracking physical activities, heart rates, and sleep patterns, wearables can play a proactive role in disease prevention, especially crucial for the elderly who are at higher risk for conditions like heart disease, diabetes, and obesity. Their continuous monitoring capabilities can facilitate earlier hospital discharges, allowing patients to be monitored remotely, ensuring their safety and freeing up essential hospital resources.

Furthermore, wearables can act as an early warning system for clinical teams, as evidenced by their ability to detect physiological signs of stress or sleep disturbances, both of which can be precursors to more severe (mental) health issues. The integration of wearables with therapeutic apps, can offer additional support for managing both physical and mental health conditions. They can alert healthcare providers of potential crises, ensuring timely interventions.

However, as we try to implement these technological advancements, it's crucial to ensure that they complement, rather than replace, the human touch in healthcare. Marzano et al. (2015) underscore the importance of co-design and collaboration between researchers, clinicians, and service users to ensure the efficacy, safety, and acceptability of these new technologies. In essence, while wearables and associated technologies present a promising avenue to address the challenges of our healthcare system, their integration should be thoughtful, ensuring they augment the care provided by healthcare professionals rather than only supplanting it.

WEARABLES: HISTORY AND USAGE

Now that we have established the importance of wearables within the field of health psychology, let's delve deeper into this technology. Many of the older members in the audience might be personally familiar with hearing aids, a classic example of wearable technology that's been around for decades. These devices enhance human functioning and contribute to well-being. Speaking of wrist-worn technology, some might also recall the Casio watches equipped with a physical keyboard, a precursor to today's smartwatches.

Another intriguing category is smart clothing, where electronics are seamlessly integrated into garments. An older example from around 2006 comes to mind: a shirt that allows for long-distance hugging. When one person hugs themselves, another person wearing the same garment feels the pressure, simulating a hug from afar. While it wasn't available for a while, it seems it's back on the market for those feeling a dearth of hugs.

Smart glasses, like the Google Glass, have also made their mark. These devices augment reality, potentially offering features like facial recognition. However, they've been met with concerns, especially regarding privacy. The public's reaction underscores that such technology can easily incite outrage.

While smartphones aren't typically categorized as wearables in the context of our discussion, it's worth noting the wearable audio devices that accompany them often nowadays. These devices currently dominate the wearable market. My children, for instance, would undoubtedly appreciate this slide! However, my primary interest lies in smartwatches, smart rings, and activity trackers (see Figure 2). These range from simple belt clips for activity recognition to advanced smartwatches capable of heart rate monitoring and app integration. The smart ring, while not typically interactive, offers an unobtrusive wearable experience, often relaying feedback through a paired smartphone. Historical data from 2018 to 2027 indicates a steady rise in wearable sales, particularly smartwatches. In the

Netherlands, for instance, 40% of the population owns some wearable, a figure that climbs to 45% in India. However, actual usage paints a different picture. In the Netherlands, only about 30% actively use their wearables.

Figure 2. Wearables: From simple step-counting clips and jewellery-like smart rings to advanced smartwatches with intricate displays.

For wearables to genuinely revolutionize our healthcare system and assist individuals in daily health management, several questions arise:

1. Are these devices good at measuring? In technical terms, what's their reliability and construct validity?
2. Can they predict other health-related variables, or in other words, what's their convergent validity? This includes both long-term health outcomes and psychological and behavioral variables such as stress, arousal and aggression.
3. How do individuals experience these wearables and the feedback they provide and is there evidence their health behavior actually changes?
4. To what extent are wearables suitable for vulnerable groups in society?

RELIABILITY AND VALIDITY OF WEARABLES

When discussing the effectiveness and accuracy of wearable devices, for example in measuring heart rate, it's crucial to understand two primary concepts: validity and reliability. To illustrate these terms, imagine an archery scenario. The bull's-eye represents an accurate heart rate measurement of 80 beats per minute (bpm). If a wearable consistently measures 70 bpm while the actual heart rate is 80 bpm, the device is demonstrating reliability—it's consistent. However, it's not valid because it's not accurate. Conversely, if the measurements from the device scatter around but average out to 80 bpm, the device is valid because, on average, it's accurate. However, due to the scatter, it's not reliable. The ideal wearable would consistently hit the bull's-eye, the true heart rate, indicating both reliability and validity.

A comprehensive review encompassing nearly 170 studies and involving around 6000 participants yielded some interesting findings regarding the reliability and validity of popular wearables such as the Apple Watch, Fitbit, and Samsung watches (Fuller at al. 2020). In controlled lab settings, steps were generally measured both accurately (valid) and consistently (reliable). However, heart rate accuracy varied among brands. No device reliably or validly measured energy expenditure. This highlights the challenges and variations in wearable technology, even among top brands.

Another intriguing wearable is the E4, which has now been succeeded by the Embrace Plus. For several years, the E4 was the go-to device in scientific studies when researchers wanted to measure not just heart rate but also skin conductance. Skin conductance offers insights into emotional (arousal) responses by measuring sweat gland activity. For instance, a sudden scare can lead to a spike in skin conductance. A PhD student, Erika van Lier, I supervised together with Marcel Pieterse (Health Psychology), Jan Maarten Schraagen (Human Factors and Engineering Psychology) and Miriam Vollenbroek (Biomedical Signals and Systems) from our university studied the E4 in detail (Van Lier et al. 2020). While the E4 provided skin conductance data that seemed reliable in some cases, it wasn't consistently accurate across all participants. In this experiment, participants also experienced a rise in skin conductance when they realized they had to sing in front of a stranger. While traditional methods detected this rise, the E4 also detected a similar trend, showcasing its convergent validity in specific scenarios.

In conclusion, the validation of wearables is of paramount importance, especially if they are to be used in research and healthcare settings. As technology evolves and new wearables emerge, it's essential to remember that newer doesn't always mean better. Some newer wearables have even been found to measure less accurately than their predecessors. This dynamic field requires continuous validation efforts. There are several ongoing national (see for example https://stress-in-action.nl/) and international initiatives (Johnston et al, 2021)) focused on this. While most wearables might never match the precision of gold standard laboratory equipment, they might still be "good enough" for certain applications, such as predicting stress or detecting emotional changes in daily life. Let’s turn our attention to a number of studies that tried to do just that.

MONITORING AROUSAL LEVELS WITH WEARABLES?

Case Study 1: Monitoring Arousal Levels in Individuals with Intellectual Disabilities

When I first joined the University of Twente, I collaborated on a project with my wife, Marleen Laroy, who was then associated with the Twentse Zorgcentra, a care facility catering to individuals with intellectual disabilities. It's noteworthy that about 20% of these individuals exhibit challenging behaviors, such as aggression or self-injurious actions. Traditionally, the detection of imminent or ongoing challenging behavior largely relies on the expert observations of caretakers. Central to their approach is the monitoring of fluctuating arousal levels.

Given the established correlation between skin conductance and arousal levels, we hypothesized that measuring skin conductance fluctuations could offer valuable insights. Such data could potentially assist caretakers in better understanding their clients' states. For instance, during our study, we observed distinct patterns of skin conductance in one participant across four different days. Notably, during one session, there were two significant spikes in skin conductance. The first spike was associated with aggressive behavior, while the second, interestingly, coincided with the individual playing the piano. This highlighted the importance of human judgment in interpreting physiological data, as the same physiological response could correspond to negative and positive emotional states (Noordzij et al. 2012).

Across the broader group, we found that challenging behaviors were often accompanied by elevated skin conductance levels. In collaboration with students from the University, we initiated the development of a tool named "Buienradar-DAVID" to provide caretakers with real-time insights into clients' skin conductance fluctuations. This tool combined a skin conductance sensor, the Q Sensor, with a mobile application that presented data in an easily interpretable format using color codes. However, our journey with this tool faced challenges. For instance, one client repeatedly threw the Q Sensor on the roof, damaging our equipment. Furthermore, the company producing the Q Sensor eventually ceased its production.

While this was a setback, the journey taught us valuable lessons about the complexities of implementing technological solutions in real-world settings. The path to full implementation is often long and requires collaboration across multiple stakeholders. Fortunately, the concept we pioneered is still alive and evolving. A company named Mentech is currently distributing a similar system, the Hume, which measures both skin conductance and heart rate, offering caretakers valuable insights into their clients' states.

Case Study 2: Monitoring Arousal Levels in forensic psychiatry

I'd like to spotlight another case study that underscores the potential of wearable technology in revealing hidden information in healthcare, specifically within forensic psychiatry. This project was a collaboration with Peter de Loof and Henk Nijman, the latter of whom, regrettably, passed away prematurely recently. The study took place in clinics housing patients who had committed severe crimes and exhibited aggressive behavior, both towards themselves and others, including staff and fellow patients (De Looff et al., 2019).

Similar to the previous study, we were curious about the potential of the E4 wearable, which measures both heart rate and skin conductance (or electrodermal activity). We aimed to determine if this device could not only monitor patients but also predict imminent aggressive incidents. It's worth noting that this research, was part of "Wearables in Practice" (founded together with Peter de Looff and Liza Cornet), a nationwide grassroots movement. This initiative brings together individuals from universities, companies, and care institutions, all interested in the practical applications of wearables in healthcare.

In this study, we tracked 100 patients who wore the E4 device for five days. Concurrently, staff members documented any aggressive incidents. Our subsequent analysis aimed to identify any correlation between the E4's measurements and the onset of aggressive behavior. On average, both skin conductance data and heart rate indicated rising physiological levels preceding aggressive incidents.

In conclusion, these case studies suggest that integrating such measurements into clinical practice can be beneficial. However, it's essential to approach this with caution. As previously highlighted, the quality of devices like the E4 isn't always optimal. Moreover, while physiological data can provide valuable insights, it's crucial to ensure that professional human judgment remains an integral part of the decision-making process.

HEALTH BEHAVIOR AND OUTCOMES

Wearables not only offer insights into basic arousal processes but are also increasingly being utilized to measure health behaviors and outcomes over extended periods. A growing trend is the collaboration between academic researchers and companies producing these wearables. Let's delve into recent studies that stand out, particularly due to the vast number of participants involved, made possible by the data access provided by these companies or by adding them to existing large cohort studies.

The Oura Ring, a piece of wearable jewellery, offers an unobtrusive way to monitor sleep. With a long battery life and ease of use during sleep, it was used to collect data from 220,000 individuals across 35 countries, amounting to over 50 million nights or an average of 242 nights per person (Willoughby et al, 2023). This vast dataset is something most psychologists could only aspire to have! The study aimed to discern sleep patterns across continents. For instance, data revealed that individuals in Asia, on average, slept less and went to bed later than their counterparts in other regions. Such extensive data allows for a deep dive into cultural and work-related factors influencing sleep patterns.

Fitbit, another major player in the wearable industry, participated in a study focusing on heart rate variability (Natarajan, 2020). While the accuracy and reliability of heart rate variability measurements using Fitbit can be debated, the sheer volume of participants (8 million) compensates for potential data noise. The study compared the relationship between heart rate variability and steps across genders and age groups. Findings indicated that as daily step count increased, heart rate variability also rose. Furthermore, younger individuals exhibited higher heart rate variability than older ones. While these findings align with physiological expectations, having empirical data at a population level reinforces these insights.

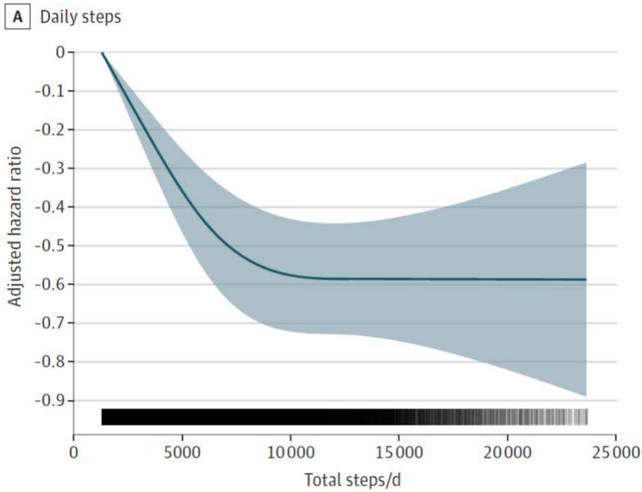

Figure 3. Dose-Response association between steps and All-Cause Mortality (Del Pozo Cruz et al. 2022)

The widely recognized benchmark of 10,000 steps per day, interestingly, originated from a marketing strategy by a Japanese company. However, a study utilizing data from the UK Biobank, a comprehensive cohort from the United Kingdom, unexpectedly validated this rough heuristic (Del Pozo Cruz et al. 2022). The study analyzed the number of daily steps against the probability of critical illnesses like coronary heart disease or cancer. Results showed a consistent decline in mortality risk with an increase in daily steps (see Figure 3). The risk reduction plateaued around 10,000 steps, but taking more steps didn't have adverse effects.

In conclusion, these studies exemplify how wearables are deepening our understanding of the relationship between health behaviors and outcomes at a population scale. On a related note, the already mentioned Stress in Action program (started in 2023) in the Netherlands spearheaded by Brenda Penninx and Eco de Geus from the VU, and led by me for the UT is a prime example of this type of initiative where we hope to better elucidate the relationship between daily life stress and health outcomes by adding wearables and other passive sensing technology to large running cohort studies in the Netherlands. Figure 4 give a good overview of all the measurements we will include, many of which are only possible because of wearable technology.

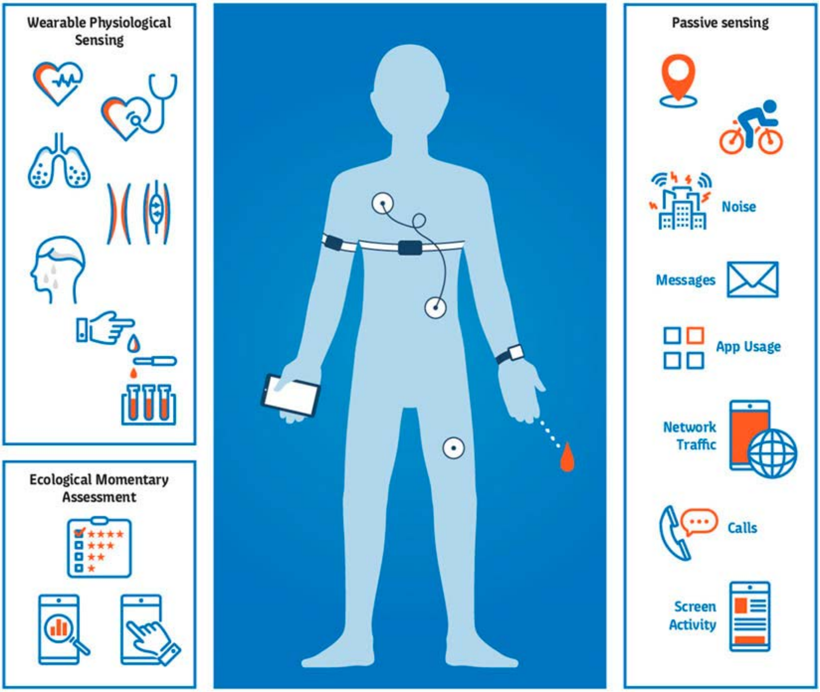

Figure 4. Passive and active sensing within the stress in action project.

EFFECTIVENESS AND USER EXPERIENCE OF WEARABLES FOR HEALTH MANAGEMENT

Now that we have established that wearables show great promise in monitoring long-term health outcomes, several questions arise. Do people genuinely want to wear these devices? Are they comfortable and enjoyable to wear? Do individuals find the feedback provided understandable, and more importantly, do they act on this feedback to improve their health? Wearables, as a relatively new form of technology, often spark initial interest. Many individuals might track their steps or sleep patterns intensively at the outset.

However, a common observation is that after a few weeks or months, some might lose interest. They revert to their usual habits and routines, relegating the wearable to a drawer.

In this context, I'd like to draw attention to a study by Liz Nelson, a Ph.D. student whom I have the privilege to supervise alongside Tibert Verhagen and Prof. Vollenbroek. The study, together with Anneke Sools of our department at the UT, is quite unique as it longitudinally tracks the embodiment of wearables, while comparing the phases of embodiment between wearables and limb prostheses. Over a span of 9 months, 12 individuals wore fitness trackers. Their experiences were captured through interviews conducted at 3-month intervals (Nelson et al, 2020). The primary aim was to discern if the pattern of usage was cyclical, with varying intensity, or if it led to eventual abandonment. An intriguing observation from the study was the blurring of self-perception when device feedback contradicted personal beliefs, leading to a dilemma: whom to trust, the technology or oneself?

Two quotes from a participant named Matthew from the study are nice to highlight. He referred to the sleep notifications as his "mother," emphasizing the personal connection some users felt with their devices. In another instance, he mentioned using the device again after some time, viewing it as “a fresh start”. The study's findings revealed that individuals experienced technology embodiment akin to limb embodiment in terms of adjustment, wearability, awareness, and body extension. This suggests that wearables, over time, can become an intrinsic part of an individual's life, much like a physical prosthesis. The cyclical nature of engagement, where users oscillate between intense usage and periods of disinterest, underscores the complex relationship people have with wearable technology. However, the value of wearables will be fully realized if they genuinely assist individuals in leading healthier and more meaningful lives. The question remains: Do they?

The answer to this question at present is mixed. Recently, an authoritative systematic review of systematic reviews and meta-analyses (called an umbrella review) was published that analysed 39 systematic reviews of experimental studies on the effectiveness of wearable activity trackers, covering 163,992 participants and spanning various age groups and health conditions (Fergusson et al. 2022). When it comes to physical activity outcomes, the review made it clear that wearables play a significant role in enhancing them. For those curious about the specifics, the review highlighted that when wearables were introduced as an intervention, participants on average took an extra 1,800 steps per day, walked an additional 40 minutes every day, and experienced a daily increase of 6 minutes in moderate to vigorous physical activity. These findings are indeed encouraging and underscore the potential of wearables in promoting physical activity.

However, the physiological outcomes painted a more nuanced picture. While there was a recorded weight loss of 1 kg and a modest reduction in body mass index by half a point, the effects on other physiological markers like blood pressure and cholesterol were minimal and often statistically non-significant. Furthermore, when it came to measures such as experienced pain, disability, and overall well-being, the effects were even weaker and mostly absent. This suggests that while wearables have a clear impact on promoting physical activity, their influence on broader health outcomes are currently doubtful.

PERSUASIVE TECHNOLOGY WITHOUT COMPASSION IS A CURATIVE FANTASY

Given the lack of a significant impact of wearable technology on certain physiological and psychological outcomes, I will now go into the challenges associated with wearable technology. As we navigate through this topic, I've identified three challenges that I believe are important to be aware of and discuss. The first challenge with wearable technology is the undisclosed algorithms they use. When wearables measure steps or stress levels, the methodology behind these calculations is often opaque. Particularly with stress, it's unclear whether the device is indicating physiological stress or psychological pressure. Universities have a pivotal role in supporting the creation of transparent and explainable algorithms, ensuring users understand what a "stress level" on a wearable truly signifies.

This leads to the second challenge: naïve realism. Most users lack expertise in understanding their physiological systems. When presented with data like heart rate or other physiological metrics, how should they interpret it in relation to psychological states such as stress or well-being? People often resort to simple heuristics and one-to-one mapping (Cacioppo et al. 2016), like associating a higher heart rate with stress and stress with higher heart rates. However, these relationships can be different between and within people over time ánd context-dependent. Wearables should guide users towards more realistic interpretations. Efforts to develop better models for stress, for instance, can lead to improved algorithms and more comprehensible and convincing cues for users.

The third challenge pertains to the target audience of wearable technology. Current wearables and their associated apps seem tailored for those already interested in a healthy lifestyle. Spiel et al. (2018) discussed the "normative ontology of fitness trackers," suggesting they push everyone towards becoming fitter, happier, and more productive. Such devices might only reaffirm the fitness of already fit individuals and could negatively impact others, especially vulnerable populations. I would argue that persuasive technology, like wearables, if implemented without compassion, can sometimes be more of a "curative fantasy" than genuinely helpful. For instance, while maintaining activity and good sleep can alleviate some chronic pain, it won't eliminate it. The overly optimistic messaging in some wearable technologies can be off-putting and might deter many from using them.

At the University of Twente, we've initiated a project titled "Compassionate Technology." Collaborating with Geke Ludden and Benedetta Lusi from Industrial Design, Randy Klaassen from Computer Science, Peter-Paul Verbeek from Philosophy, the company Mind District, and care organization Dimence Groep, we're examining if current technology aligns with the value of compassion and exploring ways to enhance and measure it. So, what is compassion? Strauss et al. (2016) offers a comprehensive definition comprising five actionable steps that together form a compassionate process. These steps can be a tool to evaluate technology, determining if they support or perhaps neglect some of these steps. Strauss, drawing from academic literature and medical codes, emphasized that many medical conduct guidelines centralize compassion as a core value. I would argue that given its foundational role in healthcare, it's crucial that technology designed for healthcare doesn't overlook compassion.

These are the five steps:
(1) recognizing suffering (e.g. pain, depression) in others;
(2) understanding the common humanity of this suffering (i.e. it could happen to you);
(3) feeling emotionally connected with the person who is suffering (i.e. empathy);

(4) tolerating difficult feelings that may arise (i.e. avoiding empathic distress);
(5) acting or being motivated to act to help the person.

So to what extent has the value of compassion been connected to the use and design of wearable technology? PhD student Charlotte van Lotringen and above mentioned colleagues from the University of Twente, together with Gerben Westerhof, Hanneke Kip and Saskia Kelders from my department did a systematic scoping review aimed to provide an overview of how elements of compassion have been linked to digital technologies for mental health (Van Lotringen et al. 2023). The review identified three main ways technology contributes to compassion in mental health care uptil now: 1. By showing compassion to people (e.g. compassionate text from a chatbot).2. By enhancing self-compassion in people (e.g. doing breathing exercises in an app such as Headspace). 3. By facilitating compassion between people (e.g. allowing people to video chat during the Covid pandemic).

However, none of the included technologies met all five elements of compassion, nor were they evaluated in terms of compassion. Also the role of the care professional was rarely mentioned, while they would often have to assist the patients and integrate the wearable technology into the care path. Finally, the review did not find studies focussing on wearable technology in the context of compassionate technology. However I would argue that the past ten years a set of projects has been under development, which could partly qualify as compassionate wearable technology. Earlier in the talk I already mentioned the 'Buienradar' work, using physiological sensing to give people with severe intellectual disabilities a voice. Shortly after that project I got involved in similar work that is still ongoing up to today. Let's turn our attention to these projects now.

THE SENSE-IT FRAMEWORK: DESIGNING BIOCUEING WITH VULNERABLE GROUPS

About a decade ago, the Ph.D. project of Youri Derks commenced. Youri, a clinical psychologist at GGNET, collaborated with myself, Randy Klaassen, Prof. Westerhof and Prof. Bohlmeijer to explore the potential of integrating wearable technology into the treatment regimen for individuals diagnosed with Borderline Personality Disorder (BPD). BPD is a profound mental health condition that significantly impacts almost every facet of an individual's life, including their professional life, physical health, financial stability, leisure activities, and interpersonal relationships. This disorder is marked by a persistent pattern of volatile relationships, a skewed self-perception, and deep-seated disruptions in the perception and regulation of emotions. Existing research underscores a specific need to enhance the recognition of the 'arousal' component of emotions in BPD patients. Experimental test results have shown that individuals with BPD tend to focus considerably less on their emotional arousal compared to control participants (Derks et al., 2017).

Our basic question revolved around the potential of utilizing simple bio cues, as measured by commercial smartwatches, to assist individuals in identifying moments of heightened arousal. The aim was to aid them in their emotional self-management and also to enhance communication and reflection with their therapists and peers. While we could have opted for readily available feedback and coaching applications that came with the hardware we chose, many of which have been discussed previously, we were hesitant due to several concerns. The undisclosed algorithms, potential misinterpretations of feedback on physiology provided by standard apps, and the absence of therapist involvement in the development of the current software were issues we were facing. To address these issues, we embarked on a series of co-design projects. In these sessions, patients, therapists, and user-centered design experts collaboratively and iteratively worked on crafting a tailored, and I would argue, compassionate bio-cueing technology, which was named ‘Sense-it’.

So, what exactly is Sense it? Sense it is compatible with any Android Wear OS smartwatch, meaning the hardware is over-the-counter, a lesson I gleaned from the Buienradar project. In that endeavor, we were solely reliant on a single manufacturer for a specific type of hardware. This dependency made us highly vulnerable, especially in the realm of new technology development where a timeline spanning 10 to 15 years is normal. By opting for a standard operating system supported by numerous wearable manufacturers, we fortified our resilience in this rapidly evolving tech market. Another pivotal decision was to store data locally on the participant's phone, ensuring it wasn't transmitted to a central server. Given the sensitive nature of the data we were gathering, this approach alleviated many privacy concerns typically associated with such technology.

We also designed a system offering significant flexibility in terms of when and how users receive biocues from their device about potential physiological changes. Our primary focus was on basic heart rate measurements, especially in low-movement scenarios. The device's activity algorithms can detect sedentary behavior or slow walking, and compare at those moments the heart rate to the user's baseline heart rate and the standard deviations of heart rate variations. Users can then receive feedback if their heart rate exceeds the norm in these contexts potentially indicating the presence of strong emotions they have a hard time detecting themselves. This feedback is subtle and neutral, represented by circles that hold meaning for the wearer but are not discernible to onlookers. Additionally, there's an option for vibration alerts and therapeutic pointers at specific thresholds, which users can set and design, in consultation with their therapists. The final interpretation of the simple biocue is left with the patient in their daily life.

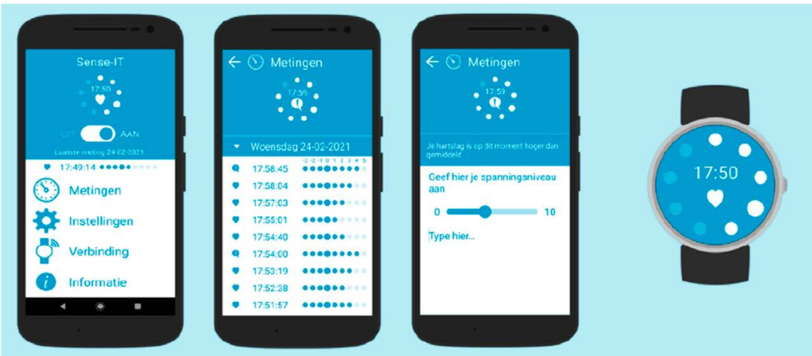

Figure 5. Sense-it application (see senseitapp.nl)

For those keen to delve deeper, there's a comprehensive website showcasing the technology, software, and our collaborators (https://senseitapp.nl/). While this project originated at the University of Twente, it soon expanded as partners from Amsterdam UMC (Arne Popma), Arkin, Inforsa (Annemieke ter Harmsel, Thimo van der Pol, Lisanne Smulders), and Pluryn (Karin Nijhof) joined the consortium. Here, as depicted in Figure 5, you can observe the current design of Sense-it. As evident, it functions as an application on the smartwatch, capable of operating independently from the smartphone. Additionally, there's a corresponding application on the smartphone. On both the watch and phone, users can view their current heart rate, represented by a series of circles. There's one subtly larger circle that denotes the baseline value. As the heart rate rises, more circles appear. The pace at which these circles move is determined by a sensitivity setting and the variance of the heart rate in the baseline measurement (Ter Harmsel et al. 2021)). On the smartphone app, users can also access a history of their measurements. They have the option to input their personal observations via text input. Additionally, there's a slider feature that allows users to indicate their current arousal level based on their subjective perception.

I'm afraid that discussing all the sense-it projects that since have been developed would require another 45 minutes. But I would like to summarise that there have been a number of clinical trials have been finished and published already showing positive user experiences with the Sense it indicating higher awareness of emotions and support for emotion regulation although this is not true for all participants. Those participants have become quite diverse. We've included younger people and also people from forensic psychiatry and people with intellectual disabilities and diagnosed with autism (together with Rianne Bosch and Farid Chakhssi).

Currently new research projects are underway with Arkin and GGnet where we will be specifically focusing on how we can integrate this type of bio cueing technology in treatment. It also involves developing a business case together with support of the TechMed centre here at the UT. This will hopefully allow us to scale up and test bio cueing technology for vulnerable groups in larger trials and studies, while complying to new Medical Device Regulations.

CONCLUSIONS

In wrapping up today's discussion of wearables, let's underscore a clear message: Wearables are good for you! Especially if you already lead a healthy lifestyle and have a keen interest in achieving personal health goals. However, the evidence is also compelling that wearables can significantly boost physical activity across a diverse range of individuals.

As we move forward, it's crucial to remember that wearables require constant and systematic validation. We must include them in large cohorts to more effectively measure, predict, and understand stress and health in our daily lives. And as we design and refine these tools, it's imperative to approach their development for both persuasion and compassion. This is especially true for our more vulnerable populations. By doing so, we can ensure that wearables have a more positive impact on both physiological and psychosocial variables than they currently have.

The various research and design methodologies I've discussed for wearables, I believe, align seamlessly with the research and education agenda for health psychology and persuasive technology here at the University of Twente. On one hand, there's an imperative need to shift our focus towards daily life health research supported by technology, encompassing physiological, psychological, behavioral, and contextual processes. We must move beyond relying only on surveys or isolated lab measurements. Instead, we should monitor individuals in their everyday environments over extended durations. This approach not only offers rigorous tests for existing theories but also paves the way for the inception of novel psychological theories and intervention that can actually make robust predictions and suggestion for specific individuals.

Furthermore, we must capitalize on our unique strengths. Being an engineering and entrepreneurial university, our prowess lies in collaboratively designing persuasive health technologies with relevant stakeholders. This collaborative approach has always been our primary strength, and I'm committed to further nurturing and amplifying it.

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Ik heb gezegd.

Image Credits

Figure 1: Made by Matthijs Noordzij with R and Rstudio.
Figure 2: Image courtesy of Shutterstock.
Figure 3. See Figure 1A in Del Pozo Cruz et al. (2020), p. 1144 for a visual representation. Image reproduced under a CC-BY license.
Figure 4. Image courtesy of Stress in action (stressinaction.nl)
Figure 5. Image courtesy of Sense it consortium (senseitapp.nl)

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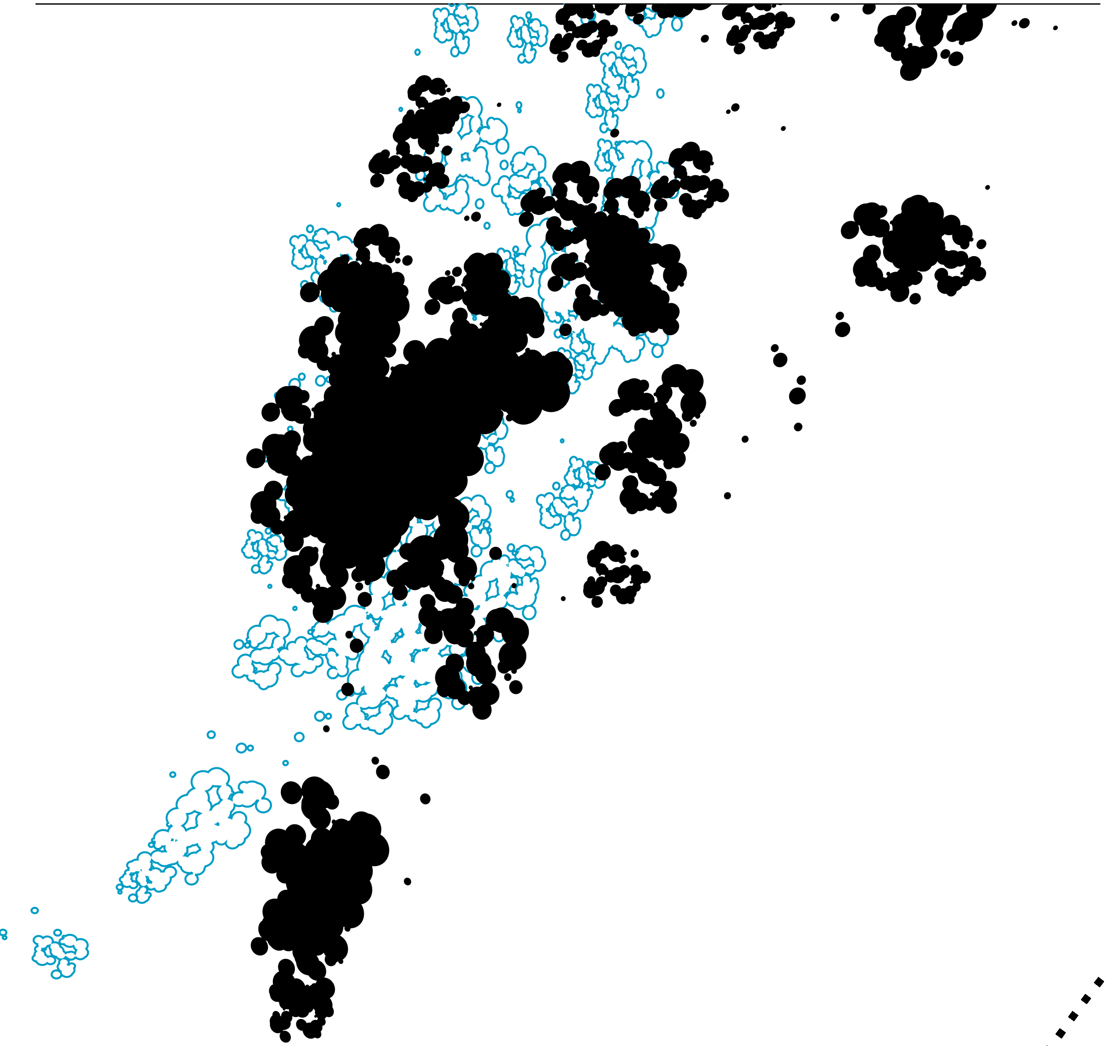

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