Supporting Meaningful Personal Fitness: the Tracker Goal Evolution Model

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ABSTRACT

While the number of users sporting fitness trackers is constantly increasing, little is understood about how tracking goals can evolve over time. As recent studies have shown that the long-term health effects of trackers are limited, we need to readdress how trackers engage users. We conducted semi-structured interviews and an online survey to explore how users change their tracking goals. Based on our results, we created the Tracker Goal Evolution Model. The model describes how tracker goals can evolve from internal user needs through qualitative goals to quantitative goals that can be used with trackers. It also includes trust and reflection as key contextual factors contributing to meaningful transitions between goals. We postulate showing how tracker goals relate to other personal fitness goals as key for long-term engagement with trackers. Our model is useful for designers of future trackers as a tool to create evolving and meaningful tracking goals.

ACM Classification Keywords

H.5.m Information interfaces and presentation: Miscellaneous

Author Keywords

wellbeing; well-being; health; fitness trackers; model

INTRODUCTION

Wearable fitness trackers, available as standalone devices or part of smart watches have now established themselves on the consumer market. Trackers promise the users opportunities to improve fitness and lead a healthier life. The first longitudinal studies on the health effects of wearing a fitness tracker are now available, showing that while an initial health effect was observed, fitness trackers failed to offer long-term wellbeing support to users [22]. Concurrently, past research reported that users find it hard to express their expected fitness levels through metric-based goals supported by fitness trackers [16]. As a consequence, there is a need for a new generation of fitness trackers that support long-term health goals taking the complex facets of how the fitness and motivation of a user evolves into account. Research in Human-Computer Interaction (HCI) is yet to address the next steps in understanding tracking in order to build better, long-term supportive trackers.

Recent work in HCI which explored issues such as lapses [12], aesthetic appeal [25], adherence [32] and competition [16] for using a tracker indicates that goals are a recurrent theme when users interact with trackers. However, the field is yet to explore the intricacies of managing and setting goals. Thus, a better understanding of how users choose and use their goals is required. We propose readdressing the question of how, when and why to set goals in trackers. To this end, we studied users' relationship with goals, how they adapt and plan goals and how their goals relate to their data collection practices. Through a series of interviews and a survey, we established an account of the roles goals may play in fitness tracking. Based on our findings, we propose a new understanding of goals for fitness trackers in the form of the Tracker Goal Evolution Model. The model uses hedonic and eudaimonic wellbeing as underlying concepts that help create more meaningful goals for trackers. Hedonic wellbeing focuses on the presence of positive affect and the absence of negative affect. Furthermore hedonic wellbeing is often associated with pleasure and fun. Eudaimonic wellbeing is about self-fulfilment, finding meaning in life and developing one's potential [30]. Our model is intended to serve as a submodel for existing models of personal informatics. Our approach provides new insights for designing fitness goals that evolve with the user and support long-term tracker usage.

This paper contributes the following: (1) a qualitative study of the practices in using tracker goals consisting of 19 interviews and a survey with $n = 162$, (2) an account of the users' current practices with tracker goals and (3) the Tracker Goal Evolution Model — a new understanding of goals that uses the lens of hedonic and eudaimonic wellbeing.

In this work, we first introduce the reader to hedonic and eudaimonic wellbeing and review related work in HCI on understanding user practices around trackers. Next, we report on the details of how we conducted the interviews and the survey. We then introduce the Tracker Goal Evolution Model. The following section illustrates how the model describes user practices around fitness tracker goals. Finally, we propose how our results may be operationalised to enable designing meaningful goals for personal trackers.

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RELATED WORK

In this section, we first introduce the reader to the hedonic and eudaimonic wellbeing literature to build the understanding lens we apply in this paper. We then review past work in the HCI field in the area of personal informatics and showcase how an extended understanding of tracker goals is needed.

Hedonic and Eudaimonic Wellbeing

In this work, we use the lens of hedonic and eudaimonic wellbeing to understand a subset of the user's internalised needs that are manifested through goals. These goals can be supported with fitness trackers. These concepts form the theoretical basis of the understanding of current practices in our model. Research in Psychology has been using two different conceptualisations of wellbeing for the last two decades, hedonic wellbeing and eudaimonic wellbeing [30, 34]. The main focus in the field of wellbeing research lies in hedonic theories. This concept has mainly been associated with the presence of positive affect and the absence of negative effect. However, recently scholars have begun to recognize the potential of eudaimonic wellbeing as a means of gaining a deeper understanding of user behaviors and needs. Eudaimonic wellbeing focuses on self-fulfilment and meaning [30]. Positive psychology (the scientific study of positive human functioning and flourishing [31]), points out that the notion of subjective wellbeing is often used for the concept of hedonic wellbeing and the notion of psychological wellbeing for the eudaimonic approach [10]. Hedonia and eudaimonia are not opposites, nor are they mutually exclusive; they are complementary psychological functions [19]. As the literature does not agree on a single conceptualisation of hedonia and eudaimonia [21], we focus on recurrent characteristics of hedonic and eudaimonic wellbeing to use them to understand fitness tracker goals.

Four distinct categories of wellbeing definitions can be found [21]: *Orientations* focus on people's aspirations, motives, goals, values and ideals; *Behaviors* describe activities of individuals; *Experiences* are constituted through emotions, cognitive or affective appraisals; and *Functioning* addresses the individual's potential of living a healthy, functioning life. The concepts of hedonia and eudaimonia have been featured in recent HCI research. Notably, Mekler and Hornbæk [27] discussed how user experience research can benefit from embracing the concepts of hedonia and eudaimonia. Our work is the first, to our knowledge, to apply these concepts to tracking. Here, we do not address hedonic and eudaimonic experiences. Instead, our work addresses the concepts of hedonic and eudaimonic wellbeing with a focus on *orientations*.

Hedonic wellbeing

The philosopher Aristippus introduced the term Hedonism in the fourth century BC. He postulated that the search for pleasure was the most desirable good [33]. Hedonic wellbeing is often associated with the term 'happiness' and its dimensions can be positive feeling, pleasure, enjoyment, positive emotions, painlessness, ease and satisfaction amongst others [10, 20]. The hedonic concept can include physical pleasure as well as feelings of emotional or cognitive comfort. In a hedonic mindset people focus on wellbeing as an outcome [14]. However, the concept of life satisfaction does not fall into the classic understanding of hedonic wellbeing [9].

Eudaimonic wellbeing

The first one to define the concept of eudaimonia was the Greek philosopher Aristotle [18]. Aristotle postulated that the key to wellbeing was to develop one's potentials and live a meaningful and authentic life. Even though definitions of eudaimonic wellbeing vary widely, some recurring aspects can be found [20]. Eudaimonic wellbeing can relate to many aspects of an individual's life such as: value, relevance, maturity ethics or autonomy.

We believe that hedonic and eudaimonic wellbeing, as it offers an operationalisation of needs related to oneself, offers a way to gain a deep understanding of fitness tracker goals. Fowers et al. [14] found that hedonic and eudaimonic wellbeing are directly related to goal orientation. That is why, in our inquiry, we use the concepts to study and chart how users manage, change and define fitness tracker goals. We noticed that these can evolve like the ever-changing wellbeing needs of an individual. Using this analysis lens resulted in the emergence of our Tracker Goal Evolution Model.

Personal Informatics

A large array of past research efforts explored the understanding of user practices around trackers. As more and more users buy fitness-tracking wearables, it remains a challenge for HCI to enable designing trackers that offer tangible and reproducible benefits to wellbeing. This is a key consideration as currently available trackers have been proven to offer limited health and wellbeing benefits by studies in the medical field (e.g. [22, 3, 6]). Consequently, HCI looked for design guidelines that understood fitness trackers as instances of persuasive technology. Notably, Consolvo et al. [8] built a mobile application prototype to establish design requirements for health support technologies. They stressed that fitness systems 'should give users credit for their activities' thus recognising that building a sense of achievement was key for fitness technologies. This indicates the importance of understanding goal practices and how systems can support goal setting.

Challenges of Numeric Goals

As fitness trackers became a mass-market phenomenon, HCI scholars began to study different aspects of the tracker experience. Particular attention was given to step goals and step programs. Gorm and Shklovski [15] found that workspace step counting programs affected the users' privacy concerns. They also determined that the competition caused by step goals in trackers called for users making moral choices and possibly raising social tension while providing no tangible health benefit [16]. These examples show potential drawbacks to fitness goals that need to be addressed further.

Understanding Lapsing

Concurrently, understanding why users abandon and return to fitness trackers became a major question. Clawson et al. [7] studied craigslist users disposing of tracking technology to find that it could be equally motivated by perceived failure, success or social pressure. Further, Epstein et al. [11] found that the practicalities connected with maintaining data or the practices revealed by tracking may also be reasons for lapses. To mitigate possible drawbacks of lapses, Agapie et al. [1] proposed a design strategy to enable users to consciously

lapse by using 'cheat points' and showed that this approach produced positive behavioral effects. Our work is interestingly different as, instead of mitigating or finding reasons for lapses, we investigate them as possible manifestations of insufficient motivation provided by the tracking system.

Models of Personal Informatics

Finally, a number of efforts aimed at building a holistic understanding of practices around fitness trackers. Notably, Epstein et al. [13] proposed the lived informatics model of personal informatics that inspires designing for data-driven reflection and described cycles of tracker use. They extended earlier work by Li et al. [26] by, inter alia, accounting for users returning to trackers after lapsing. Epstein et al. model personal informatics as consisting of four major phases: (-) deciding, (-) selecting, (-) tracking and (-) acting and lapsing. The lived informatics model presents the most comprehensive view of personal tracking presented so far, yet the authors explicitly state that one consequence of applying their model is the need to harness goal migration. We aim to extend existing models by focusing solely on the *tracking and acting*. Our work aims to take another angle from previous works as it looks specifically at goals related to fitness in order to aid in designing more engaging tracking experiences. We strive to understand goals better to help users continue what Epstein at al. call *tracking and acting*, thus possibly producing long-term benefits. Hence, a need for a model that specifically addresses goals emerges.

Additionally, Rooksby et al. [29] identified tracking styles that characterised different data-driven needs of users. Tang and Kay [32] studied data practices of those using trackers long-term and found that users appreciate feedback about their adherence and can reflect upon their own tracker practices. In contrast, this work endeavors to understand user practices specifically around tracker goals, thus investigating how tracker goals can contribute to maintaining and/or improving the user's wellbeing. Our work is further motivated by the fact that past research has shown a large array of user behaviors and attitudes around trackers, yet current devices only support a small number of goals.

METHOD

In order to explore the users' relationship with tracker goals and the ways they choose, manage and interact with goals, we conducted a two-part inquiry. First, we conducted exploratory interviews with participants who were active users of fitness trackers. Based on the interviews, we designed an online survey to explore aspects of tracker goals in a larger population sample.

Interviews

The semi-structured interviews lasted an average of 31 minutes (20–65). Each of the interviews was a one-on-one session with a single researcher. We recruited $N = 18$ participants through snowball sampling starting with social media posts. The participants were aged 18–41 ($M = 26.67$, $SD = 5.42$). Nine interviewees were male and nine female. Interviews were only conducted with participants who identified as users of fitness trackers. All the sessions were audio recorded upon receiving consent from the participant. Table 3.1 shows an overview of the interview participants.

ID	Age	Sex	Profession	Tracking Time	Primary goal	Device used
P1	29	M	IT specialist	2 yrs.	Steps	Fitbit
P2	30	F	Teacher	2 yrs.	Steps	Fitbit
P3	21	M	Student	3 m.	Steps	Xiaomi
P4	18	M	Student	2 yrs.	Steps	Polar
P5	29	F	Researcher	2 yrs.	Body mass	Xiaomi
P6	22	M	Engineer	8 m.	Active hrs.	Garmin
P7	29	F	Researcher	1 yr.	Steps	Xiaomi
P8	26	M	Engineer	5 yrs.	Steps	Fitbit
P9	29	M	Programmer	6 m.	Exercise sessions	Apple Watch
P10	35	F	Researcher	2 yrs.	Calories	Apple Watch
P11	28	M	Unemployed	9 m.	Exercise sessions	Apple Watch
P12	27	F	IT specialist	1 yr.	Steps	Xiaomi
P13	29	F	Data specialist	6 yrs.	Steps	Fitbit
P14	32	M	Car mechanic	1 yr.	Exercise sessions	Pebble
P15	41	F	Researcher	6 m.	Steps	Fitbit
P16	20	M	Student	2 yrs.	Steps	Xiaomi
P17	27	F	Unemployed	4 yrs.	Steps	Fitbit
P18	26	F	Student	6 yrs.	Steps	Fitbit

Table 1. An overview of the interview participants. All participants were active tracker users. The duration reported is the time since the participants stated tracking and in some cases includes lapse periods. Participant IDs are used throughout the paper to indicate interview quotes.

Interview protocol

In the interview, we first obtained demographic data and information about their daily usage of the tracker. We then inquired about the goals set, the motivations behind setting the goal(s) and the interviewees' history of changing goals. We paid particular attention to whether they planned the evolution of the goals and the reasons for changing (or not changing) them. In the next part of the interview, we investigated if the way users managed goals may have been connected to a history of lapses (which might have been key to understanding their tracker experience as shown by Epstein et al. [11]). Finally, we explored if and how users reviewed and reflected upon tracker data and how goals may have facilitated that process.

Analysis

All audio recordings were transcribed verbatim and imported into Atlas.ti analysis software. Two researchers coded a representative sample of 15% of the material using open coding. Next, a coding tree was established through iterative discussion. The remaining transcripts were split between the two researchers and coded individually. A final discussion session was conducted to finalise the coding tree after the material was coded. We then identified emerging themes in the transcript

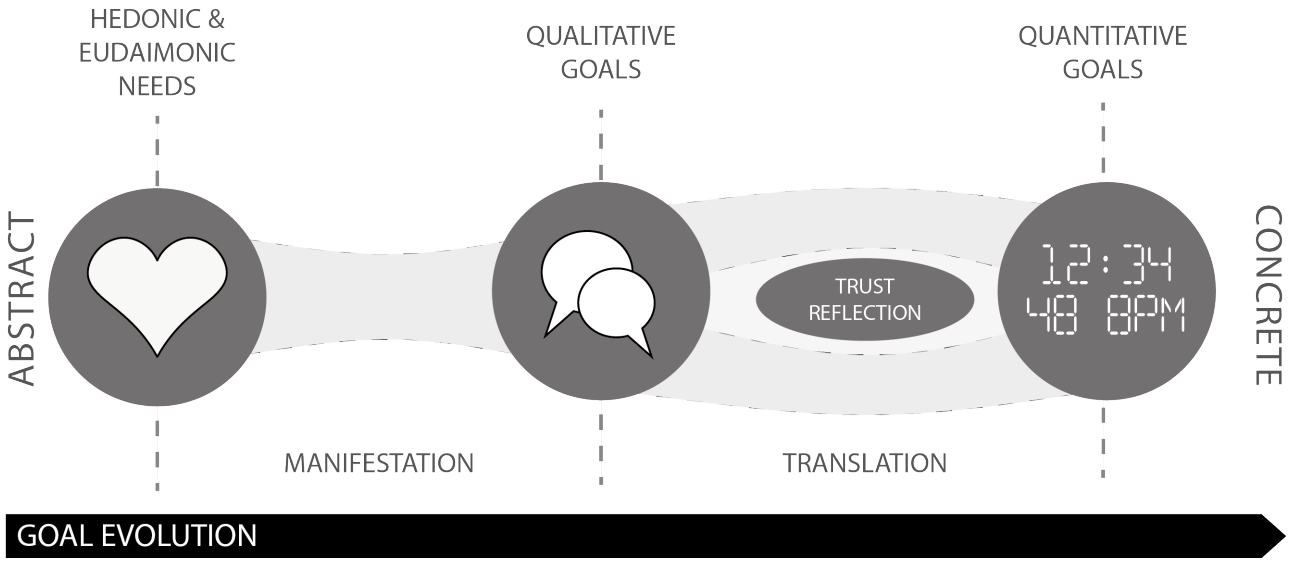

Figure 1. Our Tracker Goal Evolution Model. The model describes how qualitative goals emerge from internalised hedonic/eudaimonic needs. It then illustrates how qualitative goals are translated to quantitative tracker goals through reflection and trust.

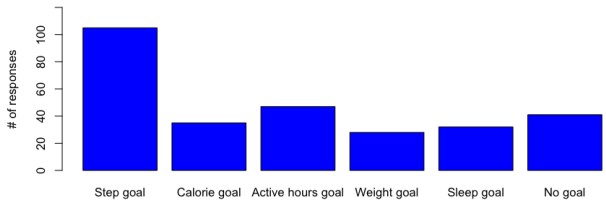

Figure 2. The quantitative tracker goals set by survey respondents. Note that users were able to report multiple goals as setting multiple goals is common in current commercial trackers. A free text field was provided for other goals, but none of the participants used it.

describing the practices around goals to further investigate in the survey.

Survey

Our online survey further investigated tracker goal practices identified in the interviews. The survey contained questions about whether the users had a goal set in their tracker and what kind of goal it was. Further, we explored how tracker goals related to qualitative personal fitness goals. We also asked participants whether they had a history of changing goals and reasons for (not) changing goals. Finally, we asked about the role of goals in their social environment. We used promoted social media posts and university mailing lists to recruit $n = 162$ participants (85 male, 77 female, aged 17–66, $M = 27.96$, $SD = 8.21$). The survey was available over three weeks.

All survey respondents were active users of fitness trackers. 137 participants were based in the European Union and 15 in the US. 75% (121 participants) of the participants had a goal set in their tracker, with the majority using a step goal. Figure 2 presents the different tracker goals the respondents used. Further, the majority (109 participants, 67%) of answers reported experiencing a lapse in tracking, defined as a break from using the tracker longer than a month. Most of the respondents (112, 69%) acquired the trackers themselves, but 50 participants had received a tracker as a gift.

THE TRACKER GOAL EVOLUTION MODEL

Based on the interviews and survey, we developed a new model of how fitness trackers goals evolve. The Tracker Goal Evolution Model focuses solely on understanding the needs of the users in terms of fitness tracking and meaningfully translating them into fitness goals. Further, it enables designing new goals and adjusting them as the user's fitness changes.

Our model is intended to be a subordinate construct to Epstein et al.'s [13] lived informatics model and, to a lesser degree, the stage-based model of personal informatics [26]. We extend the lived informatics model by addressing goals in more detail. We found that assuring that the user's goals can effectively evolve and keeping them engaged may prolong the time in which the users stay in what Epstein et al. call the *tracking and acting* stage. Similarly to Epstein et al., we do not adopt a behavioral change goal, but attempt to account for all motivations for tracking. However, while the lived informatics model addresses goals (discussed as *motivations for deciding to track*), it does not include changing goals and evolving needs, which we integrate into our model.

The Levels of the Model

Our model divides the understanding of fitness trackers into three levels: hedonic and eudaimonic needs, qualitative goals, and quantitative goals. We use the word 'levels' to distinguish them from Epstein et al.'s 'stages' as the constructs in our model are simultaneous rather than sequential. Each level in our model represents a different level of abstraction with regard to a fitness goal. The levels are highly coupled, so that success on any of the levels is tightly related to achievement

on the other levels, and a lack of satisfaction on one of the levels negatively affects the rest of the model.

We define the most abstract level as *hedonic and eudaimonic needs*. This level refers to the highly internalised needs of a user which are often not explicitly verbalised. While these needs vary significantly between tracker users they form both the core of their motivation and the anticipated benefits of tracking. In our model, the user primarily evolves on this level and the consequences of that evolution are then carried onto the following levels.

Qualitative goals form the next level in our model. They constitute a manifestation of the *hedonic and eudaimonic needs*. *Qualitative goals* are often verbalised and users consider them rational. The verbalisation of needs is often connected with social exchange. Users are able to share and discuss their goal with their social environment, e.g. their peer group. Furthermore, they are often regarded as sources of motivation and provide a personal reference for fitness achievement.

We define the most concrete level in our model as *quantitative goals*. These goals are often expressed by numbers and can be input in a fitness tracker. *Quantitative goals* are translations of *qualitative goals* into a form that can be used in a tracker. We further define two supporting factors necessary for this translation to be successful. Building trust in the goal and in the tracker is required for the goal to be relevant and stay meaningful for the user. The goal must enable reflection so that it can evolve and connect to the higher levels of the model. Here our model differs significantly from Li et al. [26]. While they saw reflection as a necessary condition, our model suggests that reflection and trust reinforce a pre-existing connection between qualitative and quantitative goals.

UNDERSTANDING THE MODEL

In this section we show how our model relates to the data we gathered in our studies and how it describes the current user practices around fitness tracker goals. Here, we present the recurring themes from the interview and survey data. As the model is closely tied to fitness tracking practice, it can be used to support designing meaningful goals.

Hedonic and Eudaimonic Needs

Through the coding process we found that users often used vague descriptions of their needs and motivations in the tracking context. Even though a broad spectrum of needs was expressed by the interviewees, they struggled to explicitly describe qualitative goals and a desire to transition from hazy descriptions to something 'easier to access' (P6). They struggled to specify what they hoped to gain from tracking:

> [...] *it is just more gadget for me than something that I really need. But I bought another one when the first one broke, so it means something. (P7)*

Another user expressed that she lacked clear goals as obtaining a tracker was motivated simply by her curiosity:

> *I really like playing around with technology and I also wanted to get a little more active. (P2)*

Another interviewee mentioned that an important goal quality is that the goal should make you feel good. Yet they found it hard to provide a more detailed description of what 'feeling good' would entail and they questioned the meaning of quantitative metrics:

> [...] *all the metrics we look at right now are really subjective. Everyone has a different stride which is then counted as one step* [...] *a meaningful goal is when you're satisfied with yourself, so with your fitness level* [...] *on a meta level* [...] *When you're satisfied with yourself and the metrics are in a way that they feel right for you. For example, maybe you're already fit if you run only 6,000 to 7,000 steps but the tracker recommends 10,000 steps. That's a really stupid metric because some people are also fit even if they run much more or just less. I think this is a very, very important factor for this* [...] *the tracker says for each person 10,000 steps is the ultimate goal. That's probably a stupid metric. (P11)*

The interviews showed that many users assessed the meaning and value of what they were striving for through their own feelings, instead of specifying a goal based on how they would like to feel. The following statement of one of the users shows that the connection between the user's feelings and his goal remained intangible.

> [...] *every time when you realize that it has an effect on your life, health and condition. I also saw the difference on myself and how do I feel when I was running and when I was not. And the general awareness that when you train you are feeling better and you are in a better condition what affects on your family life in the future. (P8)*

Users would often communicate a general need to evolve. They outlined their striving to become a 'better person'. Yet, they were still vague when queried about the nature of what the goal to achieve that should look like:

> *Going with the goals helps me achieve more. I'm this type of person. It's simpler to make new habits and just be better. (P11)*

One user emphasised the desire to regain a former fitness level. Interestingly, the means to achieve that were not described in detail:

> *Ah, my idea is just to get back to where I was before pregnancy. That's it. I think I reached a plateau there. I couldn't do more than that. If I wanted to do more than that then I should stop working and do sports! (P10)*

Our results show that users often find it hard to express their fitness goals. It becomes especially hard if one tries to formulate goals using the means available in current commercial trackers. On one hand, this is caused by the multitude of motivations for tracking (here our finding connect to Epstein et al.'s model [13]). On the other, we observed that participants often struggled with expressing their fundamental human needs with regard to wellbeing. That is why, in our model, we employ the theories of hedonic and eudaimonic wellbeing. Our model describes current practices as it shows that users need support for manifesting basic wellbeing needs (defined through hedo-

nia and eudaimonia) in the form of qualitative goals. Hedonia and eudaimonia can manifest goals, needs or both.

Qualitative and Quantitative Goals

Models of personal informatics list different motivations for starting the tracking experience [13], yet they do not discuss how these motivations relate to tracker goals. We observed that motivations (which stem from hedonic/eudaimonic needs) are often manifested through qualitative goals and then translated to quantitative goals that can be input into trackers. Thus, understanding the relationship between qualitative and quantitative goals is a key element in our model.

We noted that 97% of the participants in our survey reported having a qualitative goal. This was reflected in the interviews, where most users replied with a qualitative goal when asked about 'a goal'. One participant explicitly stated that she did not find a quantitative goal meaningful in contrast to her qualitative goals:

> [...] *since I remember, I did a lot of sports. The numbers don't motivate me. (P17)*

Further, when we reflect upon perspectives on their desired fitness, participants would often refer to mental states and a personal perception of being on track as a reference. The ultimate goal for fitness was often described in terms of motivation and perception of progress:

> *The most important thing is that the goal actually is related to some kind known level/range to some extent, that we consider ourselves active or advanced and* [...] *also motivates us to perform better. (P1)*

We further observed that the users would set qualitative goals for fitness activities that were not explicitly tracked. They used quantitative metrics as approximations of their activity, but they were concerned primarily with the untracked activity. P18 reflected how step counting complemented her activity in football practice where team expectations were her main focus:

> [...] *in the past things that have motivated me have been being part of a team. Not necessarily for step count but I did play soccer for my university and knowing that I had a bunch of other team mates who were counting on me to be fit really motivated me to make sure that I was actually working out and getting steps in... well really, getting runs in at that point. (P18)*

Similarly, users reported making day-to-day decisions using qualitative goals. Participants would often aim to keep a perceived activity level without referring to qualitative measures thus prioritising their perception of activity over tracker metrics:

> [...] *OK, today I will work in the lab with my computer, so the day will be a bit lazy, so it will be good if I will take a longer walk and I'm OK with that. (P4)*

In contrast, our study also included users who had very well manifested hedonic needs which were easily translated into quantitative measures. These users would build their entire experience around documenting progress in numbers:

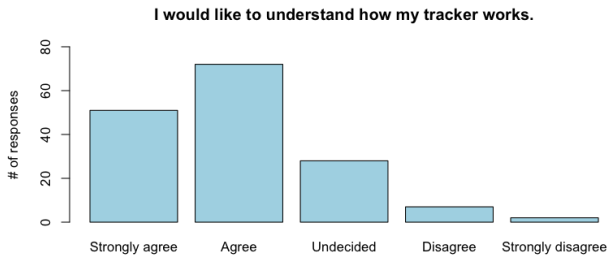

Figure 3. 76% of the survey participants reported that they 'strongly agree' or 'agree' with the sentence 'I would like to understand how my tracker works.'.

> *I'm just obsessed with the weight. I mean I have phases. At some point I was really obsessed with the steps, so then I would just really walk in the apartment,* [...] *so it's kind of claustrophobic.* [...] *But now I'm really obsessed with the weight. And the scale is really accurate. You can really see if there's 100g on or off. So I feel like I document this, I did it. (P7)*

While P7 experienced an effective match between her needs and the quantitative measures, other users stated that numeric metrics posed some challenges. One participant who had an active hours goal expressed that the time periods were arbitrary and could sometimes be disruptive, which illustrates a mismatch between the qualitative goal ('be active throughout the day') and the quantitative translation in the tracker ('Make 250 steps in 9, 60-minute periods starting at the full hour'):

> *Yeah, I actually sometimes get annoyed, 'cause sometimes I'm pretty focused and then it interrupts me. I've never really appreciated that... being the middle of a thing and be like 'Yeah get up!' It's not really my behavior. (P18)*

It can be observed that the translation from qualitative to quantitative goals is a factor that determines the quality of the experience of tracker goals. Our model encourages making that translation explicit and empowering users to realise how the quantitative goals that their tracker uses relate to their perception of fitness. Our results show that the awareness of that relationship can lead to increased engagement and foster potential for long-term usage. Tracker goal designs should make this relationship approachable and ensure the users are aware of the purpose of their qualitative goals. We determined that two factors, reflection and trust, are key to strengthen the user's understanding of how tracker goals relate to their personal fitness goals.

Supporting Factors: Reflection and Trust

Our survey has shown that 76% of the participants expressed the desire to understand more about their tracker as shown in Figure 3. Simultaneously, 48% of the users perceived their tracker as accurate (see Figure 4). This illustrates that those using fitness trackers have a need for increased knowledge of how the tracker works. Further, they do not fully trust the data provided by current commercially available fitness trackers. These opinions also resonated in our interviews.

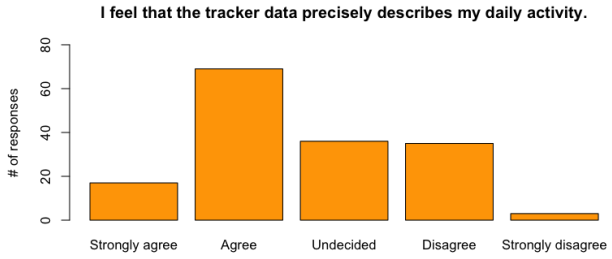

Figure 4. 47% of the survey participants reported that they 'strongly agree' or 'agree' with the sentence 'I feel that the tracker data precisely describes my daily activity.'

Goals and Trust

We noted that many of the interviewees explicitly requested that the tracker suppliers provide more information about the inner workings of the device:

> [...] *they have to describe precisely, or more or less precisely if they don't to want to show the algorithm, how is this calculated or something. Or, just to show a description would be enough. Here we take your heart rate variability and multiply it by 60. I don't know. That would be enough. (P8)*

Further, most interviewees recalled being surprised by tracker measurements or thinking that the measurement was incorrect. This often led to confusion or immediate doubt in the accuracy of the device. One participant was concerned by the discrepancy between their perceived sleep quality and the data provided by the tracker:

> *But when you're tired and you have the feeling that you've slept only for three hours and it shows you eight, you cannot believe. Or sometimes, I don't actually know how it works, but it shows how many times did you wake up at night and sometimes it shows 15 and you don't remember waking up at all. But then I still cannot say that it's true, 'cause you move when you sleep and you're not so sure that you woke up. Maybe just the device didn't recognise it. (P16)*

In contrast, another user also believed that the tracker provided sleep data that was not fully accurate. However, they decided to use the offered precision as an acceptable reference metric:

> *Yes, it's not 100% trustworthy, but you can get a hint of quite well of what was your sleep and how was your sleep. (P17)*

We also observed that a lack of accuracy and/or trust in the data may have led to partial abandonment. One of the interviewees reported initially tracking sleep, but then realising that the metrics provided did not enable him to understand his sleep patterns well enough:

> *Before I was also using it to track sleeping, but I'm not using it anymore, because it was not giving me enough data. (P9)*

The limited accuracy of current trackers caused some users to wonder how much knowledge about their body their trackers should provide. For users who aimed to get a deep understanding of the metrics, a mismatch potentially caused by lack of accuracy was a reason for concern:

> *For the heart rate it's very difficult because it's often very different and I'm not sure if this is a measurement error or is this my real heart rate? Because sometimes I am working really slowly and then I have a heartbeat of 140 where I usually have a heart rate of 90 or 100. (P7)*

Another aspect of trust that we found in our data was trusting in the fitness goal being meaningful. Users endeavored to understand enough about the goal so that they could find it actionable and feel in control of their progress. They also expressed the desire to trust in their tracker helping them manage activity towards their goal. One user was disappointed at the notifications reminding them to move when they have already exceeded their goal for the day:

> *Maybe if I would understand a step goal a little bit more I could say 'OK, I [want to] accomplish 20k steps'. I think that I would appreciate it a little bit more* [...] *but when it tells me to move I'm kinda annoyed, when I've achieved this step goal* [...] *It usually happens when I've been walking a lot. (P12)*

Users also appeared to lose trust in their goal when it did not adjust with significant changes in their life. Participants found that they could not connect tracker goals with changing training regimes, nutrition patterns or family situations. One interviewee remarked that she found her goal useful before her pregnancy, but the goal became confusing after the birth. This shows how the user trusts the goal to be meaningful and expects to be able to reflect upon it.

> *But before pregnancy I was looking at the green cycle, circle, the exercise thing [referring to Apple Watch activity visualisation]. But I don't have really intense exercise right now, so doesn't really tell me more. But before I was looking at it, for example to cycle more, faster or something like that.* [...] *I don't really understand it, I don't know. Maybe I need an explanation why this is useful or not, I don't know. (P10)*

Reflecting on Goals

Several participants reported that they not only expected the tracker to reflect profound changes in their lives, but also respond to slowly changing routines on an everyday basis. One reported that the tracker understood their erratic work and sleep patterns caused by a medical condition:

> *Sometimes when I work from home the step counter value is much lower. I can tell that I worked from home like 2 days or something over the weekend. Then I feel like* [...] *it's kind of nice to work from home, but then the step counter is not really active. So next time, maybe next week, I'll have a full work week, so I won't work from home next week.* [...] *My medication is actually influencing my sleeping patterns and I'm actively taking medications to avoid this. And I change them according to how effective they are. So I just check the sleeping time,*

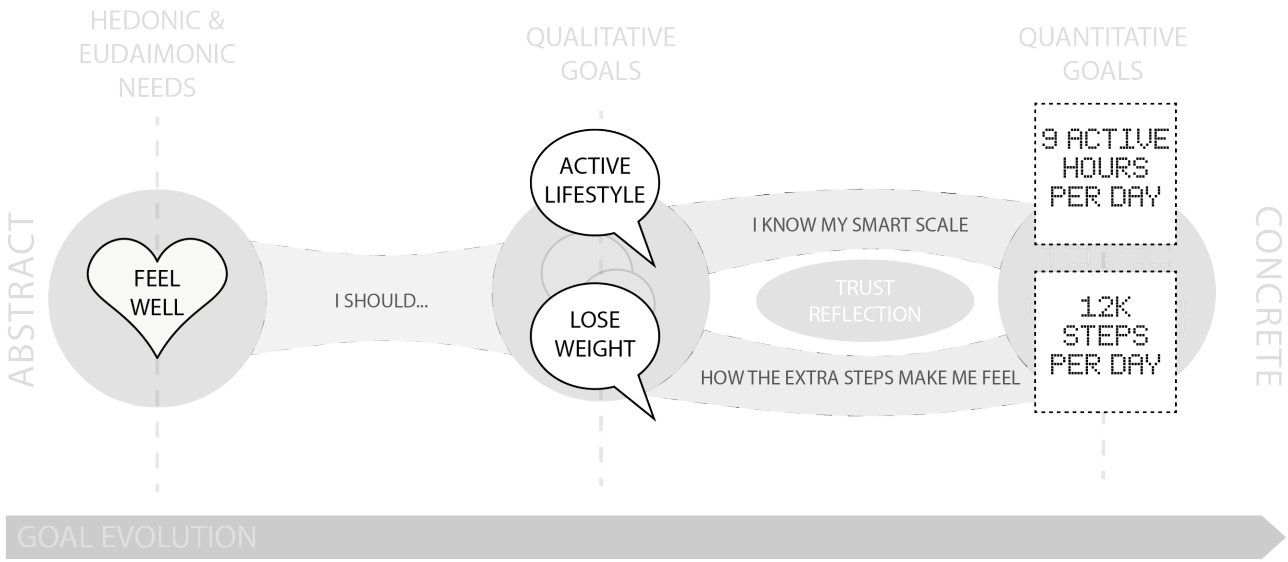

Figure 5. Example of how the Tracker Goal Evolution Model can be used to understand a part of the goal practices of a single user. The user's goals are built around the eudaimonic need to feel well in one's body. The need is then manifested through the desire to lose weight and lead an active lifestyle. The tracker can then help translate those goals into an active hours goal and a step goal. In order for the goals to provide engagement and allow for evolution, the user must know the relationship between the numeric metrics and their qualitative perception. They also need to trust and understand their goal and tracking technology.

> *not the quality but the time. So like when I went to sleep when I woke up and stuff like this. Yeah, it's kind of an overview of how things were this week. (P5)*

We further observed that users wanted to reflect upon activities that were not explicitly tracked and relate them to tracker metrics so that they could have an overview of their fitness. One participant tried to compare their car mechanic work with running:

> *If a wheel weighs 120 pounds and I have to move that around a lot, granted, it rolls, but you also have to pick it up half a meter-ish. The amount of work I do is generally in spurts. Translate that to the running side, it would be more like sprinting a lot, because I'll drive for an hour to a location, work on a couple trucks and even when I'm working on a truck, I'll work in one spot for 15 minutes to an hour. (P15)*

Some interviewees reported that they had moments when they explicitly decided to reflect on their data. To that end, they used opportune moments; periods when they had time to spare:

> *Last time I had some problems with falling asleep, I went to the beach, I synchronized my Fitbit with my smartphone and checked some data. It makes more sense to check it after a longer time because then the plots are showing better data. (P1)*

Another participant used the metrics explicitly to calm down and maintain a slow walking pace in a stressful situation:

> *During my master exams I was stressed and I didn't know what to do with myself. I wondered what I could do to just free myself from the surroundings and be less stressed out and I just started walking with my dog.* [. . .] *I had a slower pace, so I could chill and think about different things. (P16)*

Finally, many of our participants expressed the desire that the tracker should have provided them with an overall assessment of how well they were in general. They wanted an objective measure that would go beyond a perception that could be gathered from other sources:

> *I also consider my tracker as a good summary of what I do with my body. For example, for running, I do use a running app, which tracks my activity while running and I have in-depth stuff in it but for other activities I don't use any software or separate device to monitor the goal* [. . .] *'cause this I do more for fun and cause I like being active* [. . .] *but the tracking could give me an opportunity to sum it up and get a more or less precise view* [. . .] *on all these activities. (P4)*

Our results show that different dimensions of trust are instrumental in the user's interactions with a fitness tracker goal. In our model, trust must be mediated to maintain engagement with a fitness goal. Two aspects of trust are key: trusting the accuracy of the tracker and trusting that the fitness goal is meaningful. The first kind of trust can be built by making the operation principles of trackers available to users. We observed that participants need more information about how trackers store and process fitness data in order to maintain a more informed relationship with their fitness goals. Trust in the meaningfulness of one's fitness goals can be through providing a clear link between the numerical metrics and their envisioned consequences for health and wellbeing. This shows how trust is a mediating factor in our model that is necessary for users to connect qualitative and quantitative goals.

However, we observe that trust cannot exist without the ability to reflect. In our interviews, users often connected their qualitative achievements to quantitative goals through reflection. Through using opportune moments to reflect users are looking to qualitatively assess their progress towards their qualitative goals with the help of the measures provided by the tracker. Consequently, reflection is a necessary mediating factor in our model. Together with trust, reflection forms two intertwined requirements to keep the user engaged and provide a rich experience of fitness tracking. Our results suggest that these two qualities are necessary for the user's goals to keep evolving and empowering them to adjust their goals according to the changes in their life.

USING THE MODEL

Having illustrated how our model reflects current user practices around trackers, we now show how it can aid the design of tracker goals in a future generation of trackers. In order for users to maintain engagement with their tracking experience, they need to engage with goals on the three levels of the model.

Understanding of whether a goal stems from a hedonic or eudaimonic need can help to design how the goal is communicated and presented, and how progress is reported. However, *hedonic and eudaimonic needs* of users are highly internalised, so it may be hard to query the user and obtain explicit accounts. Thus, we propose that systems begin the interaction with goals on the *qualitative goals* level. This is in contrast with current systems, which usually propose an arbitrarily selected quantitative goal and, in some cases, help adjust it. Our model shows that **users require an explicit connection between the numeric values presented by trackers and their qualitative goals**. That is why we propose that tracker applications should ask users about qualitative goals first. Then, as the system processes the user's qualitative goals, it can propose a connected set of quantitative goals that would lead to their achievement. Figure 5 presents an example of how our model can be operationalised to map the goals of a specific user.

We argue that the process of explicitly translating between qualitative and quantitative goals is key for meaningful interaction with trackers. Our results show that **the translation needs to be accompanied by building trust**. On one hand, trackers should provide information on how goal metrics relate to goals. Numeric metrics should be directly linked to anticipated health and wellbeing benefits. On the other hand, we observed that users also desire to understand how the metrics involved in their goals are obtained. Consequently, trackers should provide information on how progress towards a given goal is measured, in a form that is understandable by the user.

Further, our model can also be used to support the constant evolution of goals that go beyond the current practice of simply increasing goals by an arbitrary number. Firstly, trackers should **empower users to reflect on their qualitative progress by referring back to qualitative goals** and showing how daily quantitative goals contribute to a larger qualitative meaning. This will enable them to understand progress in qualitative terms and adjust their qualitative goals in conjunction with quantitative goals. Secondly, being aware of the user's qualitative goals will enable designing systems that link them to hedonic and eudaimonic needs. This, in turn, will enable suggesting meaningful qualitative goals that foster reflection.

DISCUSSION

While we built the Tracker Goal Evolution Model to be as descriptive of current practices around fitness trackers as possible, it still constitutes a simplification. Our model proposes a way of thinking about fitness tracker goals that highlights the key elements of goal evolution that are needed to keep the user engaged. However, our approach is neither exhaustive nor fully analytical.

Hedonia and Eudaimonia are a Spectrum

Mapping a user's needs into hedonia and eudaimonia is difficult and a topic of discussion in the field of Psychology. Our model does not require one to fully analyse a user's needs as this can only be done by the user themselves. Instead, the fact that hedonia and eudaimonia are directly linked to qualitative goals in our model stresses the fact that fitness goals are manifestations of internalised needs. Remembering about hedonic and eudaimonic wellbeing while setting fitness goals can assure that the user's internalised motivations are part of the goal setting process. While we recognise that the understanding of how fitness goals relate to hedonia and eudaimonia presented in this paper is not complete, our research shows that quantitative goals are hard for users to relate to wellbeing.

Emphasising Transitions

The two transitions in our model (manifestation and translation) form an axis of goal evolution that should be strongly supported by fitness tracker designs. As our results show that users are in need for additional aids in making those transitions, a challenge for future design emerges. Concurrently, users expressed a desire to understand how trackers work and how the tracking metrics are obtained. Yet, current fitness tracking solutions usually offer a quick questionnaire at the beginning of the tracking experience and there is little engagement with the internals of the tracking system throughout the usage period. We believe that future trackers should make the infrastructure and the algorithms they use more transparent. In line with the concept of seamful design [5] trackers could show users parts of the details of their operations. Exposing the ways data is gathered in fitness trackers can help users understand the metrics they generate and thus build trust in the tracker. Showing how trackers decide to suggest goals to users and making their anticipated benefits explicit will help users understand how their qualitative goals translate to their quantitative goals better.

We recognise the possibility that some qualitative goals translate to quantitative goals better than others. For example, the interview data showed that participants concerned with weight were more number-driven. This creates on opportunity for future systems to offer multifaceted experiences that communicate with the user using a mix of qualitative and quantitative terms tailored to the user's personal goal. If future designs can chart where the user is on the hedonia-eudaimonia spectrum

and how number-oriented their fitness goal can be, new trackers should be able to offer more effective feedback and more personalised experiences.

Relation to Other Models

In this work, we illustrated how our model is subordinate to other models of personal informatics. However, as our work also addresses a number of high-level concepts, there are other theories and models that can be used to understand elements of the Tracker Goal Evolution Model. While reflection features prominently in our model and we provided examples of how users engage with trackers to reflect, we do not offer solutions for designing for reflection nor does our work describe the process of reflection. We see an opportunity to apply the knowledge and practices in reflective informatics (i.e. the design and understanding of interactive artefacts that promote and support the process of reflection [2]) to our model. Our model can contribute to understanding technologies for reflection by helping chart goal evolution that lead to developing reflective practice by users.

Further, we recognise that a model of trust could also be applied to our model. For instance, the trust-theory model from Castelfranchi and Falcone [4] provides a socio-cognitive computational model that could potentially help unpack the concept of trust in the Tracker Goal Evolution Model. This, in turn, can enable a deeper understanding of the trust dynamics involved in trusting the accuracy of the tracker and finding one's fitness goal meaningful. Our model shows that future tracker designs should embody trust to offer long-term engagement. Thus, we see that future research on building trust in tracker design is required.

Limitations

While we strived to make our model as comprehensive as possible, we are aware that it is prone to some limitations. Firstly, our user sample consisted primarily of Western European participants. Past work used primarily US-based populations recruited through Mechanical Turk. We recognise that our findings are still constrained within the Western culture. Fitness trackers are not only prominent in Asia, but they are also entering emerging markets and further studies are needed to understand the user practices around trackers in these settings. The user experience of personal informatics is likely to be affected by cultural biases. The risks and opportunities that come with the ubiquity of fitness trackers may be experienced differently based on the sociocultural context of the data collected.

Moreover, we decided to focus our inquiry solely on fitness tracking, while other models endeavored to cover the entire field of personal informatics. Our focus enabled us to engage with the intricacies connected to fitness, but it also limits the applicability of our model. The relationship between quantitative and qualitative goals in our model is described based on user practices with very specific metrics, e.g. steps and calories. Consequently, our model would need to be adjusted to scale to other domains of personal informatics.

Future work

We believe our approach to understanding and designing fitness goals for trackers offers a more effective operationalisation than applying complex motivational theories from psychology to designing for fitness, in contrast to work by Knaving et al. [24]. However, we see further improvements to understanding fitness tracker goals that can be addressed by future research. Firstly, we envision that users can be queried about the nature of their goals to identify how their goals are placed in the hedonia-eudaimonia spectrum. This would enable designing goals that build on internalised motivations. How the tracker could communicate with the user to obtain such information is an open question, cf. [28].

Secondly, we wonder how a better understanding of one's goals and the goals of others can enhance social interaction. Future research can explore how better fitness goals can help use tracking data in communication (much like HeartChat[17]) and sharing data to build insight, cf. [35]. Our model also offers the possibility to understand the social dynamics in families or groups behind goals to build situated reflection systems (like [23]), but this potential must be verified in further studies. Finally, we wonder how our model generalises and if it needs to be adapted to domains other then fitness tracking, e.g. menstrual cycles, breastfeeding, diet tracking, or sleep. While our inquiry was limited to tracking physical activity, it may address other personal informatics experiences, much like the lived informatics model [13].

CONCLUSION

In this paper, we introduced the Tracker Goal Evolution Model. Our model describes the user practices around fitness tracker goals on three levels: *Hedonic and eudaimonic needs*, *Qualitative goals* and *Quantitative goals*. These three levels are connected with two transitions: manifestation and translation. We based our model on a series of semi-structured interviews and an online survey. Our model enables charting an individual's goals in order to build more engaging and evolving tracking experiences. The model can be used as a complement to models of personal informatics as it offers a new perspective on how a user's goals evolve through the journey through personal tracking.

We hope that our work will help researchers and designers address new challenges with personal tracking and build trackers that offer long-term benefits. Our model aims to contribute to a new generation of trackers that offer engaging experiences and tangible benefits. In future work, we hope to investigate how it can help generate alternative designs for fitness trackers and ways to communicate its levels and transitions to the user in a meaningful way.

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