FutureSelf: What Happens When We Forecast Self-Trackers' Future Health Statuses?

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ABSTRACT
The adoption of self-tracking services to improve health-related behavior is increasing. Although psychologists claim that thinking about the future has a motivational impact on current behavior and cognition, few studies have explored using future forecast in self-tracking services. In this paper, we explore how future forecast information can be used in the design of self-tracking services. We conducted a four-week study that qualitatively investigated 11 participants' perceptions of and practices with future forecast information. Participants used the FutureSelf app that we developed, which forecasts dieters' future weights and expected goal achievement rates based on their current behavior. The findings reveal that predicting future weight based on prior performance induced participants to imagine their future selves and reminded them of their ultimate goals. In fact, the predictions became the participants' primary source of motivation. We also suggest design implications for self-tracking services that forecast users' future statuses.

Author Keywords
Consequence Information; User Experience; Design; Health; Activity Tracker; Self-Tracking; Personal Informatics.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
As Ebenezer Scrooge says after seeing the Ghost of Christmas Yet to Come in the novel ***A Christmas Carol***, "*Men's courses will foreshadow certain ends, to which, if persevered in, they must lead, but if the courses be departed from, the ends will change. Say it is thus with what you show me* [9]." After being visited by ghosts showing his future, Scrooge realizes that he will meet with a tragic end if he continues to be cold and miserly, and it transforms him into a changed man. He compares his future image as shown to him by ghosts to what he actually wants to be. The difference between these two images acts as a new stimulus, persuading him to change his behavior. This phenomenon was already studied by psychologists; they report that considering possible futures influences an individual's current cognitive/emotional state and goal-setting behavior [17].

Designers in the human-computer interaction (HCI) field have studied how to design self-tracking services to better induce, improve, and maintain health behavior change. One popular approach is to express self-tracking data in a more understandable and actionable way for users. Since thinking about the future affects motivation, predicting the future can be a viable approach to helping health behavior change. Self-tracking services also offer the potential to predict the future of the user. Self-tracking services store a wealth of personal health data that can be used to generate predictions by adopting advanced medical understanding. However, the information provided by current services is mainly related to past performance, not allowing people to imagine the future.

To explore how people's experiences with self-tracking services change as they gain access to predictive information, we devised a study in the form of a four-week weight-loss program and recruited 11 people who wanted to lose weight. Participants were asked to track their activities and food intake using a wearable activity tracker and to use the FutureSelf app, which forecasts the future consequences of continuing current behavior by analyzing the collected data. Interviews and journaling were employed to qualitatively probe participants' experiences both with and without future consequence information with respect to how they set and changed goals, how they planned strategies to satisfy these goals, and what motivated them to engage in certain behavior to achieve their goals. As a result, we determined that forecasting future weight based on current self-tracked data motivates users to change their behavior.

This paper makes following contributions: First, we suggest a new type of information to represent self-tracked data, which we term *consequence information*, i.e., the predicted future information based on collected data. Second, we reveal that this type of information can help increase users' motivation to engage in healthy behavior through in-depth qualitative user studies, and propose several points to consider when designing such type of information.

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RELATED WORK

Potential of Imagining the Future in Behavior Change

Psychologists have already sought to bridge the gap between people's conceptions of the future and their current statuses. There are two different ways that people conceive their futures. One way is to imagine possible selves, conjecturing how they might act, look, or feel in the future [7]. People may construct positive (want to achieve) or feared (want to avoid) selves, and individuals' knowledge, moods, and expectations affect the construction of those possible selves. In this process, people who imagine the future more explicitly are more confident that the future event will happen and tend to do more things that can catalyze it [1, 30]. In addition, people felt more motivated when a fictional future story was described from the third-person perspective rather than from the first-person perspective [35]. Additionally, Oettingen et al. distinguished expectation from fantasy, verifying that expectation has a greater motivational impact [21]. These studies imply that a conception of the future based on more objective criteria can better motivate people.

The second way that people can imagine their futures is to be reminded of their goals. When people set a goal, they fabricate several possible futures, select the one they most prefer, and conceive a plan to achieve that end state [3, 20]. Thus, a goal is a representation of a desired future and can motivate people, guide their behavior, and elicit better performance [2, 11]. "*The future, as represented by goals, exerts a major influence on current behavior* [17, p. 595]*."* Based on the potential of predicting people's future behavior changes, we suggest that the investigation of how people's experience is influenced when images of their futures are conceived in an objective and unbiased manner is important.

Limitations in Self-Tracked Data Interpretation

A large number of self-tracking services are available in the form of activity trackers and diet logging apps that help people collect and reflect on their personal information to foster health behavior changes. However, limitations exist regarding how people interpret self-tracked data. Although the ultimate goal of health behavior change occurs over the long term, self-tracked data are currently employed with reference to short-term goals and decision-making [29]. In addition, people cannot fully exploit the data to gain insights—not due to a lack of collected data, but because they lack the methodology for proper interpretation [8].

Providing people with the expected consequences of continuing their current behavior based on self-tracked data may eliminate the limitations in interpreting the data. If we forecast a dieter's future weight, that forecast can be connected to a long-term goal (to lose weight), rather than to a short-term goal (to have salad for lunch). Additionally, people do not need to contemplate their self-tracked data to conjecture the consequences of their current behavior; instead, the system can analyze the self-tracked data and make predictions for them.

Forecasting the Future in Current Self-Tracking Services

Although many self-tracking services help users set and attain their goals, current self-tracking services do not attempt to forecast a user's future status based on his or her current behavior. A few services provide some futuristic information; however, they do not reflect the consequences of users continuing their current behavior. "Noom Coach (https://www.noom.com/about/)", which is a smartphone app for dieters intended to help them develop better eating habits and lose weight, provides a tailored plan for users to follow after they set a goal weight. The plan includes suggestions such as how many steps to walk. The app tells users that if they stick to the plan, they will be able to reach their goal. However, it does not predict the future based on a user's current behavior.

Another application is "UP by Jawbone (https://jawbone.com/up)", which is a smartphone app that gathers data from users' fitness trackers to analyze and display information. It offers a "Smart Coach" function that provides personalized advice to help users make better choices. For instance, the Smart Coach might say "It's almost time for bed. Getting ready now will help you get in bed by your 23:15 bedtime." Smart Coach analyzes a user's current behavior to deliver the best advice and meaningful insights but delivers it more as a suggestion than as a predicted consequence of a user's behavior.

Suggesting healthier behavior can be helpful, but many scholars in the HCI field have discussed the subject of user autonomy in ubiquitous technology. Rogers has pointed that we are becoming more dependent on technology; thus, we need to design new technologies to encourage people to be proactive in their lives [28]. Forecasting future consequences has the potential to provide users with opportunities to set their own goals; rather than assigning a goal, the technology provides information to aid users' own goal setting. Forecasting benefits from technology being able to predict the future, but leaves the goal-setting process to the individuals.

DEFINITION OF CONSEQUENCE INFORMATION (CI) AND PERFORMANCE INFORMATION (PI)

To clarify what we have termed "the future consequence", we define Consequence Information (CI) as follows:

- CI: Information showing a consequence of an anticipated activity, measured from the average speed of an activity observed from the past up to the present.

As opposed to the concept of CI, we refer to the user performance data accumulated from the past up to the present, which is the most common method for reporting self-tracked data in existing services, as Performance Information (PI) and define it as follows:

- PI: Information showing a person's performance of an activity completed from the past to the present.

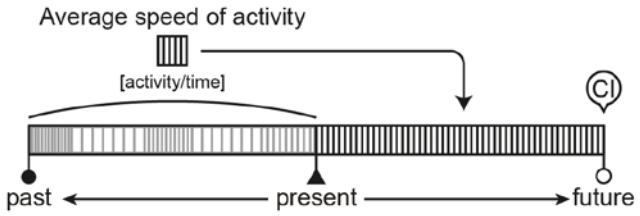

Figure 1. Definition of Consequence Information (CI)

The average speed of an activity (e.g., walking 10,000 steps per day) means the pace at which behavioral data have been accrued—such as a person's number of steps per day or daily caloric intake—from a past timepoint to the present (Figure 1). This value is used as a base to predict one's future activity; we assume that a user will maintain the same speed of activity up to a certain moment in the future. Given this information, we can obtain CI by predicting the future consequences based on the speed of the expected activities.

Consider Sarah (female, 60 kg), who tracks her step count. She walked between 7,000 and 12,000 steps each day, and her average step count per day over the past week was 10,000 steps per day. Thus, if we assume that Sarah will maintain the same speed of activity, she will walk 70,000 steps during the next week. A variety of consequences can be expected from this prediction: 1) she will reach 70% of her weekly step goal if her goal was to walk 100,000 steps in a week; 2) she will burn approximately 3,000 kcal if she maintains a pace of 5 km/h [16]. She can obtain different types of CI by tracking diverse health-related data. By defining CI in this manner, we can predict individuals' possible futures that are grounded in self-tracked data. CI is not a lie; it is a probable future state that can act to amplify the effect of a person's past performance. The future prediction length is adjustable to vary the size of amplification.

STUDY DESIGN

We devised a study to probe how the participants interact with CI; the study focused on the *weight-loss-related behavior* of dieters. CI can be clearly expressed for weight loss because people trying to lose weight tend to quantify their desired weight goals (e.g., 50 kg). Furthermore, a wearable activity tracker can provide adequate information to predict future weight, e.g., caloric intake and burn data. The FutureSelf app was developed as an example of how a self-tracking service can provide CI to dieters. The FutureSelf app accesses a user's personal data, generates messages based on these data and sends the messages to users. By adopting the FutureSelf app, the study was devised as a one-month weight-loss program, and people who wanted to lose weight by tracking their daily activity and food intake were recruited. During the study, journaling and five semi-structured interviews were conducted. And a year after the study, one follow-up interview was conducted in order to enable the participants to provide more objective reflection of their experience of this concept.

FutureSelf App Development

In the FutureSelf app system, the activity tracker Fitbit Flex was employed to log the participants' daily activities and food intake using built-in functions, and the messaging app Telegram was employed to send messages (Figure 2). First, users manually input their age, gender, current weight, height, goal calorie intake/burn, and wakeup/bedtime information to the FutureSelf app. Next, the FutureSelf app connects to the user's Fitbit server to collect caloric intake/consumption data. Then, it generates messages based on those data. To contrast experiences with and without CI, the FutureSelf app produces not only the CI messages but also messages that report only the accumulated user performance data (e.g., caloric intake). It sends the messages to users at designated times. To reduce bias from visual elements or a nuance, information was delivered as short text messages in a neutral tone, without any compliment or criticism.

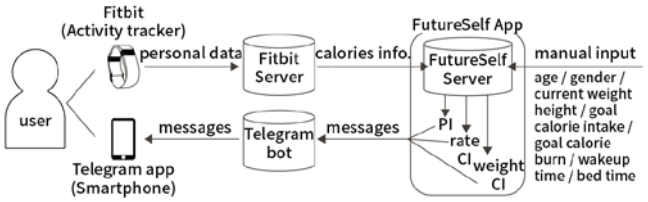

Figure 2. Data flow diagram of the FutureSelf app

To obtain PI, we need to select a certain point of time in the past. For instance, if we choose the timepoint as 00:00 today, PI corresponds to what Sarah has completed from 00:00 up to the present. If she walked 7,000 steps during that interval, her performance can be described as follows: 1) Sarah has walked 7,000 steps so far; and 2) she has achieved 70% of her daily step goal if her goal was to walk 10,000 steps a day.

The FutureSelf app generates PI and two types of CI (Figure 3). The PI describes caloric intake/consumption because this information is a fundamental factor with regard to weight loss. Since we initially did not know how CI would work, we created two types of CI and aimed to explore how the participants experience two types of CI: goal achievement rate CI (Rate CI) and future weight CI (Weight CI). Rate CI is calculated by comparing a user's goal for caloric intake/consumption to that user's expected future caloric intake/consumption. This calculation assumes that a user will make a linear progression during waking hours. Weight CI is produced using the weight-loss calculator, which predicts future weight by modeling the correlations between people's weight changes and information about age, gender, current weight, height, and calorie reductions/increases [34].

The FutureSelf app sends push notifications 30 minutes before sending PI and CI to induce manual logging (Figure 3) [4]. The FutureSelf app creates its messages based on users' updated Fitbit data, and the time lag between the actual behavior and the logging is reduced to avoid recall bias and produce more accurate data [6].

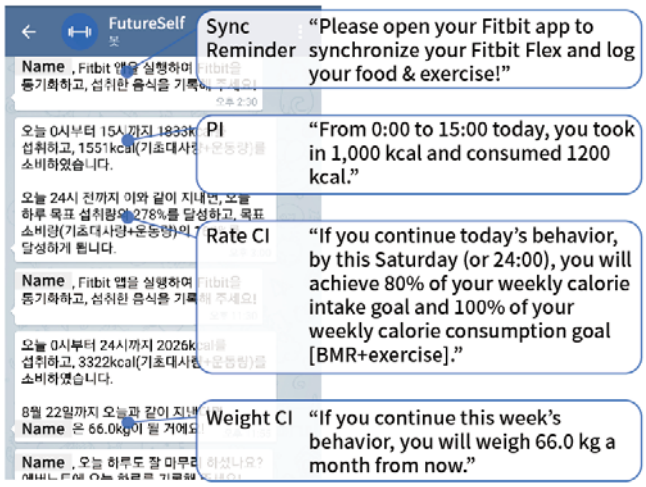

Figure 3. Examples of FutureSelf app message (screenshot)

Participant Recruiting

To observe various situations in which CI is addressed, we aimed to recruit participants with diverse qualities in terms of current weight, body mass index (BMI), and weight-loss goal. Five selection conditions were imposed on participants by conducting a preliminary survey. First, people who were already on a diet were excluded because time factors may affect people's engagement levels of weight loss [33]. Second, people who require clinical support were excluded since the goal was to observe how people manage their health behavior using their volition. Thus, people with a BMI that exceeded 25 were not selected because they were recommended to consider clinical support [10, 33]. Third, people with a BMI less than 18.5 after achieving their goal weight were not selected because the prediction tool that we employed did not offer predicted weight values for BMI values less than 18.5, which indicates that a person is underweight. Fourth, people in approximately the same age range were selected since physical condition can affect weight-loss performance. Last, people with similar lunchtimes and bedtimes were selected since message receiving times may affect the use of information.

This study was advertised on online communities where many local people spend time. All the participants were required to accomplish and adhere to four major tasks; 1) track daily activity and food intake using Fitbit, 2) check all messages from the FutureSelf app, 3) complete a short diet journal using online notes, and 4) participate in five weekly interviews. As a reward, those who completed the study received the activity trackers we provided for the study. Six men and six women in their twenties were recruited from among 110 applicants and were divided into two groups with even distributions of age, gender, and BMI (Table 1). However, one participant dropped out due to lack of active participation; therefore, the final analysis included data for 11 participants. The average BMI was 22.3 in Group A (SD=1.62) and 22.4 in Group B (SD=1.81).

Group	P#	Age, gender	BMI (Weight)	Weight-loss goal
Group A	P1	23, M	22.34 (78.3 kg)	-1.0 kg
	P2	23, F	20.60 (54.4 kg)	-2.0 kg
	P3	25, M	23.20 (77.7 kg)	-4.7 kg
	P4	23, F	22.73 (58.2 kg)	-3.0 kg
	P5	29, M	24.49 (74.9 kg)	-5.0 kg
	P6	23, F	20.22 (56.6 kg)	-1.6 kg
Group B	P7	22, M	21.40 (67.8 kg)	-1.0 kg
	P8	28, F	20.73 (51.1 kg)	-1.0 kg
	P9	28, M	24.18 (70.7 kg)	-1.0 kg
	P10	25, F	21.33 (54.6 kg)	-1.5 kg
	P11	27, M	24.58 (65.3 kg)	-5.0 kg

Table 1. Participants' information

Study Setup

In the beginning of the study, we planned to observe two weeks first, and then change into the most suitable settings to inquire design implications for CI. Participants were divided into two groups in order to clearly understand how the experience of CI is different from the experience without CI. During the first three weeks of the study, we provided CI only to Group B and concentrated on comparing the experience between Groups A and B to find out the unique potential of CI. After two weeks of observation, we found that the participants experienced Weight CI and Rate CI in profoundly different ways. Weight CI led participants to believe that their weight-loss goal was more attainable and, thus, motivated them, whereas Rate CI did not show such an impact: *(P10, week 1; CI provided) "I liked the percent value (Rate CI), but, it seemed natural after few days. However, after seeing this digitized value (Weight CI), I thought, oh, really? Can I lose weight if I continue this? No, but, no I didn't agree, I doubted it, but I became strong-minded. I was very motivated to do so."*

Thus, in the third week, we changed the CI setup to better investigate in what ways Weight CI motivated the participants to keep exercise and control diet. In the last week, Group B stopped receiving CI, whereas Group A started to receive CI. Each group's interview results of the 4th week were compared to the interview results of that same group's first three weeks, rather than making a comparison between Groups A and B. In this way, all participants were able to experience both situations—both with and without CI. We asked participants in Group B what they missed most in the last week without CI and asked Group A what they found most interesting in the last week with CI.

Message Generation (CI setup)

The FutureSelf app sends push notifications to users four times a day; twice (15:00 and 24:00) to provide PI and/or CI and twice (14:30 and 23:30) to request Fitbit synchronization and manual logging. These times were selected by considering participants' normal routines; all participants typically went to bed after midnight, had lunch between 12

PM to 2 PM, and did not eat a regular breakfast. Thus, we aimed to have them check the first message after finishing lunch and the second message before going to bed. The CI included in messages varied between weeks and the time at which the messages were sent (Table 2).

In the first two weeks, we sent Rate CI from Sunday to Friday because we assumed no large differences among the Weight CI if we provided it every day. Messages sent at 15:00 predicted participants' daily goal achievement rates, and messages sent at 24:00 predicted their weekly goal achievement rates. By doing this, we expected participants to plan the remainder of their day at 15:00 and to plan the rest of the week at 24:00. On Saturdays, we sent Weight CI messages, which predicted participants' future weights at the end of the study. These weights were calculated on the assumption that the participant would repeat the same performance as during the past week.

In the last two weeks, we decided to focus on Weight CI because we found that Weight CI has greater motivating power than Rate CI. Thus, we sent Weight CI at 24:00 every day to predict a person's weight at the end of the study based on their performance for this day. To investigate the influence of time represented in Weight CI on the user experience, we provided Weight CI predicting body weight two months after the start date based on this week's performance on Saturday.

Journaling, Interviews, and Data Analysis

We conducted six personal semi-structured interview sessions per participant: five during the study and one a year after the study. The first five interviews were conducted at one-week intervals. The first interview was conducted face-to-face on the day before the program began. Participants were asked to measure their body composition and bring the result sheet to this interview. A moderator asked the participants questions about their previous experiences with weight loss, other health-related self-tracking services that they had used, and why they wanted to lose weight. Then, each participant set a calorie intake/burn goal with the moderator's help based on their body composition data.

During the four weeks, participants were asked to write a short diet journal at the end of each day using a shared online notebook (Evernote) so that we could conduct interviews based on the journal entries. In the journal, participants were asked to write down the most impressive FutureSelf messages, their daily diet/workout goal, their strategy to meet that goal, and reasons for each response. In the three subsequent interviews, which were conducted by phone, we asked what the participants did after they checked the messages, how they utilized the information in the messages, whether they instituted any changes in their way of thinking or their lives due to the messages, what metaphors they would use to describe their impressions of the FutureSelf app, if they encountered any changes in their goals and diet plans, and how satisfied they were with their previous week's performance.

In the fifth face-to-face interview, in addition to asking the same questions as in the previous telephone interviews, we requested participants to compare the experiences of weeks 3 and 4 regarding their confidence, motivation, and pictured future self-image. We conducted a generative session to discuss redesigning FutureSelf messages to investigate participants' underlying needs for another type of CI or their preferences for message settings.

The final interview took place one year after the discontinuation of the FutureSelf app. This follow-up interview was conducted in the summer, just like the main study, so participants were considering diet. Through this interview session, we investigated how participants were affected by their previous CI experience when they were not exposed to CI. We also observed the participants' objective responses to their CI experience. Ten of the 11 participants responded to the interview request, and each interview lasted approximately 30 minutes.

Audio recordings were made of all interviews (27+ hours), and the recordings were transcribed within 2 days of each interview session. We separately analyzed the data collected when CI was provided and the data when CI was not provided, and extracted the influence of CI on weight-loss-related behavior by comparing those two groups of data. Our data were iteratively open and axial coded until we had clearly identified the issues that emerged. Affinity diagramming was also conducted to categorize those issues. Three of the authors who conducted the interviews were mainly responsible for analyzing the data; after individual analysis, the three interviewers analyzed all the data together.

Week	Time	Time period selected to calculate the average speed of activity	Future timepoint represented in CI	Type of CI (unit)
Week 1&2	15:00	15 hours	24:00 (the end of the day)	Rate CI (%)
	24:00	A day	Saturday (the end of the week)	
	24:00, Sat.	A week	A month after the start date	Weight (kg)
Week 3&4	15:00	15 hours	24:00 (the end of the day)	Rate CI (%)
	24:00	A day	A month after the start date	Weight (kg)
	24:00, Sat.	A week	2 months after the start date	

Table 2. How we generated CI

FINDINGS

We determined that Weight CI was imperative for dieters; one participant who was not given CI messages during the first two weeks tried to calculate his CI from PI: *(P1, week 3; CI not provided) "Every day, my caloric intake is 400 calories less than caloric burn, and if I assume only carbohydrates burn, I'm supposed to lose 100 g. That will be 3 kg in a month. I don't think that's accurate, but I think I will lose at least 1 kg."*

In the following section, we present findings from the interview analysis regarding how Weight CI, Rate CI, and PI were utilized during self-management of health behavior.

Weight CI Makes Participants Imagine the Future Self

Motivational impact of Weight CI originated from the participants' imagination of their future selves. Since Weight CI directly shows the weight (kg), participants were able to easily create their future self-images when Weight CI was given. Since participants did not have to translate or re-calculate given information, participants were able to acquire their future self-images in a concrete manner compared with when they had to estimate how their body would change based on information other than Weight CI. This imagination led participants to be more confident in their ability to lose weight and resulted in increased motivation. This finding is consistent with previous research findings, which indicate that people who explicitly imagine the future are more confident that the future event will occur and tend to do things that can catalyze it compared with people who do not explicitly imagine the future [1, 30]: *(P6, week 4; CI provided: commenting on Weight CI) "This week's alarm was much more helpful than the one from week 3 (CI was not provided). When I step on the scales, I see kg, not calories. […] I can picture detailed images and I feel more likely that I will really lose weight. I also thought I should work out more, and become more determined."*

Accordingly, some of the participants mentioned that having their weight forecast too far into the future may not be desirable because of the many possible variables that can influence events during that time. Those variables disrupt the clear envisioning of future self-images: *(P9, week 3; CI provided: commenting on Weight CI) "I'm not certain of what will happen in two months. Thus, I think predicting [weight] a month later [but not two months] is most appropriate since I can plan my schedule and imagine that I will lose some weight if I continue what I've done last week."*

Weight CI Reminds Participants of Their Ultimate Goal

In addition, because Weight CI represents information related to the dieters' ultimate goals, it naturally evoked participants' thoughts about their ultimate goals. What P6 conceived in the aforementioned quote corresponds to the ultimate goal (to lose weight) rather than a means to an end (to restrict calorie intake). After receiving Weight CI, participants tried to imagine their changed body, which spontaneously sparked recall of their ultimate goals. Remembering one's goal is important as a starting point in the cognitive process of behavior change; *"Thinking begins with goals and cannot move without them"* [31, p. 19].

Therefore, participants also wanted to be able to personalize the forecast date based on their goal dates. In this case, it was reasonable to forecast weight after a month because at the beginning of the study we asked participants to set a weight-loss goal for a month later. Likewise, participants wanted to be able to get specific forecasts targeting a specific goal date they had in mind: *(P4, wrap-up interview: commenting on Weight CI) "The weight forecast should tell me my future weight on my goal date, not on some arbitrary date such as three months from the start. Let's say I'm on a diet for my wedding. I'm going to be interested in my weight on my wedding day, not other days!"*

Accordingly, participants wanted CI to predict something related to their ultimate goal, not necessarily limited to weight (kg) information. Although the ultimate goal of all the participants was to lose weight, they approached it from different aspects: some wanted to reduce body fat, while others aimed to fit into smaller jeans. Participants perceived that CI directly refers to their ultimate goal to be more intuitive: *(P8, week 3; CI provided: commenting on Weight CI) "The weight forecast was useful, but it may also be good to forecast my clothing size. […] Saying 'you will be able to fit into your size 24 jeans!' will make me say 'wow!' and I will diet even harder."*

The Use of Weight CI Depends on the Individual's Ultimate Goal

The impact of Weight CI on participants' experience differed according to their ultimate goals. Weight CI was more important for participants who wanted to lose weight than participants who wanted to maintain their current weight. In the follow-up interviews, some participants' diet goal was not to reduce but to maintain current weight. In this case, Weight CI was not as influential as it was during the diet program. Since they were not expecting a change in the value, to step on a scale every day and confirm that their weight was within the acceptable range was an easier way to manage their weight. If a person's goal is to "maintain" a certain value, CI is not the best form to present this value: *(P1, follow-up interview: commenting on Weight CI) "Now my goal is to maintain this weight, not losing or gaining too much. […] There is a scale at the gym, and it shows my weight if I step on it. […] So, information that I will be xx kg in the future is not really relevant to me. I can check my weight right now, so there is no need to know my weight a week later."*

P6 wanted to incorporate Weight CI in her daily life, even when she is not on a diet to ensure that she is alerted before she gains weight. She regarded weight as a simple indicator to keep an eye on her health. Thus, after she stopped using the FutureSelf app, she tried to use her knowledge from Weight CI to calculate her Weight CI each day. However, since her weight changed, she could not use this knowledge anymore. Therefore, she wanted Weight CI to act as an alarm clock to warn her that she needed to be careful: *(P6, follow-*

up: commenting on Weight CI) "I want FutureSelf to exist in my usual life, not only for a diet but for checking my health condition before it actually goes bad. Like an alarm clock. If I skip exercise or sleep less, then I have to change my lifestyle, and FutureSelf can predict the consequences of that and alert me to control my habits."

When the participants' ultimate goal is to lose weight, Weight CI predictions that are closer to the goal weight tended to boost their confidence. Weight CI close to the goal weight convinced participants that they would lose weight as long as they continued the same behavior, which motivated them to meet their sub-goals. This is in accord with Locke's description: people's commitments to goals increase with the belief that those goals are attainable [19]: *(P1, week 4; CI provided: commenting on Weight CI) "The forecast said 77 kg and I thought I could reach that goal. Just 1 kg more to go. It was too vague at first, but after I got the messages [containing Weight CI] in Week 4, I became confident. All I had to do was just to keep going."*

However, Rate CI Is Not Construed as a Prediction

Participants discovered that Rate CI was less easy to imagine in the future perspective. After receiving Rate CI at 15:00, some participants divided the number in half and tried to construe it as an "achievement rate so far". Other participants perceived that they had done 120% of the activity amount that should be done by 15:00 when their Rate CI value was 120%. This representation of achievement rate can hardly be regarded as a prediction for the future: *(P8, week 2; CI provided: commenting on Rate CI) "But, when I tried to understand the achievement rate prediction, if it said 80%, I divided it in half and thought I did about 40% so far. But I don't know why I did so. It doesn't make sense."*

Goal achievement rate information (%) was preferred to kcal information since percent value has a standard to be compared. However, no participant wanted this information to be presented in the future perspective; they all wanted to know "what percentage of the goal they have achieved so far". This observation demonstrates that the goal achievement rate indicated by Rate CI is consumed not in the future perspective but in the present perspective. The goal achievement rate represents the activity amount, and thus it is utilized while making a decision on how much more/less to do a certain activity. Therefore, when participants received Rate CI, they had to somehow translate it into "achievement rate so far" to use the information to plan their activities.

Weight CI and PI Collaborate with Each Other

Weight CI motivated the participants, but it did not provide enough information to plan detailed strategies to meet their goals; it did not indicate how much more to exercise or how many calories to intake. Thus, participants needed information regarding "activity" to organize a weight-loss plan and set sub-goals to hit the ultimate goal. For example, one day, P3 received Weight CI predicting that he would meet his weight-loss goal, and he tried to repeat that day's activity. However, he could not acquire enough information from CI, so he checked Fitbit to find more detailed information to plan his strategy, how he should behave to lose weight. The information he found in Fitbit can be regarded as PI: *(P3, week 4; CI provided) "My goal for this week was to eat the same as on Monday and Tuesday. On Monday and Tuesday, I received a forecast saying that I would be 74 kg. So I thought I was doing well. I checked the data on those days on Fitbit and set them as a standard."*

We observed two types of collaboration between Weight CI and PI. First, as you can see from the example above, Weight CI served as a criterion that helped people evaluate their current performance. This is beneficial because taking a subjective view of health-related symptoms is risky and easily biased [27]. People may notice their obesity only after they have already become obese, without having a chance to prevent it. Thus, it is important to be vigilant to health-related symptoms and to take an objective view of them. Using Weight CI as an objective criterion, participants reinterpreted PI to set a sub-goal; this phenomenon was observed in every case, whether the predicted weight was higher or lower than the participants' goal weight:

(P9, week 3; CI provided: commenting on Weight CI) "One day I ate so little and my forecast said 60 kg. I thought that was too small, so I planned to eat more."

(P2, week 4; CI provided: commenting on Weight CI) "It was shocking. I am participating in a one-month diet program and I am hardly losing any weight. I thought I ate a bit much that day and decided to change my diet the next day."

Second, PI acted as evidence of CI. Providing both PI and CI together helped P8 imagine how CI was calculated; therefore, CI seemed more plausible and credible. This perception is important because it is difficult to trust questionable data, and distrust may decrease the impact of data on behavior change [13]: *(P8, wrap-up: commenting on CI) "Starting a report with a fact is very convincing. Saying 'You did this, and you did that [PI]' before telling me the important information [CI] was like an introduction."*

Consequently, through gradual learning, participants were able to discover whether they would gain or lose weight from a certain behavior. Participants who were initially clueless about caloric information became able to estimate their caloric intake or consumption as they repeatedly synchronized and checked the Fitbit app. Additionally, they began to compare the difference between their caloric intake and their consumption each day with the Weight CI predictions to calculate how large the difference should be to achieve their goal weight. As a result, participants learned to judge whether they were losing or gaining weight: *(P9, week 4: commenting on Weight CI received in week 3) "Now I have my own way of estimating calories while eating. It's like, 'I feel like I'm going to get fat because I ate this much,' or, 'eating this much is okay.' It's embodied cognition."*

Tolerance for Imperfect Prediction of Weight CI

Participants' attitude toward the prediction accuracy of CI differed greatly depending on the type of CI. When participants were asked in the follow-up interviews if they would use the FutureSelf service again, most of them did not want to receive Rate CI since it includes an irrational assumption: people do not repeat their daily experiences. Although this assumption is also made in the prediction of Weight CI, all participants indicated in the follow-up interviews that they wanted to receive Weight CI.

Three participants mentioned that they distrusted Rate CI because the prediction assumes that they will repeat their experiences at the same rate in the future, which is not guaranteed. Because goal achievement rate information is employed in the present perspective, the prediction of Rate CI, which inevitably entails reducing the credibility of information, was not necessary. Even if prediction accuracy was increased by adopting a personalized prediction algorithm with machine-learning technology, the participants continued to reject Rate CI: *(P1, follow-up: commenting on Rate CI) "I think I am not going to use it [Rate CI] even if it adopts deep learning. Prediction quality may become better than before, but I don't think my lifestyle is that predictable."*

Five participants questioned the prediction algorithm of Weight CI; in this case, however, they gained confidence and motivation. For instance, P5 became so skeptical that he tried to find the calculation algorithm, but was unable to find the right answer. Although he remained doubtful, he continued to be impacted by Weight CI: he believed that he could lose weight when he saw the Weight CI. This phenomenon was shared by another participant, P3, who regularly (3 times per week) weighed himself. He said that the gap between measured weight (76 kg, measured on Monday) and predicted weight (74.4 kg, his Saturday forecast, received on Monday) was so large that he could not trust the forecast, but he still gained hope and confidence from it.

As these two examples show, participants tended to understand the technical limitations of the weight forecast. To benefit from the positive impact of Weight CI, they were willing to tolerate some inaccuracy: the participants wanted to feel hopeful and maintain a positive attitude rather than focus on exact numbers. However, they still wanted CI to be more credible. Thus, we consider that the participants tolerated inaccuracy as compensation for positive impacts rather than preferring low accuracy. In particular, P6 described this feature of forecast as a "fortune teller:" *(P6, week 4; CI provided: commenting on Weight CI) "Predicting my weight was amazing but not that credible. It was like a fortune teller. […] But my future self-image changed along with kg. Last week [CI was not provided], I thought I would 'probably' lose weight. But this week [CI was provided], I could really imagine my future image specifically."*

DESIGN IMPLICATIONS AND DISCUSSION

Based on these findings, we discuss several points that designers should consider when producing and delivering CI in self-tracking services.

What Type of Information Should CI Indicate to Stimulate Future Envisioning?

When people receive CI that illustrates activity amount data, such as Rate CI, they have difficulty imagining what CI actually means in the future perspective because activity amount data are consumed in the present perspective: first, to analyze what they have done so far, and second, to plan detailed strategies to satisfy sub-goals (e.g., how to satisfy the daily goal before the end of the day). Thus, if activity amount data are presented in the future perspective, as in CI, people have to reinterpret the future perspective in the present perspective. Since this reinterpretation process may confuse users, we should avoid presenting activity amount data as CI.

By contrast, when people receive CI that illustrates status change data, such as Weight CI, they can easily imagine their future body state. Because this type of CI helps people delineate the future self-image more explicitly, people become more confident and more inclined to meet their goals [1, 30]. Consequently, they begin to believe that their goal is attainable, strengthen their self-efficacy, and gain motivation. These changes in a user's attitude are difficult to achieve but are required to produce sustainable behavior change, as previous research findings illustrate [22].

Therefore, we should design CI to *indicate status change data rather than activity amount data* to help users change their attitudes and maintain changes in their behavior. As an example, if a user's workout goal is to increase muscle, workout hours could be used as an example of activity amount data, and muscle mass could be used as an example of status change data. If we present workout hours in the form of CI, it will be "if you continue your workouts, you will have worked out for 100 hours in one month". Users cannot intuitively understand what this sentence means, and since it is not construed in the future perspective, there is no impact as CI. However, if we illustrate muscle mass in the form of CI, it will be "your muscle mass will be 40 kg in a month." This CI causes users to conjecture their changed future self-images and subsequently gain hope and confidence.

The same data can be transformed into various types of information, resulting in various types of CI. Some types of data become more negative when presented as CI, whereas other types of data can produce new positive impacts that were not observed when the data were not presented as CI. These impacts align with previous research findings, which indicate that the form in which data are presented is crucial in behavior changes since it impacts how users understand the data [25]. Recently, S Health by Samsung provided estimated active minute information to users, which corresponds to Rate CI. Although providing a novel type of

information is a good attempt, this information would not have been construed in the future perspective. Thus, designers should carefully select the type of information presented in CI.

How Can We Design a CI System to Better Assist Users in Recalling Their Ultimate Goals?

CI with forecast content, which directly refers to users' ultimate goals, intuitively sparked recall of their ultimate goals. This finding is important in behavior changes since reminding people about a goal can motivate people [17]. Conversely, when people receive CI that does not directly correspond to their ultimate goals, they are forced to reinterpret the information to compare their ultimate goals with the provided forecast. Therefore, designers should *carefully select forecast content of CI that is related to users' ultimate goals*. Many types of status change data, from which we should choose data that represent users' ultimate goals, are possible.

Content and the time represented in CI should be personalized based on users' goal dates. Although the app can be designed to predict CI for any future date, people with a specific goal date are particularly stimulated by CI that targets this date. Thus, we recommend designing CI to *forecast the future regarding the fixed goal date*. In this way, people can better observe their progress toward the specific goal date. Furthermore, if we do not provide CI prediction for the user's goal date, the user may have to reinterpret the given CI to guess the CI on the goal date, which is an unnecessary and inaccurate process.

However, if the goal of a user is too distant, she or he may have difficulty conjecture the future self-image even though the prediction is personalized to the user's ultimate goal. Since the motivational impact of CI is attributable to the imagination of future selves, the time represented in the CI should be in the foreseeable future. People often had stable schedules within a one-month period, but there were too many variables over a two-month period. They found it easier to imagine a future only one month away and therefore preferred one-month forecasts to two-month forecasts. The ideal prediction timeframe can differ from individual to individual; however, the bottom line is that *CI should predict an imaginable future that is not too far away*.

To bolster motivational impacts of CI, we can design a system to help users divide a distant goal into several short-term goals. If a user's goal date is too distant to imagine, the system can break down the distant goal into several time points. For example, if the goal date is one year from now, we can split one year into twelve individual months and assign twelve monthly goals that the user should achieve to satisfy the goal. In this case, the inclusion of CI prediction both on the original goal date and the newly formulated goal date is recommended because the imagination of the future self on the goal date is still needed.

However, we need a different approach for users whose goal is to maintain their current statuses rather than to make a behavior change. For these users, CI is not the best method for making them imagine their future selves and reminding about ultimate goals. In this case, CI can be designed to notify users of seemingly benign symptoms that they neglected. Specifically, CI can act as objective criteria to alert users that they have to be careful by amplifying the consequence of a small change that users would have ignored. This action may enable CI to be used even when no specific goals are established.

How Can We Create an Actionable CI System?

To make CI actionable, we need to consider not only CI but also the whole system delivering CI. To be specific, we should provide PI that shows the raw data for the prediction along with CI in the system. Specifying the PI used to predict CI has two consequences. First, an environment in which both CI and PI exist creates a synergistic effect of CI and PI: CI is utilized as a reminder of ultimate goals, and the PI is utilized in setting sub-goals. Second, PI acts as evidence of CI, making CI more credible.

Create a Synergistic Effect of CI and PI

By providing PI that shows base material for CI prediction, we can inform users about the most important behaviors for changing CI. PI indicating raw data for the prediction corresponds to *Factors*, which is defined as what influences behavior over a long period of time by Li et al. [18]. Li et al. expounded on the importance of knowing factors since it allows people to assess those factors to change their behavior. Thus, providing PI that illustrates *Factors* of CI helps users understand what behavior they have to control.

In this way, we can *design PI to be useful in setting sub-goals and planning detailed strategies*. In addition, *well-designed CI can support motivation and remind users of their ultimate goal*s. Consequently, we can create an environment in which CI and PI collaborate to create a synergy effect. Since a person that is motivated by CI will check their PI, we can use *CI as a trigger to promote PI exploration*. This environment can be interpreted using Fogg's model [14]. Fogg explains that while people must have both enough *motivation* and the *ability* to perform a specific behavior, they need a *trigger* to spark a behavioral change. When both CI and PI are provided, CI will increase *motivation* and PI will provide information to help people find out what they need to do to reach their goal, increasing their *ability*. While analyzing PI, CI may act as an objective criterion for evaluating performance and planning strategies. Additionally, CI can act as a *spark as a trigger,* to motivate people by eliciting hope and fear. Hence, CI designed to motivate people and PI designed to be easily exploited for sub-goal setting will create a persuasive service environment.

Current research on self-tracking services focuses on how people engage with their sub-goals but is less concerned with their ultimate goals [18, 29]. We surmise that the reason for this focus is that the information provided by the current self-

tracking services is primarily composed of PI. However, if we adopt both PI and CI in self-tracking services, we will be able to impact not only people's sub-goals but also their ultimate goals.

Increase the Credibility of CI

Since questionable information may reduce the impact of this information on behavior changes, the information should be designed to be defensible [13]. This is particularly important in producing CI because CI may arouse user's questions on how it is predicted, which may result in low credibility of the information. One certain way to produce believable CI is to improve the quality of prediction by increasing the prediction accuracy, such as by developing a better weight-loss model or personalizing the prediction algorithm. Although these solutions require additional studies, we can make CI more credible by designing the presentation of CI to users to include the base materials employed for predicting CI.

By simultaneously providing both CI and PI, we can adumbrate how CI was predicted. PI that illustrates raw material for CI prediction serves as evidence of CI and enables users to assume the prediction algorithm. This finding makes the black-box prediction system more guessable and consequently increasing the credibility of CI to some degree. This adumbration is also important since users can be motivated to adopt misguided workarounds when the calculation algorithm is unclear [36]. Thus, CI should be accompanied by sufficient explanation to help users unveil the CI prediction process.

CONCLUSION AND FUTURE WORK

This paper proposed the concept of predicting the future weight of a dieter. By exploring how people experience and interact with these predictive information, we presented design considerations that can practically help designers use this information in their self-tracking service design. Findings from the 4-week study and follow-up interviews revealed that the forecasts of users' future weight based on their current behavior had unique impacts: it made participants imagine their future selves, reminded them of their ultimate goals, gave them hope that they could reach their goals, and motivated them to be more conscientious in making that future come true. Based on these findings, we suggested design implications to bolster these impacts: the consequences should represent status change data rather than activity amount data and refer to an individual's ultimate goal. We hope this research will be a step toward the next generation of self-tracked information representations that will change people's attitude toward their health behavior.

However, there are still unsolved questions around generating CI. In this study, all participants received reduced future weights because the participants were actively engaged in a diet program. This result may simply show that CI was successful in keeping the participants working hard to reduce their weight. However, it also means this study had no chance of discovering how people would have behaved if they received a negative forecast that predicted a weight gain rather than a weight loss. In changing health behavior, both positive and negative feedback have different impacts [12]. Thus, the question remains whether we should provide CI when the forecast is negative.

In addition, the selection criteria imposed on the participant recruitment may have affected the results. First, we observed the motivational impact of CI, but it is unclear whether the participants had previous issues related to motivation. Second, participants may have already had a fairly positive self-image because their weight loss goals were not too bold. This modest goal also indicates that participants do not need to guess a self-image that is very different from the current image. Thus, the process of imagining their future self could have been quite pleasurable and easy. Thus, future iteration of this study with different group of people will be necessary.

Furthermore, CI may have different impacts on different individuals due to individual differences in susceptibility to the consideration of future consequences. People differ in their degree of sensitivity to distant behavioral outcomes. Strathman et al. assessed this as the Consideration of Future Consequence (CFC) Scale [32]. An individual's tendency to value the immediate or distant outcomes of behaviors can interfere with the use of CI [23]. Thus, we still have to investigate whether CI is beneficial across the CFC Scale.

There is also the question of how the impact of CI will differ when users do not have a specific goal. Most people who adopt self-tracking services to become healthy have specific health-related goals [8]. However, the system can also be employed as a tool for preventive healthcare, as one of the participants commented. In this case, we need to investigate differences in how CI influences users and, consequently, how it should be designed when users do not have specific goals because the production of CI was strongly related to users' ultimate goals. Thus, our future research will investigate how CI influences users without specific health-related goals.

We glimpsed opportunities to provide CI using more concrete methods or metaphors but the design of CI requires careful consideration since the manner in which we present CI may influence its impact. Previous research suggests an avatar as an effective method for communicating risk [24]. Visual representation enables users to communicate with the information in a concrete manner. Therefore, CI could be delivered in various forms such as avatars, caricatures or realistic images. However, we could not conclude whether providing more detailed descriptions of CI in the form of images and avatars is superior to providing weight values and maintaining the imagination gap. Such presentation techniques warrant further study.

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