Staying the Course: System-Driven Lapse Management for Supporting Behavior Change

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ABSTRACT

The negative effect of lapses during a behavior-change program has been shown to increase the risk of repeated lapses and, ultimately, program abandonment. In this paper, we examine the potential of *system-driven lapse management* – supporting users through lapses as part of a behavior-change tool. We first review lessons from domains such as dieting and addiction research and discuss the design space of lapse management. We then explore the value of one approach to lapse management – the use of "cheat points" – as a way to encourage sustained participation. In an online study, we first examine interpretations of progress that was reached through using cheat points. We then present findings from a deployment of lapse management in a two-week field study with 30 participants. Our results demonstrate the potential of this approach to motivate and change users' behavior. We discuss important open questions for the design of future technology-mediated behavior change programs.

Author Keywords

Lapse management; behavior change; cheat points; tracking; field study.

ACM Classification Keywords

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

INTRODUCTION

The use of technology for personal behavior change has grown tremendously in the last decade. People use a variety of devices and apps to support their pursuit of diverse goals, from increasing physical activity to changing dietary habits, saving money, or reducing stress/environmental impact. Combined with personal mobile computing, such as smartphones and smartwatches (which themselves contain a wide range of sensors), opportunities for logging and journaling can be easily combined with personal informatics – visualizations of activity and progress.

Yet, personal behavior change, with or without technology, is a difficult process that requires motivation, discipline, and perseverance. If a person's goal, for example, is to eliminate an "undesirable behavior" (e.g., taking a long shower), more often than not, that behavior is actually desirable to them in the moment. Conversely, if a person's goal is to pick up a desired behavior (e.g. a daily workout), quite often, that behavior is undesirable to them in the moment (they might rather sleep an extra 40 minutes).

This misalignment between the desirability of the overall behavior change and the desirability (or undesirability) of a behavior in the moment, can lead to lapses. Lapses, in turn, as years of research in behavior change have shown, can lead to other lapses and, ultimately, to quitting the behavior change altogether (in the domain of addiction research, abandoning a behavior change effort and returning to old habits is referred to as "relapse"). When behavior change is supported by use of technology (such as sensing, mobile journaling, etc.), additional risks for lapsing and ultimately quitting exist. For example, as reported in [34], if automatic sensing is used, any failure in tracking for any reason (forgetting the sensor, sensor out of battery, etc.) can make the value of the activity seem wasted. This may also leave data logs incomplete and consequently reduce the effectiveness of the technology. Finally, if a user is afraid or unwilling to track or log a lapse, they may decide to avoid using their tracker (e.g., they don't log a meal where they eat something they shouldn't). As a result, not only do they incur the cost of the lapse itself, but their data become incomplete, which reduces the value of the support the technology offers, and can thus lead to quitting.

The link between lapses (intentional or technology driven) and how technology could be used to manage and overcome lapses is the focus of this work. We investigate whether system-driven lapse management can help users overcome the negative effects of lapsing in behavior change and "stay the course." Specifically, in this work, we explore how accommodating "cheating", operationalized as a lapsing allowance, may ultimately reduce the risk of repeat lapsing and program abandonment. We first review lessons from classic domains of behavior change for addressing lapses (such as smoking). We then examine interpretations of goal-reaching with a lapsing allowance through an online study.

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Finally, we describe results from a field deployment that explored lapse-management in the context of a specific real-world behavior-change domain – reducing time spent online. Results show that the lapse-management approach we designed was useful for those who lapsed and served as a "safety net" for those who did not. We found that participants were significantly better able to limit their online behavior compared to a control condition, and were marginally significantly less likely to have consecutive lapses.

This work makes the following contributions:

1. A discussion of the design space of system-driven lapse management, reviewing lessons from the domains of dieting, fitness, and addiction research.
2. An investigation of interpretations of a user's progress towards a goal when progress is supported by lapse management.
3. A field deployment and evaluation of a lapse management strategy (cheat points) showing improved goal achievement compared to a control condition.

RELATED WORK

In this section, we first review lessons about the danger of lapses and approaches for dealing with lapses from a range of behavior change domains. We then discuss technologies and tools used for behavior change before discussing the potential design space of tools for lapse management, the focus of this work.

Factors influencing behavior change

People have different reasons for behavior change and different interventional strategies have been implemented to fit these different reasons. For example, behavior change may be goal-based, or motivated by wanting to maintain or increase a behavior (e.g. increase physical activity levels) or to maintain, decrease, or eliminate an undesired state or behavior (e.g. quit smoking, lose weight, etc.) [2, 9]. It may also be influenced by individual characteristics such as intrinsic or extrinsic motivation, [31] or self-efficacy (e.g. how successful a person thinks they will be at changing their behavior [3]. Finally, social factors in the form of other people's influence can either be negative (e.g. smoking) or positive (e.g. providing social support). These factors have been incorporated, in different ways, into the design of technological tools to support behavior change.

Lapses and behavior change

Regardless of an individual's particular goal or the technology they use to help this goal, lapsing during the process of behavior change is a common and sometimes unavoidable experience. Gollwitzer [14] highlights lapsing as the third and final challenge in the behavior change cycle of (1) getting started, (2) staying on track in the face of temptation and (3) facing problems with calling a halt to unsuccessful efforts to reach a goal.

Lapses may occur when an activity requires sustained effort over a long period of time. Many goals require that people keep striving over an extended period, and staying on track becomes difficult when internal or external stimuli interfere with the ongoing efforts [14]. "Tracking fatigue" is a common challenge for people who need to keep a record of their activities or behaviors for purposes such as fitness, sleep, diet, or stress management. Because the burden for these ongoing recording actions is high, many people eventually stop tracking entirely [4]. Personal and situational factors can also cause people to lapse from their ongoing goal pursuit. These include loss of motivation or reduced novelty [34] or external factors such as a change in work schedule, weather, travel, or injury [9].

Prior work on preventing lapses and relapse has focused on changing individuals' cognitions about their actions. For example, building up a behavior change as a habit can make the behavior more resistant to motivation lapses later [13]. Encouraging people to form habits by creating an "if-then" plan (e.g. "If it is sunny out, then I go for a run") can make a person more likely to follow a behavior change plan – they operate on "auto-pilot" [1]. However, habits may take several months to form [28]. In this work, we explore designing system-driven solutions to help with lapses when a break from the behavior change occurs.

Current approaches to lapse management

Previous research work has focused on the role that lapses and relapses play in the cycle of behavior change. Considering the transtheoretical model proposed by Prochaska *et al.* [28], it is acknowledged that people in the maintenance stage of behavior change often exhibit lapses or slips [23]. Thus, relapse prevention methods should make it clear that such mistakes are common and not a sign of personal failure [22]. In other words, a slip "need not be a fall" [9]. As described earlier, one challenge of lapse management is that, on one hand, the negative impact of a lapse should be managed such that it does not lead to quitting. However, when a lapse occurs, its impact should not be ignored or concealed, especially if any direct adverse consequences of the lapse exist (e.g., less money saved, too many calories consumed, etc.). In other words, a lapse should be "forgiven, but not forgotten".

As mentioned previously, external factors such as a change in daily schedule, or vacation can cause people to break a pattern of good behavior. Getting back on track after an initial lapse can be difficult. Gamified online programs such as duolingo [8] or InterviewBit [11] have adopted a "streak freeze" paradigm to help address this issue. In these settings, individuals are encouraged to keep up a "streak" of as many daily visits in a row as they can (in order to practice a language or improve coding skills). In cases where a person does not have time on one particular day to visit the site, they can use virtual tokens to "purchase" a one-day freeze to maintain their streak. Online forum comments suggest that users perceive this as a useful feature.

A similar concept is also employed in the Weight Watchers system, which allots individuals a certain number of "points" to be used on food during a given week. This enables people who have been normally good at eating healthy food but may find themselves in occasional tempting situations (such as going to a restaurant for a social occasion) the ability to use “cheat points” to not go over their weekly limit. The benefits and drawbacks of this concept have been widely discussed on related dieting online forums (the quotes below come from a Weight Watchers community discussion board: [32]). For example, some individuals feel that cheat days allow them to stay on track when unexpected situations arise:

> *Now I do have days when I eat a lot more than normal, like on holidays, pot-lucks or Pie Day at work. I make a broad estimate of points and still list what I ate. Then I get back to precise counting the next meal. It can work if it is infrequent, but I also dislike the word 'cheat day'. It's a planned special occasion.*

An alternate viewpoint is that cheating on one day makes it much easier to break from routine for more days in the future.

> *The realities of life mean that indeed there likely will come a day where you don't track every bite, or where you have to take your best guess. But calling that a "cheat day" encourages you to just throw the whole plan to the wind, and that's an issue.*

> *I understand not everyone has this mindset, but if I have a "cheat meal," it can easily turn into a cheat day, which rolls into a few days, etc. For me it's a huge snowball effect that starts with not tracking one meal and turns into falling entirely off track.*

Technology for behavior change

A variety of technological aids for behavior change have been developed in contexts ranging from smoking cessation [27] to promoting exercise [31] to reducing stress [18]. Michie et al. [25] developed a taxonomy of behavior change techniques (BCT) that are used in behavior change interventions. They come up with a set of 16 categories and 93 subcategories of distinct and precise behavior change techniques. Some of these are based around individual cognitions, others are social in nature. A survey of papers focused around strategies for designing technology to support maintenance of behavior change and decrease lapses reveals different guiding approaches for doing so. Many of these cluster around the following techniques as strategies for behavior change maintenance:

Goals and Planning are mentioned as strategies to support lapse prevention. The most common techniques in this category focus on designing tools that support goal setting, in particular the variety of goals that people might have [19, 30]. Research also suggests that technology should support revision of goals, in particular as behavior-change goals change [9]. Research also proposed that technologies support the creation of action plans that are designed for the context, routines and preferences of the person using them [7, 27]. Goals are effective when they are self-set, realistic, the individual can see his/her progress, and receives positive feedback as progress towards the goal is made [26].

Feedback and Monitoring emphasizes the value of feedback while a user progresses towards their goal, in particular in the case of using tracking technologies: feedback that increases self-efficacy and self-control, feedback on the progress that fits with participant routines [19, 30]. Recommendations for design also include providing feedback on the outcomes of the behavior, which can highlight different benefits a person gains from performing the positive behavior (e.g. money saved by not smoking) [19, 27]. Other recommendations include providing feedback combined with comparison of different outcomes [30], or providing data visualizations to help people return to their behavior after a lapse [9]. The role of visualization can be important. For example, to mitigate motivation loss, amiable visual feedback encourages users to respond to an unfavorable state of the object with the motivation to return it to a favorable state, hence serving as a motivation for immediate task resumption [21].

Repetitions and Substitution of behavior focus on aspects of creating behavioral tasks that are of appropriate difficulty for the stage of behavior change and designing technology appropriate for different levels of task difficulty [27]. Substituting behavior through technology can offer alternatives and flexibility in prompted behaviors [30], and help with technology-driven habit formation [19].

Associations, in particular *Prompts* and *Cues*, refer to recommendations such as reminders, design of messages about behavior change in a personalized and novelty-bringing manner, or choices of recommendations provided by others [7, 16, 27, 30].

Social Support can involves practical tactics and recommendations, such as exchanging devices when goals are no longer being met as well as emotional support by using social features to help a user to connect to friends and online communities [5, 27].

Such a myriad of approaches suggests that any behavior change techniques that are emphasized or employed in a tool should create a match between the behavior, individual goal, and the characteristics of the activity.

SYSTEM-DRIVEN LAPSE MANAGEMENT

In the previous section, we described the potential negative effect of lapsing, and a range of strategies for dealing with lapses. We now turn to discussing potential approaches for incorporating lapse management into a system geared towards behavior change. Specifically, we consider lapse management in which a lapse behavior is tracked, but its negative effect on progress towards a goal is managed. We acknowledge that the range of possibilities for lapse management spans far beyond the list below; exploring the complete design space is beyond the scope of a single paper.

Program (Scenario)	Increase or Reduce	Small or Large	Goal	Available cheat points	Level 1 Goal surpassed	Level 2 Goal met	Level 3 Goal met with cheat points	Level 4 Goal not met	Level 5 Goal severely not met
SNS use	Reduce	Small	10 minutes	2	8	10	12 (-2)	12	14
Water	Increase	Small	8 glasses	1	9	8	7 (+1)	7	6
Calories	Reduce	Large	2,000 cals	200	1,865	1,980	2,160 (-160)	2,140	2,295
Step-count	Increase	Large	10,000 steps	1,000	11,037	10,479	9,156 (+844)	9,289	8,351

Table 1. The four behavior-change program scenarios and 5 levels shown to Study 1 participants.

Manage Before vs. After a Lapse

One important dimension of lapse management is whether lapses are managed after the fact (i.e., they are forgiven), whether a system gives users tools to plan lapses as a resource, or a combination of both. As mentioned earlier, in dieting, for example, people will often have a planned "cheat snack", a "cheat meal", or a "cheat day." Indeed, prior literature described the importance of managing realistic expectations [24]. It is possible that when behavior tracking is difficult but important, a system should allow forgiving a lapse after the fact, thus supporting maintaining a more complete behavior log. One approach for lapse management that we focus on is to provide users a resource (e.g., points) that they can apply towards lapsing.

Granted vs. Earned

Another important dimension is under what circumstances users are given permission (or forgiveness) for lapses. First, one must decide whether the number of lapses possible at any given time, or across a behavior change program is finite or not. We believe that it is important that the number of lapses that can be managed is finite. Otherwise, allowed lapse simply becomes a secondary, potentially unsatisfactory goal. If that number is finite, how and how often is it distributed to the user? One approach is that users "earn" points that allow them to lapse only after exhibiting the desired behavior. A second approach is to grant users points at certain intervals, or even dynamically based on progress towards a goal.

Fixed vs. Personalized

Next, lapse management can be tailored to a user's needs and status within the program. Indeed, flexibility to user current needs is desirable to support behavior change [27, 30]. In our deployed system, lapse management resources are based on a user's individual program (although we did not include any dynamic elements in our system).

Framing and Feedback

Prior research has shown the importance of immediate feedback to support behavior change [27]. Research has also shown that the framing of lapses have direct effects on whether the lapsing behavior is used as a learning opportunity or lead to discouragement and potentially a relapse. For example, the term "cheat meal" or "cheat day" is commonly used in dieting, despite, and perhaps because, of its negative connotations. While high satisfaction with positive outcomes has been shown to lead to better maintenance of behavior [2], it is important that as lapses are managed, they are not ignored. Thus, a lapse-management tool may need to provide a balanced feedback; one that does not encourage lapses, but that does not cause discouragement.

In the work presented in the rest of this paper, we explored the use of "cheat-points" as a mechanism to allow users to manage their own lapses. Cheat points may help people stick to their goal when encountering obstacles, similarly to developing action plans that have been shown to help people achieve goals [15, 17]. Inspired by implementation intentions, people can adopt such strategies to develop plans such as "If I reach my goal today, then I will use cheat points". In our work, cheat points are granted, are personalized to a person's goal, and help them manage (plan) for lapses before they happen. Using cheat-points would occasionally allow a user to recover from a lapse (if they perform a behavior they should not), or allow them to "pad" their progress (if they did not perform enough of a desired behavior to meet their goal). Thus, in order for a system that employs lapse management to be able to permit or forgive a lapse but without actually encouraging lapses, representation of progress should be able to convey a positive and negative message simultaneously. To examine how progress towards a goal while using cheat-points is interpreted, we conducted the study reported next.

STUDY 1: VISUALIZING SUCCESS WITH CHEATING

Providing immediate feedback about progress is commonly used in behavior-change tracking and logging systems (*c.f.*, [26]). Beyond concrete representations of logged or tracked data (the number of steps taken, heart rate, and calories burnt, etc.), many systems also use 'badges' consisting of graphical depictions of items, such as trophies [26], fish [20], a flower [10], a blooming garden [6], etc. These badges afford at-a-glance understanding of one's progress, and offer visual "rewards" to the user (more stars, a prettier garden, etc.). But how should progress towards a goal be represented to help users overcome lapses on one hand, but discourage them from lapsing again?

To test this we conducted an online study in which participants were presented with a 5-day "dashboard" describing a user's progress in a behavior change program (see Figure 1). We created dashboards for four different behavior-change scenarios and with two visualizations (more below). Each dashboard included days in which the goal was met, not met, and a day in which the goal was met but through the use of cheat points. Participants were asked to rate the user's level of success on each of these five days.

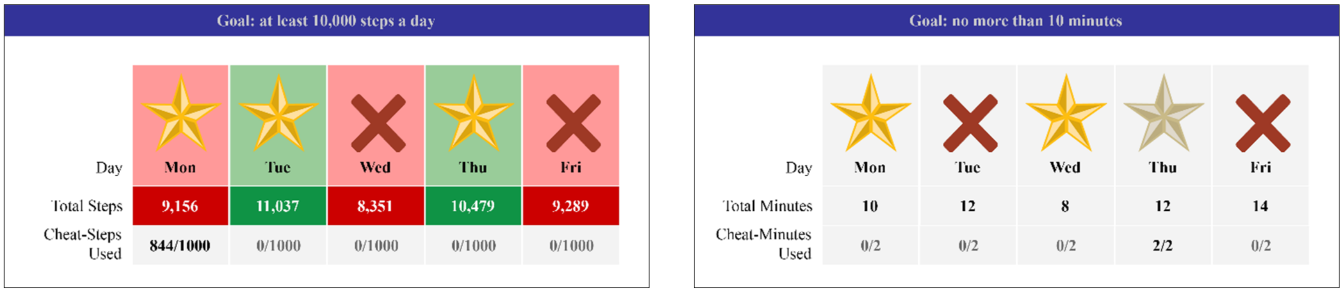

Figure 1. Two example stimuli from the Study 1: Daily step-count (left) and Daily website-visit limit (right). Each dashboard includes a day where a goal was reached using cheat points.

Method

The study was conducted as a between-subject design, with each participant seeing a single 5-day dashboard. We created dashboards depicting progress in 4 behavior-change program scenarios: A daily step-count goal, a daily water-drinking goal, a daily SNS website-visit limit (where a user's goal is to spend no more than a certain number of minutes on a particular website), and a daily calorie limit (Table 1). We chose these four programs as they represent behavior change along two dimensions: Increase vs. Reduce behavior, and Small vs. Large numbers.

Increase vs. Reduce Behavior

One dimension that may influence how progress towards a goal is interpreted is whether the program involves increasing (or starting) a desired behavior such as step-count (an *Increase behavior*), or whether the program involves reducing (or stopping altogether) an undesired behavior such as reducing time spent on an SNS website (a *Reduce behavior*).

Small vs. Large Numbers

The size of numbers in which a program is measured and tracked may affect interpretations of success (and thus, the use of cheat points). For example, reaching 9,000 steps out of a 10,000-step goal may seem different than drinking 9 cups of water out of a 10-cups goal (and thus, the use of cheat-points in those cases may have different impacts).

Visualizations

We tested two visual variations of the dashboard. All the dashboards participants saw included both the daily values tracked (e.g., number of calories consumed per day) as well as a daily badge (either a star or a red *X*). In the first design (Figure 1, left), when a goal is reached (with or without cheat points), a gold star is awarded. Independently, a red or green background is used for each day depending on the daily values tracked. Thus, when a goal is reached using cheat-points, it is represented by a gold star on top of a red background (simultaneously suggesting meeting the goal and failing to meet the goal). In the second design (Figure 1, right), if a goal is reached using cheat points, a bronze star is awarded. No color background is used in this design.

Materials

Table 1 shows the goals and progress levels for each scenario. Goals were based on common values used in practice. Available cheat points were set to ~10% of a goal. We then selected 5 levels of daily progress: Two representing meeting the goal, two representing missing the goal, and one representing meeting the goal using cheat-points. The goals and five levels (Levels 1-5) for each program are shown in Table 1. Importantly, note that in each program, Level 3 (meeting the goal with cheat-points) and Level 4 (missing the goal) contain similar daily values tracked (e.g., 2,160 and 2,140 calories). However, in level 3, a star was awarded due to the use of cheat points. These two levels (3 and 4) will be a focal point for our analysis.

The order of levels in each dashboard was counterbalanced using a 5x5 balanced Latin-square. We thus had a total of 40 dashboards: 4 (programs: Steps, Water, Calories, and Website) x 2 designs x 5 orders.

Participants and Procedure

We recruited US-based participants from Amazon Mechanical Turk. Participants were required to have an approval rate of at least 95%. In the instructions, participants were told that they would see the dashboard of a person and asked to rate their daily success based on a presented goal. Additionally, the instructions included a minimal explanation of the concept of cheat points stating, "The person was given [*two "cheat minutes"*] that they could use whenever they wanted." Each participant was presented one of the 40 dashboards described above and asked to provide a rating of success towards reaching the goal for each day on a 7-point Likert scale ranging from "Completely Unsuccessful" to "Completely Successful". To ensure that participants understood and completed the task correctly we use the sign of the difference in ratings between levels 1, 2, 4 and 5 (see Table 1), since those represent, unambiguously, meeting and missing the daily goal.

A total of 407 participants completed the study, taking a median of 1 minute and 4 seconds to complete the task. Each participant was paid $0.15 for their time. We removed the data of 43 participants (10%) who failed our check. We further excluded the data of 6 participants whose completion time was outside the norm based on a Mahalanobis outlier analysis (completion time longer than 7 minutes). Our final set contained 1790 ratings provided by 358 participants.

Results

We performed a mixed-model repeated-measures ANOVA, in which the dependent measure was the aligned-ranked ([33]) Likert-scale ratings of success towards the goal. *Level* (1…5, see Table 1) was our main independent measure of interest and was modeled as a fixed effect. We included Program Type (*Increase* vs. *Reduce*), Number Scale (*Small* vs. *Large*), Visualization design and all 2-way interactions as fixed effects. Finally, we included the order of presentation as a control, and Participant ID as a random effect, since each participant provided five ratings (one for each day).

Our results show a main effect of Level on ratings of success (F[4,1428]=1624.7, *p*<.001). As can be seen in Figure 2, Levels 1 and 2 were rated as successful (M=6.8 and M=6.5, respectively), while levels 4 and 5 were rated as unsuccessful (M=3.0 and M=2.3, respectively). Level 3 (meeting a goal with cheat points) was rated slightly above the neutral point (M=4.1). A post-hoc Tukey HSD pairwise comparison shows that all levels were rated significantly differently from one another. Importantly for our investigation, Level 3 is considered significantly *more* successful than Levels 4 and 5, but also significantly *less* successful than Levels 1 and 2.

While we found no significant difference between the two design variations, we found significant effects of Program Type and Number Scale. Progress in "Increase" programs was rated as significantly more successful than progress in "Decrease" programs (M=4.7 vs. M=4.3; F[1,356]=40.0, *p*<.001). The significant interaction between Level and Program Type (F[4,1424]=25.0, *p*<.001) revealed that this difference was most pronounced in the evaluations of failure to meet a goal (Levels 4 and 5). In those two levels, ratings in Increase programs were nearly a whole point higher on the Likert scale. This suggests that participants attributed more value into the effort put into reaching a goal, than the effort needed to avoid a limit – consider the difference between walking 9,900 steps out of a daily goal of 10,000 steps a day, vs. consuming 2,160 calories with a daily goal of 2,000.

Similarly, when represented by large numbers (steps and calories), progress was rated significantly higher than when represented by small numbers (cups of water and minutes on site) (F[1,356]=7.9; *p*<.01). The significant interaction between Level and Units Scale (F[4,1424]=4.6; *p*=.001) shows that ratings were affected by the number representation in Levels 2, 4, 5, but not in Levels 1 and 3.

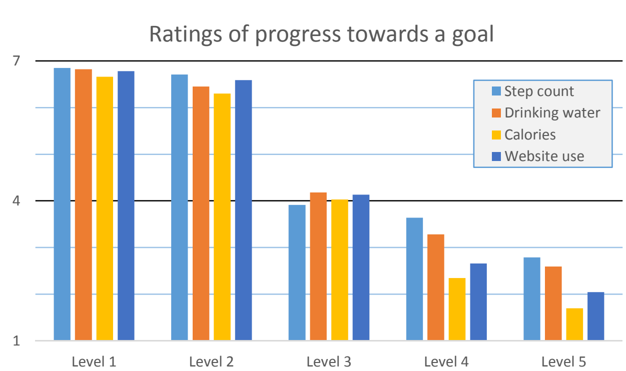

Figure 2. Ratings of success by level shown. Level 3 depicted meeting a goal using cheat points.

To summarize, these results suggest that when interpreting reaching a goal with cheat points, users simultaneously interpret badges as signs of success, but are also sensitive to the actual progress depicted in the dashboard. This result is encouraging; it shows that managed lapses are not seen as failure, but also not seen as simple success. We were now ready to test the effectiveness of the cheat-points lapse-management strategy in a field deployment.

STUDY 2: FIELD DEPLOYMENT OF CHEAT POINTS

To assess the effect of the cheat-points lapse-management approach on behavior and participation, we conducted a two-week field experiment of a real-world behavior-change program. The criteria for selecting a behavior-change program for the study was (a) that behavior is tracked automatically (rather than relies on journaling), (b) that users have measurable daily goals, and (c) that, even in a short duration, participants are likely to exhibit lapsing. We chose a behavior-change program designed for people who wish to reduce the time they spend online on a particular website (e.g., social media, news, or other leisure-based websites). We selected this program in light of recent findings from Sleeper *et al.* [29] that suggest that reducing behavior online is a common goal (44% of Facebook users in their data wanting to spend less time on the social network). We used a two-condition, between-subjects design to compare the online behavior and lapses of participants in a Lapse-Management condition who received *cheat minutes* to participants in a Control condition who did not.

Study Instrument

We designed and implemented a custom browser extension for the Chrome browser. The extension is able to log and visualize time spent on a user-chosen website relative to a selected daily goal. Upon installing the extension, the user first chooses a website they want to reduce their time using (we will refer to this as their *vice website*). The user then selects one of seven possible daily goals (0 to 30 minutes in 5-minute increments). We used 30 minutes as the longest goal based on a pilot survey in which 10 respondents interested in reducing time on certain websites described their current use as ranging from 30 minutes and higher. Finally, the user chooses whether to track their vice website visits all day (24 hours) or only during work hours.

During use, the extension tracks (and logs on our server) attempts to go to the vice website either by entering a URL or by bringing a browser tab with the site to the foreground. Instead of the vice website, the extension first displays a Dashboard (see Figure 3). The dashboard contains buttons for the user to choose to either proceed to their website or not (selecting this latter option replaces the dashboard with a blank tab). If the user proceeds to their vice site, their time is logged on our servers. If, during their time on the vice site, they reach their daily goal, they are automatically forwarded

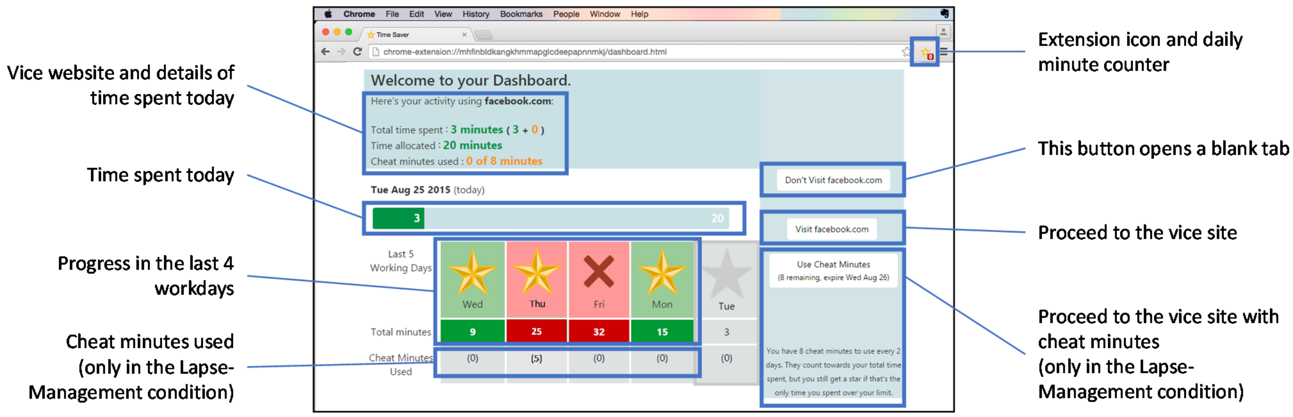

Figure 3. Dashboard of a custom browser extension designed for Study 2 showing progress and progress history. Users see the dashboard when attempting to go to their "vice website" or when they use all the minutes towards their daily goal. From the dashboard users can proceed to their vice website by clicking on right.

to the dashboard. As before, they can then choose to return to their vice site or not.

The dashboard also contains information about the current-day's time spent on the site and information about the previous 4 days. Following the first visual design from study 1, the background color for each day conveyed whether the user spent less time than their goal (green) or exceeded their goal (red). A gold star was awarded for days where the goal was achieved, and a red *X* otherwise.

Experimental Conditions

We created two versions of the dashboard, one for each condition, as follows: In the Lapse-Management condition, starting on the second day of the study, participants were granted cheat minutes totaling 20% of a daily limit *every other day*. Cheat minutes expire every two days, whether the participant used them or not (i.e., no "rollover" of cheat minutes). Participants in this condition were instructed how cheat minutes work in both the study instructions and in the dashboard interface itself (*"You have [4] cheat minutes to use every 2 days. They count towards your total time spent, but you still get a star if that's the only time you spent over your limit."*) The decision to have cheat minutes awarded every other day (and expire) was so that they don't simply become a participant's secondary goal. Participants in the Lapse-Management condition were made aware of the concept of cheat minutes. In order to avoid influencing the daily limit goals set, careful language was used that did not guaranteed the availability of cheat minutes at all (specifically, the instructions stated that "It is possible you might not receive cheat minutes at all.").

The dashboard for participants in this condition contained a designated button that had to be clicked in order to use the cheat minutes (see Figure 3, right) as well as information about cheat minutes used and cheat minutes remaining. If a participant stayed under the limit thanks to using cheat minutes, the gold star that they were awarded appeared on top of a red background (as seen in the second day in the dashboard in Figure 3). Participants were redirected to the dashboard if they used up their cheat minutes. Participants in the Control condition did not get cheat minutes. Their dashboard did not contain any mention of cheat-minutes, and included only a single button for proceeding to the website.

Procedure

Participants were recruited through mailing lists and social-network groups at three academic institutions. We targeted participants who were interested in spending less time on certain websites. Participants were asked to fill in a screening questionnaire that asked about the websites they wanted to reduce time on, the amount of time they currently estimate spending on one of these websites, and whether (and how) they have tried to change their behavior with regard to website use in the past.

Based on questionnaire responses, we invited participants who were actively interested or planning to change their behavior (or had been trying to do so already) to install and use our browser extension for one day (we excluded participants who did not use Chrome as their primary browser). Participants were assigned at random to one of the two conditions (recall that no cheat minutes granted on the first day). After using the extension for one day, participants were invited to continue using the extension for the following 9 weekdays (for a 2-workweek study).

Compensation

To ensure that continued participation in the study was not driven by compensation, participants were compensated for the entire study at the end of the first day of participation. Those who chose to withdraw at the end of the first day received a $5 gift card, and those who chose to continue received a $15 gift card. This approach intentionally did not prevent participants from dropping out of the study before the end of the 2 weeks (they were told they could withdraw at any time by uninstalling the browser extension).

Participants

30 individuals participated in the study (16 women, 9 men, 5 did not disclose) and were assigned at random to the Lapse-Management and Control conditions (15 participants per

condition). Three additional participants were removed (two who had technical issues with the browser extension one participant who never visited his vice website). Participants were told that the study was set for two weeks but that they could withdraw at any point (by uninstalling the browser extension) or could extend their participation beyond the two weeks. Since our study and dashboard were designed to assist users during the workweek, we only report behavior recorded Monday through Friday.

As described above, before starting, each participant was asked to select a website they wanted to reduce time on and a daily time goal. Of the 30 participants, 23 (77%) chose to reduce time on Facebook, 2 chose reddit.com, and the remaining chose BuzzFeed, hulu.com, Gmail, Pinterest, and a personal livejournal (see Figure 4, left). Two of the participants switched their goal after the first day (from Netflix to BuzzFeed and from YouTube to Facebook).

Participants selected a wide range of daily goals, as seen in Figure 4, right. Twelve of the participants wanted to reduce their time on the site only during workhours (9am-5pm, and in one case 8am-5pm). The remaining wanted to reduce usage throughout the day (3 participants wanted the day to extend past midnight and for them a day in the dashboard started and ended at 4am). We found no statistical difference between the two conditions in the daily limit goals set ($F[1,29]=0.24$; $p=.6$, n.s.).

In their pre-study survey, participants described wanting to reduce time on a site for work-productivity purposes (56%), since it was a waste of time/not worthwhile (46%), or for emotional reasons such as feeling depressed, insecure or less happy (10%). Participants also reported having tried different strategies for quitting or reducing use of a website: six had used extension blockers, three tried deleting an app or bookmark, and six tried using self-control/willpower.

On average, participants in the Lapse-Management condition participated in the study for 9.9 workdays, (Min=2, Max=14, SD=4.1, Median=11). Participants in the Control condition participated for 12.4 workdays, on average (Min=2, Max=24, SD=6.6, Median=13). Two participants (one from each condition) quit the study after two days. Three participants quit after 3 days (2 from the Control condition and 1 from the Lapse-Management condition). Two additional participants quit within 6 days (one from each condition). There was no overall difference between the conditions in days of participation or likelihood of quitting ($F[1,28]=.7$, *n.s*), not surprising for a study of this duration.

RESULTS

On average, participants visited their vice websites 85% of the days they participated in the study (238 days total) spending a grand total of 62 hours on the different vice sites (16 minutes a day, on average) in 2327 visits (9.7 visits per day, on average). To understand the effect of lapsing (exceeding one's daily limit) and the value of lapse management we first examine lapsing occurrences and participants' attitudes towards lapses. We then examine overall differences between the conditions. Finally, we investigate participants' use of cheat minutes and their impressions of the use of cheat minutes in behavior change. We quote participants' responses to the end-of-study survey with LM1-LM15 and C1-C15 for participants in the Lapse-Management and Control conditions, respectively.

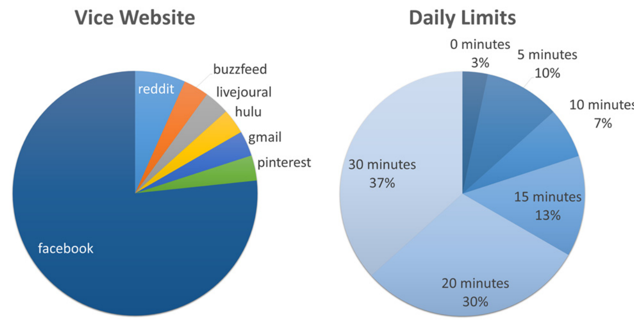

Figure 4. Sites chosen for time reduction and daily goals.

Condition	Average days in study	% of days visiting vice site	Average # of daily visits	% days exceeded time limit
Lapse Management	9.9	84%	9.9	15%
Control	12.4	80%	8.4	23%

Table 2. Average site-use behaviors for Control and Lapse-Management conditions.

Exceeding the Daily Limit (Lapsing)

During the study, 18 of the 30 participants exceeded their time limit at least once: 11 participants in the Control condition lapsed 30 days (out of 128 days), and 7 participants in the Lapse-Management condition lapsed 17 times (out of 110 days). In five of these 17 lapses, using cheat minutes helped participants still receive a star. The remaining participants did not exceed their daily time limit. When asked at the end of the study to describe how they felt about exceeding their daily limit, attitudes varied from neutral (e.g., "*Annoyed me but didn't particularly make me want to do better the next few days.*" <LM11>) to negative (e.g., "*I tried to avoid using Facebook after exceeding the limit.*" <C13>, and "*looking at that big red block was pretty guilt-inducing so I didn't do it again!*" <LM14>). One participant expressed the risk of tracked lapses, *"Going over limit made me care less about going over in future."* <LM3>.

Time Towards (and Past) a Goal

To identify differences between the Lapse-Management and Control conditions, we examined all days where participants visited their vice site (N=238). We compared the time participants spent on their vice site relative to their daily limit. (In order to avoid giving unfair advantage to the Lapse-Management condition, we count all time spent on the site, regardless of whether cheat minutes were used.) Before analysis, we excluded 3 days from participant <C13> where they spent over 1 hour and 50 minutes on Facebook (with a daily limit of 30 minutes). We conducted a mixed effects model with Time Left at the end of the day (relative to each person's goal) as the dependent measure. Condition (Lapse-Management vs. Control) and Daily Limit were set as fixed effects. ParticipantID was set as a random effect.

The analysis found a significant main effect of Condition, with participants in the Lapse-Management condition having more time left at the end of the day than participants in the Control condition ($F[1,27]=4.21$, $p<.05$). Daily Limit had only a marginally significant effect with more time left at the end of the day with higher goals. To better understand this difference, we repeated the analysis, this time adding to the model a Boolean dummy variable labeled *Lapse,* indicating whether the participant exceeded their daily goal or not, and the two-way interaction Lapse x Condition.

The difference for Condition was again significant indicating that, on average, participants in the Lapse-Management condition had 3:54 minutes *left* on average at the end of a day, while participants in the Control condition had *exceeded* their goal by 4:18 minutes (see Figure 5). This finding is especially interesting given that technically, participants in the Lapse-Management condition were "allowed" to use their vice site more and still receive a star.

The interaction was also significant ($F[1,225]=8.1$, $p<.01$) and showed that when going over the limit, participants in the Control condition tended to go over their limit by a significantly greater amount than participants in the Lapse-Management condition (18 minutes *over* vs. 5 minutes *over*, on average). This result suggests that while cheat minutes did not always prevent lapses from occurring, they nevertheless lessened the amount by which people over-shot their stated goals when they did lapse.

Consecutive Lapsing

An important risk of lapsing is the likelihood of them leading to additional lapses (and ultimately a relapse). In order to test whether our lapse management approach helps reduce the likelihood of repeated lapsing, whenever a participant lapsed, we examined the next day they visited their vice site and noted whether they lapsed again, or stayed within their limit. Overall, 38% of lapses were followed by a second lapse. Testing the difference between the two conditions found only a marginally significant difference; 50% of lapses in the Control condition were followed by a second lapse, while only 25% of lapses in the Lapse-Management condition were followed by a lapse ($X^2(1, 44) = 2.73$, $p<.1$).

Using Cheat Minutes

Six of 15 participants in the Lapse-Management condition used cheat minutes. One participant used cheat minutes 5 times, one participant used them twice, and the remaining four used them once, for a total of 11 days. Participants used all their cheat minutes only twice. Recall, that participants in this condition only got cheat minutes every other day.

When asked about their use of cheat minutes, attitudes ranged from feeling guilty to positive. For some, using cheat minutes was seen as something to avoid. As stated by LM14, *"I only really used the cheat minutes once but it was to contact someone for a work-related purpose who I know sits on FB chat all day. Otherwise, I felt guilt using the cheat minutes, which is something I really need!"* Succinctly expressed by LM11: *"It felt like, well, cheating."* For others, however, cheat minutes were seen as useful: *"I think we would feel more guilty if we didn't have them"* <LM5>. Cheat minutes were particularly useful for "special" days: *"The cheat minutes helped me to feel like I'm still minimizing my interaction with the site and staying on the goal while also being realistic about my ability to be distracted and occasional need to use the platform for work"* <LM14>. This is not unlike special cheat snacks or cheat meals in dieting and bodybuilding. However, one participant's response also highlights a potential danger with cheat minutes: *"It felt like a waste not to use what was given to me."* <LM11>

Having, but Not Using Cheat Minutes

We were also interested in understanding participants in the Lapse Management condition who never used their cheat minutes. While two participants stated they did not use cheat minutes because of the need to explicitly "choose" them (i.e., click a different button on the dashboard), others expressed that having the cheat minutes, even without using them was positive. For example, LM13 stated that *"[It was] nice to have them so that if I found a REALLY funny article I wouldn't be cut off in the middle or anything"* and LM15 stated, *"It was good to have the cheat minutes because they provided a safety net for my 20 minute goal."* Finally, for some, not using available cheat minutes was *"sort of like a reward"* <LM1>.

Taken together, these responses indicate that overall cheat minutes were good for those who used them for sporadic (and sometimes unexpected) extra website use needs. At the same time, we also saw that simply having cheat minutes available was seen as a reassuring safety net; their mere availability did not necessarily mean people would use them to go over their limit.

Cheating without Cheat Minutes

Finally, we examined responses from participants in the Control condition who did not have cheat minutes. Using a mobile device to circumvent the extension was described as an available, but undesirable option, "*I didn't cheat much on my phone when I was at my computer working, but if I was away from my computer (say on the bus), I viewed it on the phone more than my 10 minutes allotted."* <C11>

The desire to have the extension represent a goal being met led some participants in the Control condition to increase their use of other means (such as their smartphone) to spend time on their vice site. For example, *"I spent less time on Facebook as I became aware of it. I more carefully used my 20 minute daily allotment. However, I did start accessing Facebook on my phone, which I previous didn't really do, but it wasn't during "real work" time - it was in the bathroom (gross, I know!) or while commuting on public* *transportation. I still wanted to use Facebook, so I guess I found better times to do it on the mobile device."* <C7>.

These statements illustrate that participants wanted to be compliant with the time limit goals they had set. However, in the absence of any system-driven or "authorized" mechanism to manage lapses, they elected to lapse outside of the tracking environment by circumventing the dashboard and accessing their site of choice via other, non-tracked means such as on their mobile phone. In other words, without "cheat minutes," participants appeared to be more likely to "cheat the system", resulting in a log that does not properly capture their behavior.

Limitations

Our study found both significant quantitative differences as well as qualitative indications for the potential benefits of the cheat-points lapse management approach. However, it is important to remember that the study was relatively short (just over two weeks, on average) and tested one of many possible lapse-management approaches in the context of a single (albeit real-world) behavior-change program. Nevertheless, we believe our findings serve as important and insightful first steps for exploring the general concept of system-driven lapse management. We also note that the first study relies on findings from Mechanical Turk, a participation population that may evaluate reward and success differently.

DISCUSSION

Our work shows the potential value of lapse management for a program that involves reducing an unwanted behavior (time spent on a vice website). Results from the field deployment showed that giving users tools to manage their lapses led to significantly better performance. Despite having cheat minutes to use beyond their goal's limit, participants with lapse management spent significantly less time on their vice site (relative to their goal) compared to a control. It also resulted in positive sentiment toward maintaining realistic progress in the face of changing circumstances.

Other behavior-change programs, however, may differ along a range of dimensions. For example, a program with a goal of picking up a new behavior (e.g., exercising) or one with a goal of abstinence (e.g., eating gluten-free) might require an adapted lapse-management approach. In future work, we plan to investigate system-driven lapse-management in the context of other programs. Additionally, in our two studies, we examined a single instantiation of system-driven lapse management – cheat points. However, as mentioned earlier, the design space of lapse management is broad. Some dimensions include the scheduling, frequency, and quantity of lapses that a system could permit, or the degree of personalization used. For example, a system may choose to increase or decrease the number of lapses permitted dynamically, based on the user's behavior over time.

One dimension of lapse-management that we wish to explore in the future is rewarding users for *not* using their cheat points as a way to ensure that cheat points are only used when necessary. Another important dimension to explore is how lapse-management may interact (or interfere) with behavior change that relies on social support. Would users want to share with others accomplishments and progress that were made with the help of lapse management? Moreover, would they receive the support they need if their network becomes aware of the involvement of lapse management? While our first study provides some initial insights, with participants placed in the role of third-party observers, a more careful investigation is needed.

Still, we believe that successful system-driven lapse management must maintain a delicate balance between supporting unavoidable lapses and encouraging lapses (or at least not sufficiently discouraging them). Our use of the term "cheat minutes" appears to have achieved this goal; participants who used their cheat minutes were thankful to have them, but did not wish to exploit them. Cheat points are similar to other lapse management techniques, by helping people realistically adjust their goals and limits when needed [27]. Further work should examine the set of mechanisms through which cheat points motivate behavior change.

Finally, an interesting observation from the Control condition of Study 2 was the acknowledgement of some participants of increasing use of their mobile device to access the vice site. In the case of Study 2, participants had the ability to go to their vice website on a mobile device, a different computer, or simply a different browser. This challenge is not unique to our study; any tracking system or device can be fooled or circumvented, and journals can have false or incomplete information entered. As mentioned earlier, lapses that are not tracked not only result in the cost of the negative behavior, but also leave an incomplete and potentially meaningless record. Our system demonstrated that allowing users to manage their own lapses can reduce the need to circumvent the system, helping maintain more complete and representative records.

CONCLUSION

In this work, we implemented and deployed a system that helps users manage lapses in a behavior-change program. In a two-week controlled field study, we empirically evaluated the effectiveness of the use of "cheat points" for lapse management. Through quantitative and qualitative data, we describe how lapse management had both positive behavioral and attitudinal effects on participants compared to a control condition. This work gives initial insight into how the design of interventions to support and visualize lapse management can be integrated and used in conjunction with data collected from other devices, interfaces, and systems. Our results suggest the promise of such approaches for supporting and encouraging users in behavior-change programs to "stay the course."

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REFERENCES

1. Anja Achtziger, Ute C. Bayer, and Peter M. Gollwitzer. 2012. Committing to implementation intentions: Attention and memory effects for selected situational cues. *Motivation and Emotion* 36, 3: 287–300. http://dx.doi.org/10.1007/s11031-011-9261-6
2. Austin S. Baldwin, Alexander J. Rothman, Andrew W. Hertel, Jennifer A. Linde, Robert W. Jeffery, Emily A. Finch, and Harry A. Lando. 2006. Specifying the determinants of the initiation and maintenance of behavior change: an examination of self-efficacy, satisfaction, and smoking cessation. *Health Psychology* 25, 5: 626. http://dx.doi.org/10.1037/0278-6133.25.5.626
3. Albert Bandura. 1977. Self-efficacy: toward a unifying theory of behavioral change. *Psychological review* 84, 2: 191-215. http://dx.doi.org/10.1037/0033-295X.84.2.191
4. Eun Kyoung Choe, Nicole B. Lee, Bongshin Lee, Wanda Pratt, and Julie A. Kientz. 2014. Understanding quantified-selfers' practices in collecting and exploring personal data. *Proceedings of the 32nd annual ACM conference on Human factors in computing systems*, ACM, 1143–1152. http://dx.doi.org/10.1145/2556288.2557372
5. James Clawson, Jessica A. Pater, Andrew D. Miller, Elizabeth D. Mynatt, and Lena Mamykina. 2015. No longer wearing: investigating the abandonment of personal health-tracking technologies on craigslist. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ACM, 647–658. http://dx.doi.org/10.1145/2750858.2807554
6. Sunny Consolvo, Predrag Klasnja, David W. McDonald, Daniel Avrahami, Jon Froehlich, Louis LeGrand, Ryan Libby, Keith Mosher, and James A. Landay. 2008. "Flowers or a robot army?: encouraging awareness & activity with personal, mobile displays." In *Proceedings of the 10th international conference on Ubiquitous computing*, 54-63. http://dx.doi.org/10.1145/1409635.1409644
7. Felicia Cordeiro, Daniel A. Epstein, Edison Thomaz, Elizabeth Bales, Arvind Jagannathan, Gregory Abowd, and James Fogarty. 2015. Barriers and Negative Nudges: Exploring Challenges in Food Journaling. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, ACM, 1159–1162. http://dx.doi.org/10.1145/2702123.2702155
8. Duolingo: http://www.duolingo.com
9. Daniel Epstein, Felicia Cordeiro, Elizabeth Bales, James Fogarty, and Sean Munson. 2014. Taming data complexity in lifelogs: exploring visual cuts of personal informatics data. *Proceedings of the 2014 conference on Designing interactive systems*, ACM, 667–676. http://dx.doi.org/10.1145/2598510.2598558
10. Fitbit: http://www.fitbit.com
11. InterviewBit: http://www.interviewbit.com
12. Ira Flatow. "Making Resolutions that Stick." National Public Radio. http://www.npr.org/2012/12/28/168203195/making-resolutions-that-stick (Accessed September 18, 2015).
13. Benjamin Gardner, Kate Sheals, Jane Wardle, and Laura McGowan. 2014. Putting habit into practice, and practice into habit: a process evaluation and exploration of the acceptability of a habit-based dietary behaviour change intervention. *International Journal of Behavioral Nutrition and Physical Activity* 11, 1: 135. http://dx.doi.org/10.1186/s12966-014-0135-7
14. Peter M. Gollwitzer. 2014. Weakness of the will: Is a quick fix possible? *Motivation and Emotion* 38, 3: 305–322. http://dx.doi.org/ 10.1007/s11031-014-9416-3
15. Peter M. Gollwitzer and Bernd Schaal. 1998. Metacognition in action: The importance of implementation intentions. *Personality and Social Psychology Review* 2, 2: 124–136. http://dx.doi.org/10.1207/s15327957pspr0202_5
16. Rúben Gouveia, Evangelos Karapanos, and Marc Hassenzahl. 2015. How do we engage with activity trackers?: a longitudinal study of Habito. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ACM, 1305–1316. http://dx.doi.org/10.1145/2750858.2804290
17. Richard Koestner, Natasha Lekes, Theodore A. Powers, and Emanuel Chicoine. 2002. Attaining personal goals: self-concordance plus implementation intentions equals success. *Journal of Personality and Social Psychology* 83, 1: 231-244. http://dx.doi.org/10.1037/0022-3514.83.1.231
18. Artie Konrad, Victoria Bellotti, Nicole Crenshaw, Simon Tucker, Les Nelson, Honglu Du, Peter Pirolli, and Steve Whittaker. 2015. Finding the Adaptive Sweet Spot: Balancing Compliance and Achievement in Automated Stress Reduction. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, ACM, 3829–3838. http://dx.doi.org/10.1145/2702123.2702512
19. Amanda Lazar, Christian Koehler, Joshua Tanenbaum, and David H. Nguyen. 2015. Why we use and abandon smart devices. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ACM, 635–646. http://dx.doi.org/10.1145/2750858.2804288

20. James J. Lin, Lena Mamykina, Silvia Lindtner, Gregory Delajoux, and Henry B. Strub. 2006. "Fish'n'Steps: Encouraging physical activity with an interactive computer game." In *UbiComp 2006: Ubiquitous Computing*, 261-278. http://dx.doi.org/10.1007/11853565_16

21. Yikun Liu, Yuan Jia, Wei Pan, and Mark S. Pfaff. 2014. Supporting task resumption using visual feedback. *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*, ACM, 767–777. http://dx.doi.org/10.1145/2531602.2531710

22. G. Alan Marlatt. 1996. Taxonomy of high-risk situations for alcohol relapse: evolution and development of a cognitive-behavioral model. *Addiction* 91, Supplement 1 to Issue 12: 37–50. http://dx.doi.org/10.1111/j.1360-0443.1996.tb02326.x

23. G. Alan Marlatt, John S. Baer, and Lori A. Quigley. 1997. 10. Self-efficacy and addictive behavior. *Self-efficacy in changing societies*: 289-315. http://dx.doi.org/10.1007/978-1-4419-6868-5_4

24. G. Alan Marlatt and Dennis Michael Donovan. 2005. *Relapse prevention: Maintenance strategies in the treatment of addictive behaviors*. Guilford Press.

25. Susan Michie, Michelle Richardson, Marie Johnston, Charles Abraham, Jill Francis, Wendy Hardeman, Martin Eccles, James Cane, Caroline E. Wood. 2013. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of behavioral medicine* 46, 1: 81–95. http://dx.doi.org/10.1007/s12160-013-9486-6

26. Sean A. Munson and Sunny Consolvo. 2012. Exploring goal-setting, rewards, self-monitoring, and sharing to motivate physical activity. *Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2012 6th International Conference on*, IEEE, 25–32. http://dx.doi.org/10.4108/icst.pervasivehealth.2012.248691

27. Jeni Paay, Jesper Kjeldskov, Mikael B. Skov, Nirojan Srikandarajah, and Umachanger Brinthaparan. 2015. Personal Counseling on Smart Phones For Smoking Cessation. *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, ACM, 1427–1432. http://dx.doi.org/10.1145/2702613.2732847

28. James O. Prochaska and Wayne F. Velicer. 1997. The transtheoretical model of health behavior change. *American journal of health promotion* 12, 1: 38–48. http://dx.doi.org/10.4278/0890-1171-12.1.38

29. Manya Sleeper, Alessandro Acquisti, Lorrie Faith Cranor, Patrick Gage Kelley, Sean A. Munson, and Norman Sadeh. 2015. I Would Like To..., I Shouldn't..., I Wish I...: Exploring Behavior-Change Goals for Social Networking Sites. *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*, ACM, 1058–1069. http://dx.doi.org/10.1145/2675133.2675193

30. Tammy Toscos, Sunny Consolvo, and David W. McDonald. 2011. Barriers to physical activity: A study of self-revelation in an online community. *Journal of medical systems* 35, 5: 1225–1242. http://dx.doi.org/10.1007/s10916-011-9721-2

31. Greg Walsh and Jennifer Golbeck. 2014. Stepcity: a preliminary investigation of a personal informatics-based social game on behavior change. *CHI'14 Extended Abstracts on Human Factors in Computing Systems*, ACM, 2371–2376. http://dx.doi.org/10.1145/2559206.2581326

32. Weight Watchers message board. "Cheat days??" http://www.weightwatchers.com/community/mbd/post.aspx?page_size=25&rownum=15&threadpage_no=1&thread_id=169887989&board_id=1&forum_id=1 (Accessed September 18, 2015).

33. Jacob O. Wobbrock, Leah Findlater, Darren Gergle, and James J. Higgins. 2011. The aligned rank transform for nonparametric factorial analyses using only anova procedures. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 143-146. http://dx.doi.org/10.1145/1978942.1978963

34. Rayoung Yang, Eunice Shin, Mark W. Newman, and Mark S. Ackerman. 2015. When fitness trackers don't'fit': end-user difficulties in the assessment of personal tracking device accuracy. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ACM, 623–634. http://dx.doi.org/10.1145/2750858.2804269