
ewrapper: Operationalizing engagement strategies in mHealth

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Abstract

The advancement of digital technologies particularly in the domain of mobile health (mHealth) holds great promise in the promotion of health behavior. However, keeping users engaged remains a central challenge. This paper proposes a novel approach to address this issue by supplementing existing and future mHealth applications with an engagement wrapper – a collection of engagement strategies integrated into a single, coherent model. The engagement wrapper is operationalized within the format of an ambient display on the lock screen of mobile devices.

Author Keywords

Engagement, Just-in-time adaptive interventions, mobile health (mHealth)

ACM Classification Keywords

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

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Introduction

The mobile platform provides exciting possibilities for the promotion of health behaviors through mobile health (mHealth) applications. It enables passive data collection, timely and personalized intervention delivery, and anytime/anywhere accessibility to self-monitoring and self-management tools. Despite these promising developments, a critical issue remains: the law of attrition (Eysenbach, 2005). That is, a large proportion of users abandon mHealth apps and wearables quickly and after minimal use (e.g., Grist & Porter, 2017; Clawson et al., 2015). As a result, there is a pressing need to develop strategies to retain users, or to sustain user 'engagement'. Intervention engagement is defined as a multifaceted state with behavioral, affective, and cognitive elements that contribute to maximizing the intervention's positive outcomes (King & Petersen, 2012). In the context of mHealth, engagement behavior is most commonly captured via passive measures of app usage (Scherer et al., 2017).

Various domains of research in psychology, human-computer interaction (HCI), and marketing highlight strategies for engaging individuals. For example, social influence tactics are extensively researched in the field of social psychology. These tactics include different means by which a request for an eventual end (e.g., using a mobile app) can be made in order to capitalize on principles and processes underlying an individual's susceptibility to outside influences (Cialdini & Goldstein, 2004).

While studies have shown the positive average effect of various engagement strategies on people's compliance to requests (Cialdini, 2001), research also suggests that susceptibility to engagement strategies varies between people (e.g., as a function of cultural differences, Cialdini et al., 1999; personality traits such as need for cognition, Cacioppo & Petty, 1982; or preference for consistency, Cialdini et al., 1995), as

well as within an individual (e.g., as a function of changes in social relationships and need for belongingness, Cialdini & Goldstein, 2004; or changes in mood, Sinclair et al., 1994). Hence, certain strategies can be ineffective and undermine efforts to engage individual participants in particular settings (Kaptein, Eckles, & Davis, 2011). These ideas have motivated the development of e-commerce platforms that dynamically adapt the use of engagement strategies to the unique characteristics and changing responses of an individual consumer, in an effort to mimic face-to-face selling practices (Kaptein & Parvinen, 2015).

Building on these ideas, our goal is to develop and integrate a collection of engagement strategies that will dynamically adapt to the unique characteristics and changing responses of mHealth users. Specifically, this work will support the construction of a just-in-time adaptive intervention that aims to increase and maintain engagement in mHealth applications by accommodating between-person and within-person heterogeneity in responses to various engagement strategies.

The current paper describes our multidisciplinary collaboration to develop an "engagement wrapper" (*ewrapper*)— an ambient display for a mobile device that enables the implementation and adaptation of a wide variety of engagement strategies grounded in social psychology, marketing, cognitive psychology, decision research, and HCI. We begin by explaining the conceptual framework that guided the selection of engagement strategies, as well as the design and functionality of *ewrapper*. We then discuss the components of *ewrapper* and how we operationalize the engagement strategies in order to promote self-monitoring behaviors among obese/overweight adults via a weight-management mobile application.

Developing a conceptual framework

To identify engagement strategies with the potential of being effectively operationalized in mHealth settings, we first conducted an extensive review of the literature across a wide range of disciplines. Over one dozen engagement strategies were selected and organized using a framework that focuses on two key dimensions that underlie engagement: 1) automatic versus deliberative processes, and 2) intrinsic versus extrinsic motivation (See Figure 1).

The first dimension, automatic versus deliberative processes, is based on dual process perspectives (Evans, 2010), and focuses on the extent to which human decisions are driven by processes that are more automatic (i.e., nonconscious, intuitive and associative in nature, nonverbal, emotional, and typically fast) versus more deliberative (i.e., conscious, require cognitive effort, verbal, and typically slow).

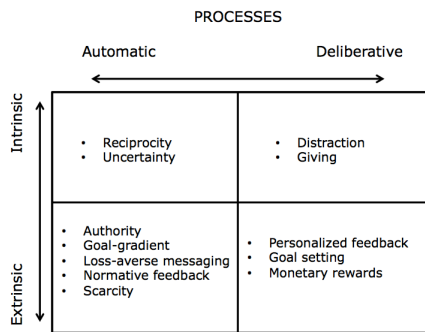
Cognitive theories of motivation and self-regulation mainly emphasize the importance of deliberative procedures (Brewin, 1996), building on the notion that individuals are active planners, and they invest time and effort to increase desirable outcomes (e.g., Bandura, 1986; Carver & Scheier, 1981). Among the many processes involved in self-regulation, considerable research attention has been devoted to goal-setting, self-monitoring, the activation and use of standards, self-evaluation, and self-reinforcement. For example, control theory (Carver & Scheier, 1981; 1982) highlights the action control processes that underpin the regulation of behavior. The theory proposes that setting goals, monitoring behavior, receiving timely feedback, and reviewing relevant goals in light of feedback are central to self-management and behavioral control. A meta-analysis of behavior change interventions supported the efficacy of these self-regulatory techniques in engaging individuals in health behaviors (Michie et al., 2009). However, other

engagement strategies in marketing and social psychology, are guided by the need to minimize burden on modern consumers who are barraged by pleas for engagement in every part of their lives. For example, this literature suggests that six basic psychological principles underlie the majority of successful influence tactics (Cialdini, 2001): *reciprocity*- people feel obligated to return a favor; *scarcity*- items and opportunities become more attractive as they become less available, particularly when this is a result of competition with other individuals; *authority*- people value the opinion of experts; *consistency*- public commitments promote consistent future action because they tap into a potent human motivation to be, or at least to appear, consistent with previous commitments, attitudes, and actions; *consensus*- people do as other people do; and *liking*- people have a tendency to agree or commit to those they like. Tactics that capitalize on these principles rely heavily on innate psychological tendencies that operate at an implicit level, rather than on facilitating effortful reasoning or logic (Kaptein & Duplinsky, 2013). In other words, social influence tactics target automatic processes.

The second dimension is based on motivational theories that differentiate between intrinsic (i.e., “doing something because it is inherently interesting or enjoyable”) and extrinsic motivation (i.e., “doing something because it leads to a separable outcome”) (Ryan & Deci, 2000). Many engagement strategies are extrinsically motivating, such as strategies that involve monetary rewards contingent upon engagement (Volpp et al., 2008). Empirical evidence suggests that although strategies that are extrinsically motivating can be effective in the short-term, they tend to undermine learning and long-term change compared to strategies that are more intrinsically motivating (Ryan & Deci, 2000; Benabou & Tirole, 2003).

We propose a 2 x 2 engagement strategy framework comprising the two key dimensions (extrinsic versus

Figure 1



Note: Figure 1 includes a few examples of the engagement strategies that may be operationalized in mHealth settings.

intrinsic, and automatic versus deliberative) that can be useful in guiding the selection of engagement strategies that have the most potential in a given setting. Specifically, understanding the process and motivation underlying each engagement strategy can help ascertain the conditions in which this strategy can be useful, as well as its implications on short-term and long-term engagement. Figure 1 provides some examples of the evidence-based engagement strategies that we consider implementing in our current project. It is important to note that both of the dimensions are continuous and the engagement strategies vary in where they lie on the continuum along each dimension. In the following section, we provide an overview of how these strategies were operationalized and integrated in the *ewrapper* to engage obese/overweight adults in the use of a weight management app.

Integrating engagement strategies with *ewrapper*

As part of our ongoing collaboration with MD2K—an NIH funded center for excellence for mobile sensor data-to-knowledge (Kumar et al., 2015), we designed an ambient display on the mobile device’s lock screen to connect engagement strategies in a manner that would be accessible and pleasurable to the user. The ambient display is in the form of a tree that grows to reflect user progress; non-monetary and monetary rewards are represented by fruits that grow on the tree. Users can redeem the rewards by tapping the fruits. Brief reminders and prompts are provided via app notifications (i.e., push notifications) to accompany the ambient display.

In the current project, we implement *ewrapper* in the context of SMARTr – a weight management mobile application. SMARTr is a mobile application targeting weight loss by supporting self-monitoring of dietary intake and physical activity. Self-monitoring is one of the key mechanisms facilitating success in weight

management programs (Burke et al., 2011). For simplicity, we focus here on self-monitoring dietary intake as the main outcome of interest. In SMARTr, users are asked to log into the app any food/drink item they consume and the time at which the item was consumed. The app uses the *CalorieKing* nutrient database to help users locate and enter food items. While adherence to self-monitoring dietary intake is associated with greater weight loss, it is a challenging task for users even when supported by software programs that lessen the burden (Burke et al., 2011).

ewrapper integrates the following operationalizations of the engagement strategies to get SMARTr users perform “on-time” self-monitoring of dietary intake. Engagement is measured here as using the app to self-monitor dietary intake within an hour in which the food/drink item was consumed. We refer to this below as “on-time logging”.

Extrinsic and Deliberative Strategies

These strategies are expected to generate extrinsic motivation for engagement by capitalizing on processes that are more deliberative (i.e., conscious, require cognitive effort, verbal, and typically slow).

Goal setting

Goal setting is defined as specifying desired performance outcomes (Locke & Latham, 1990). In order to set specific, simple, and realistic goals, users are asked to specify one-hour time intervals in which they expect to consume each of 3 daily meals. Specific goals are then pre-specified for the user based on these time intervals—to log food/drink items for every meal within an hour of consumption, as well as to log up to 2 snacks within an hour of consumption. These time intervals were also used to identify times at which it might be useful to engage the users in self-monitoring depending on goal attainment (i.e., to identify decision points).

Personalized feedback

Feedback is provided based on personal goal attainment in the following ways:

Visual feedback: There are two visual feedback components in *ewrapper*. First, at the beginning of each day the tree starts out leafless and fills with leaves in increments following each meal or snack logging (24% of tree fills with each meal logging and 14% with each snack logging; see Figure 2). Leaf growth serves as a visual representation and reminder of progress toward users' daily goal (i.e., self-monitoring 3 meals and 2 snacks).

Second, the visual display implemented in *ewrapper* includes a bird, which serves as a coach or guide throughout the duration of app use. The bird is responsible for delivering points, reminders, and messaging (See Figure 3).

Messages: Upon logging meals, a bird delivers a personalized feedback message on occasion. Personalized feedback messages highlight user performance statistics and next objectives, such as, number of consecutive logged meals, and number of points away from unlocking a new fruit.

Reminders: Feedback is also employed in the form of reminders if users have yet to log a meal 2 hours past their specified meal time interval (e.g., if a user specified that they normally eat their breakfast between 9am-10am, users may receive a reminder to log breakfast at 12pm). The following is an example of a reminder that employs personalized feedback: "Log breakfast to keep your record streak alive!"

Rewards

Various types of rewards – monetary and non-monetary – are employed in order to reinforce engagement (i.e., the goal of logging food "on-time"-

within one hour of consumption). The rewards are operationalized via a point system. Points are awarded following each meal or snack logging. "Delayed" logging (i.e., outside of one hour of consumption) results in a significant reduction in the value of points rewarded. Awarded points aggregate throughout the duration of app use, and as certain thresholds (i.e., point values) are met, different kinds of fruits are unlocked.

There is a total of 5 different kinds of fruits to unlock. An unlocked fruit is made available as a possible reward for future meals logged "on-time". Each kind of fruit contains a unique type of content (see below). Users have the option of archiving any content they wish to revisit at a later time.

Fruit content includes: 1) Orange: mini games (e.g., crosswords, trivia); 2) Banana: funny media (e.g., viral memes, brief video clips, gifs); 3) Apple: inspirational content (e.g., healthy recipes, quotes, DIY projects, life hacks); 4) Pineapple: small monetary rewards (e.g., \$2 credit to Amazon); and 5) SharePear: mixture of contents from the fruits above that can be shared with others, as we explain in more detail below under the "giving" strategy.

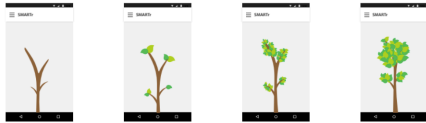
Extrinsic and Automatic Strategies

These strategies are expected to generate extrinsic motivation for engagement by capitalizing on processes that are more automatic (i.e., nonconscious, intuitive and associative in nature, nonverbal, emotional, and typically fast).

Normative feedback

Normative feedback is provided in a manner that emphasizes the difference between the user's behavior and the behavioral pattern of a salient reference group (Cialdini et al., 2008). To operationalize normative feedback, during the onboarding of the app, users are

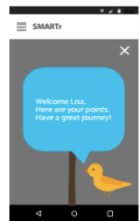
Figure 2



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Figure 2 shows how the tree gradually becomes fuller with leaves following food logging.

Figure 3



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Figure 3 shows an example of how the bird will appear to deliver points and messaging.

Figure 4



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Figure 4 shows the three types of birds that represent each team.

required to select one of three birds that vary in terms of color (see Figure 4) and the color will represent the team that the user will identify with (i.e., salient reference group) for the duration of app use. As noted earlier, the bird serves as a coach or guide throughout the duration of app use and is responsible for Messages: On occasion, the bird delivers normative feedback upon logging a meal. Types of normative feedback include: 1) user performance versus user's team performance (e.g., "You average 2.5 meal loggings per day and your team's average is 2. Keep it up!"), as well as 2) user's team performance versus the performance of other teams (e.g., "Your team can overtake the top spot for most logged meals today if 90% of your team logs lunch and dinner.").

Reminders: On occasion, the reminders are framed as normative feedback. For example, users will receive a message like the following: "85% of your team logged breakfast this morning. Don't forget to log yours!"

Authority

To capitalize on people's tendency to value the opinion of experts (Cialdini, 2001), on occasion we frame the messages and reminders based on extant literature, empirical evidence, or clinical experience. The following is an example of a reminder that employs this strategy: "Dieticians claim that self-monitoring is only effective if done consistently."

Scarcity

To make the rewards more attractive (Cialdini, 2001), a fruit that appears on the tree is only available for a limited time, and disappears after 24 hours if not redeemed. To increase the saliency of this strategy via visualization, the fruit begins rotting in appearance at hour 23 if it has yet to be redeemed.

Loss-averse messages

To capitalize on people's higher sensitivity to investment losses than gains (Tversky & Kahneman, 1991), we included messages that highlight the reward(s) users missed out on due to failing to engage in self-monitoring a meal "on time". Specifically, if users fail to log a meal, their bird may deliver a message highlighting the fruit they could have earned had they logged their meal.

Goal-gradient

We used two approaches to capitalize on people's tendency to expend more effort as they approach a reward (i.e., goal-gradient hypothesis: Hull, 1932; Kivetz et al., 2006). First, to increase engagement in low-engaged users, the points needed to unlock the next fruit are reduced as soon as signs of low-commitment are detected (i.e., user averages less than 2 meal loggings per day). In other words, unlocking the next fruit in line is made more attainable for users showing signs of low engagement. Users are blinded to this strategy. Second, boosters are provided to re-engage users who show signs of disengagement. Specifically, users are provided with booster points if no meals are logged in a 48-hour period as an attempt to move them closer to unlocking the next fruit.

Intrinsic and Deliberative Strategies

These strategies are expected to generate intrinsic motivation for engagement by capitalizing on processes that are more deliberative (i.e., conscious, require cognitive effort, verbal, and typically slow).

Giving

Giving facilitates positive emotions through benevolent behaviors (Brown et al., 2003). SharePears were added to operationalize this engagement strategies. Specifically, users have the option of sharing ("giving") earned SharePears.

Distraction

Distraction is defined in terms of shifting one's internal focus away from negative thoughts or emotions (Dekker et al., 2009). The content selected for each kind of fruit is intended to elicit positive emotion and be desirable to seek out as a form of entertainment or as a means to escape reality (e.g., funny video clips or crossword puzzles).

Intrinsic and Automatic Strategies

These strategies are expected to generate intrinsic motivation for engagement by capitalizing on processes that are more automatic (i.e., nonconscious, intuitive and associative in nature, nonverbal, emotional, and typically fast).

Uncertainty

Uncertainty refers to a lack of knowledge and/or an inability to predict the likelihood of consequences (Milliken, 1987). Empirical evidence suggests that predictable events evoke less intense emotions than unpredictable ones, meaning that uncertainty can increase pleasure (Wilson et al., 2005). Here, uncertainty is operationalized by introducing variability, namely by changing the content and ambient display in order to enhance curiosity, and reduce boredom and habituation. Uncertainty was included in the following ways:

Tree growth: At the onset of using the mobile application, the ambient display of the tree starts out as a sapling and gradually grows into a fuller and more serves as a visual representation and reminder of progress towards users' long-term goal(s). Users are not able to anticipate tree growth nor the shape and form of the growth.

Locked fruit: Users are blinded to the type of content each fruit provides until the fruit is unlocked.

Earning fruit: A lottery system is implemented whereby each time users log a meal "on-time", they have a certain chance of earning a fruit. In other words, engagement does not always lead to the earning of a fruit. Adding variation in terms of when users are awarded fruit increases anticipation and uncertainty.

Kind of fruit & contents of fruit: Each time a fruit is to be awarded, the type of fruit is selected randomly from the fruits the users have unlocked up until this point in time. Moreover, within each fruit, the content it contains is selected at random such that the same content is never delivered more than once.

Reciprocity

Reciprocity capitalize on people's tendency to feel obligated to return a favor (reciprocity: Gouldner, 1960). SharePears are also used to operationalize this strategy. Specifically, reciprocity is activated when SharePears are received from teammates. That is, receiving a "no strings attached" reward can increase the motivation to return the gesture and thereby enhance engagement.

Future research

The use of engagement strategies in the 2 x 2 framework in the current paper is based on the extant literature on engagement in various areas of research, as well as on practical considerations relating to the population and behavior targeted. Next steps include conducting focus groups to probe users in order to refine this theoretically-grounded approach.

Additionally, we plan to conduct a series of studies to optimize the timing and operationalization of engagement strategies in order to inform the development of a just-in-time adaptive engagement strategy to promote self-monitoring behaviors among obese/overweight adults. Finally, our work will focus on

Figure 5



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Figure 5 shows examples of the stages of tree growth.

investigating how the proposed framework can be generalized to other mHealth settings.

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