Putting the Long-Term into Behavior Change

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Abstract. Behavior change is a topic that is of great interest to many people. People can use apps to exercise more, eat healthier, or learn a new skill, but and digital interventions and games are also used by policy makers and companies to create a safe environment for the general public or to increase sales. Given this interest in behavior change, it is not surprising that this topic has seen a lot of interest from the scientific community. This has resulted in a wide range of theories and techniques to bring about behavior change. However, maintaining behavior change is rarely addressed, and as a result poorly understood. In this paper, we take a first step in the design of digital interventions for long-term behavior change by placing a range of behavior change techniques on a long-term behavior change timeline.

Keywords: Behavior change, long-term effects, behavior change techniques

1 Introduction

Behavior change is a topic that is of great interest to a wide audience: policy makers aim to encourage the public to exhibit behavior that results in a safe and comfortable environment, companies aim to have consumers buy their products, and many individuals use digital applications or games to change their own behavior by exercising more, eating a healthier diet, or ridding themselves of a bad habit. Given this interest in behavior change, it is not surprising that this topic has seen a lot of interest from the scientific community. This has resulted in a wide range of useful theories and techniques that are effective in bringing about behavior change [12, 14, 35].

However, many behavior change theories only consider the initial change of behavior and do not address the issue of maintaining behavior change. As a result, long-term behavior change is rarely achieved [18]. This is particularly unfortunate as common behavior change goals such as eating healthier, exercising more, or quitting smoking are intended to be long-term behavior changes.

In this paper, we take a first step towards a formalization for long-term behavior change interventions by taking a closer look at a number of behavior change techniques, particularly those that are used or that can be used in digital applications or games, and placing them on a long-term behavior change timeline. The goal of this timeline is to provide a clear picture of what behavior change techniques are most effective at different points in the behavior change process.

We discuss a number of behavior change techniques listed in the behavior change technique (BCT) taxonomy v1 [23]. These behavior change techniques differ in the way they approach behavior change by targeting different determinants of behavior. Across many theories on behavior, there appears to be a consensus that there are three

main determinants of behavior; in this paper, we use the COM-B model of [22] and refer to these three determinants as motivation, capability, and opportunity. In Sections 2, 3, and 4, we discuss the motivation, capability, and opportunity determinants of behavior, respectively, and discuss some of the behavior change techniques that target these determinants. In Section 5, we discuss our findings in the light of long-term behavior change, and place behavior change techniques on an intervention timeline. Finally, Section 6 concludes our paper and provides direction for future research.

2 Motivation

Table 1. Summary of behavior change techniques through motivation considered in Section 2.

Technique	Effects
Extrinsic rewards	+ Can reduce costs of behavior change [7]
	- Low rewards may be counter-productive [13]
	- Effective rewards can have addictive properties [16]
Persuasive information	+ Social comparison can increase motivation [25]
	+ Vicarious experiences can increase motivation [21]
Fear appeal	+ Effective in many cases [33]
	- May be counterproductive for low self-efficacy users [15]
Punishment	+ Effective in reducing bad habits [1]
	- Limited effectiveness as a deterrence [19]
	- Concrete punishment may make bad behavior acceptable [11]
Social pressure	+ Monitoring by others increases adherence [24]
Long-term effects	- Motivators lose effectiveness over time

In the COM-B model [22], motivation is the total inclination of a user to engage in the target behavior. This includes voluntary considerations based on intrinsic motivators such as a sense of pleasure, achievement, or discovery, as well as extrinsic motivators such as monetary reward, verbal praise, or social recognition. In addition, motivation also includes involuntary processes that change the likelihood to perform the target behavior, such as habits, addiction, and emotional responses. However, although habits are explicitly included in the motivation determinant of behavior, we will delay discussion of habits until Section 4 on the opportunity determinant of behavior.

One of the reasons why people may fail to change their behavior is a lack of motivation. Perhaps the most obvious solution to this problem is to incentivize these people with additional (extrinsic) motivation in the form of rewards. Gamification elements such as points and achievements, but also likes on user-created content can be rewarding. Rewards even effect behavior change in people who do not receive the reward themselves; Ma et al. [21] show that children that observed peers who were rewarded for their honesty were more likely to be honest than those that observed honest peers that were not rewarded.

Social factors can also play a significant role in motivating behavior change in general. Nolan et al. [25] experimented with different energy conservation messages and found that Californians conserved more energy when they were told that their neighbors did so, even though respondents rated such normative information as the least motivating. Even the sense of being watched by others can affect motivation.

Nettle et al. [24] show that participants were more likely to donate in the Dictator Game when a poster with a pair of eyes was present in the experimentation room.

While rewards may increase motivation, the use of rewards does not guarantee a beneficial effect. There are cases in which extrinsic rewards may actually suppress intrinsic motivation to perform a task. Heyman and Ariely [13] report on an experiment in which participants that were paid a low amount of money to perform a task put in *less* effort than those that were not paid at all. In addition, Kim and Werbach [16] argue that particularly strong gamified incentives can have addictive properties and unintentionally lead to physical or psychological harm to the user.

Extrinsic motivators can also be used to generate a positive association with the target behavior. For example, many medical treatments are boring to perform or have negative side effects that hinder adherence. By incorporating boring rehabilitation exercises in a game, such as the rehabilitation gaming system [7], the association of the rehabilitation with boredom can be changed into an association with fun.

Rather than rewarding behavior change, people can also be motivated to change their behavior by emphasizing the negative effects of failing to change behavior. Such *fear appeals* are an especially popular tool in campaigns to prevent or reduce smoking and binge drinking, or to improve road safety. While fear appeals have been shown to be effective [33], a threat alone is likely to be ineffective in encouraging behavior change and may even be counter-productive in users that feel incapable of changing behavior [15]. A threat should therefore be presented alongside concrete advice on how to avoid the negative effects mentioned in the threat. That is, a behavior change intervention that relies on fear appeals should have elements that target the motivation determinant, but also target the capability determinant of behavior (see Section 4).

If threats and fear appeals are not effective enough in discouraging negative behavior, behavior change techniques can attempt to remove the beneficial effects of the negative behavior or to add punishment. Examples of this type of behavior change technique are imposing fines for speeding by policy makers [19], applying a bitter creme to discourage nail biting [1], but also limited lives in a computer game.

Punishment may not be effective in reducing undesirable behavior. For example, Lawpoolsri and Braver [19] find that speeding tickets have a limited deterring effect. Gneezy and Rustichini [11] report a situation where a daycare center introduced a fine for parents that picked up their children too late, whereupon the number of late-coming parents *increased* rather than decreased. In this case, the fine may have been interpreted as a price for a service, making the negative behavior more acceptable.

In addition, rather than changing their behavior, people may put their effort in avoiding the punishment, such as installing a radar detector to avoid speeding tickets. This is a particular challenge for game-based interventions, where a user may simply choose to stop playing to avoid punishment rather than engaging in behavior change.

A particular problem when trying to achieve long-term behavior change by targeting motivation is that the behavior is likely to revert back to the original once the intervention ends (e.g. when a player abandons a game). After all, if intrinsic motivation was not enough to encourage behavior change originally, it is likely to be insufficient once there are no more extrinsic motivators (cf. [5]). But even if the intervention can be continued indefinitely, repeated exposure to the same reward, threat, or pun-

ishment may lead to habituation or satiation, which may reduce its effectiveness. For example, users routinely disregard security warnings from their computer [2]. For long-term behavior change, an intervention based on rewards or threats should therefore also consider planning for habituation (see also Section 4).

3 Capability

Table 2. Summary of behavior change techniques through capability considered in Section 3.

Technique	Effects
Planning	+ Planning more concrete actions is more effective [8]
Instruction	+ Seeing peers perform behavior boosts self-efficacy [29]
	+ Testimonials can increase self-efficacy [34]
Task structuring	- Setting difficult goals can reduce self-efficacy [4]
	+ Scaffolding can gradually improve self-efficacy [36]
Feedback	- Data alone may not be effective [20, 30]
Identity	+ Identifying with the target behavior increases self-efficacy [28]

In the COM-B model [22], capability refers to the user's perceived ability to perform the target behavior (i.e. self-efficacy, [3]), which includes physical ability and self-control, but also the knowledge and skill necessary to perform the task.

Conroy et al. [9] find that many top-ranked mobile apps for physical activity rely mostly on instructions or demonstrations of the target behavior. However, techniques that help users to transform their intentions into concrete behavior, for example through action planning, were rarely observed in these apps, even though these techniques have the potential to increase self-efficacy [8]. For example, a user that wants to exercise more is less likely to be effective when he commits to going to the gym this week than when he commits to go to the gym for an hour on Wednesday at 6 PM.

The successfulness of a behavior change intervention depends on whether concrete and manageable goals are set. Through chaining or scaffolding, complex goals can be achieved through a series of simpler tasks. For example, Dragonbox Algebra [36] starts teaching children how to solve algebraic equations by introducing a concept of zero. As the player progresses, the player receives incremental instructions on how to perform the more complex actions that are needed to complete later goals, while avoiding goals that are too complex. After all, a particularly challenging goal, even when the user does complete it, can reduce self-efficacy [4].

Schunk and Hanson [29] show that children that observed the subtraction skills of others were more confident that they could learn subtraction as well. This modeling effect was strongest when these children observed peers rather than teachers, which underlines that modeling is most effective when the model is similar to the target. A similar effect is shown by Ubel et al. [34], who report that testimonials of previous patients significantly influence the choice of treatment of a current patient. These effects can also be leveraged through multi-player elements in games.

A user's ability to change behavior can also be supported by feedback on or monitoring of the current behavior. For example, wearable activity trackers such as Fitbit provide continuous information on activity to help the user achieve their activity goals. However, Shih et al. [30] find that 17 out of 26 users stopped using the Fitbit

within two weeks. Lazar et al. [20] report that athletic users found the data to be least useful, while other users believed the data to be more useful to athletic users. That is, while wearable devices provide a great opportunity to provide feedback on behavior, the presentation of this feedback should be designed with the end user in mind.

An important aspect of the capability determinant of behavior is that it refers to *perceived* ability to perform the behavior. The importance is exemplified by the fact that users tend to perform the behaviors that are associated with their perceived identity. For example, users that identify themselves as a smoker tend to smoke. If a smoker starts to identify as a non-smoker, for example through some success with quitting smoking, that person is less likely to relapse [28].

4 Opportunity

Table 3. Summary of behavior change techniques through capability considered in Section 4.

Technique	Effects
Habit formation	+ Relevant cues increase adherence and automaticity [26] - Adherence is not the same as automaticity [32] - Repetition alone is not enough [10]
Environmental restructuring	+ Distraction from cues can help to remove bad habits [27]

The third determinant of behavior in the COM-B model [22] is opportunity, which refers to external factors that facilitate or prompt the target behavior. Someone who is dedicated to dental hygiene and wants to floss more often may be helped by being prompted to floss at appropriate times. Similarly, notifications on a smartphone signal the opportunity for its user to interact with the smartphone.

The opportunity determinant of behavior is strongly related to creating positive habits and removing negative habits, which in turn has strong ties with long-term behavior change. It is important to note that while repetition is an important aspect in habit formation, habits are not determined by frequency of behavior, but by automaticity in the presence of a given cue [10]. In order to form a habit, a relevant cue is therefore vital. Orbell and Verplanken [26] show their results of an experiment introducing a flossing habit in participants. They report that participants that were explicitly asked to write down a concrete cue to start flossing (e.g. after brushing teeth at night) flossed more over the four weeks of the experiment than control participants.

Habit formation relies vitally on the relevance of the cue. Ideally, the cue should only be present when the desired behavior is to be performed in order to ensure a strong connection between cue and behavior. For example, even though security warnings on a computer only occur in relevant situations, they are routinely ignored [2]. Interventions aimed at habit formation should therefore strive to select a relevant cue and make it more salient to the user, for example through prompts or reminders. Karppinen et al. [14] report that such reminders were perceived as especially beneficial features of behavior change support systems.

In addition, the cue should be salient enough to eventually trigger behavior without a prompt. Stawarz et al. [32] show that while time-based cues result in better adher-

ence, context-based cues result in better automaticity. That is, while sending an SMS message every morning at 8 AM to floss may result in better adherence, a context-dependent cue at the end of breakfast is expected to result in better habit formation. However, it is more difficult to automatically send a message whenever a user finishes brushing their teeth than it is to send a message every day at 8 AM. When using prompts to help users change their behavior, the relevant cue should be salient enough for the intervention to detect. However, if the relevant cue is particularly salient, the user may not need a prompt. Sohn et al. [31] present a possible solution by prompting based on GPS location, which may be more salient for a device than for the user.

Some behavior change techniques are closely linked to both opportunity and capability. The antecedents group of behavior change techniques revolves around stopping negative behavior by avoiding the stimuli that encourage it. For example, people that want to eat healthier may decide to restructure their environment by filling their house with healthy snacks rather than unhealthy snacks, or even to buy only at stores that do not sell unhealthy food. Similarly, a student may decide to go to the library to avoid the distractions at home. By doing so, they avoid the stimuli that encourage the unwanted behavior (eating unhealthy snacks, being distracted from studying) while allowing ample opportunity to engage in the target behavior (eating healthy snacks, studying). For internal stimuli, such as cravings for smoking, distraction may provide a suitable technique to avoid giving in [27].

5 Designing interventions for long-term behavior change

Behavior change techniques are typically described from a short-term point of view, in which the only significant influence on the user's motivation, capability, and opportunities can be assumed to be the technique itself. However, as time progresses, a user's motivation, capability, and opportunities may change, as well as the requirements a user has of the behavior change techniques that are offered by an intervention. In this section, we take a first step in placing behavior change techniques in a time frame specifically aimed at long-term behavior change.

In the process of behavior change, we identify four phases (see Figure 1), which correspond to the four stages of competence [6]. In the earliest phase of behavior change, users of a behavior change intervention are *unconsciously incompetent*. A user in this phase is unable to implement the behavior change and does not recognize that such behavior change is necessary or beneficial. At this initial phase, the intended behavior change may even be actively opposed (e.g. in addiction), or already presumed to be achieved (i.e., an illusion of mastery).

Users in this first phase will not knowingly engage in a behavior change intervention themselves but are rather entered into the intervention through outside forces. This could in the form of a game that requires its players to acquire certain skills to progress, or a government trying to dissuade negative behavior. Behavior change techniques that are expected to be effective in this phase mostly have an outcome that is attitudinal or results in declarative knowledge (cf. [17]). Users can be informed about the need for behavior change by information about the beneficial effects of behavior change, emphasizing the negative effects of failing to change behavior (e.g.

fear appeals), or feedback on the user's performance on the target behavior. In addition, extrinsic rewards, punishment, and social pressure may also be persuasive.

A user that understands the importance of the behavior change, but is unable to realize this change, transitions to a phase of *conscious incompetence*. Most serious games and other behavior change interventions focus on this stage, in which the user attempts to increase his or her competence. Behavior change techniques that have a motivational or declarative knowledge outcome (cf. [17]) play an important role here.

Users that do not perceive themselves as capable of the behavior change can be assisted through instruction, task structuring, planning, and feedback. In addition, users may feel incapable of behavior change due to a disconnect between long-term goals and short-term urges or habits. For example, someone who wants to quit smoking may feel unable to resist the urge to smoke at specific moments. Behavior change techniques that target opportunity by reducing the opportunity to perform negative behaviors (i.e. environmental restructuring) may be particularly effective. Users may also benefit from extrinsic rewards, punishment, or social pressure. Note that while in the unconscious incompetence stage these motivation-centered behavior change techniques are aimed at increasing the perceived *benefit* of the behavior change (i.e. attitudinal outcomes), in the conscious incompetence stage they are aimed at reducing the perceived *cost* of behavior change (i.e. motivational outcomes). For example, rehabilitating within the context of a game does not make the outcome of the treatment more appealing, it makes the perceived cost of the rehabilitation process acceptable.

The third phase is characterized by *conscious competence*. A user in this phase is capable of performing the target behavior at any given moment, but it requires conscious effort to do so, which results in a risk for relapse. In this phase, extrinsic rewards and punishment may need to be removed in a controlled manner. After all, as mentioned in Section 2, habituation and satiation of the extrinsic motivator may eventually render it ineffective (cf. [5]). However, if these extrinsic motivators were instrumental in achieving behavior change, intrinsic motivators may not be enough to maintain the behavior change. Social support may be especially useful in compensating for the reduced effectiveness of other motivators (see also [14]).

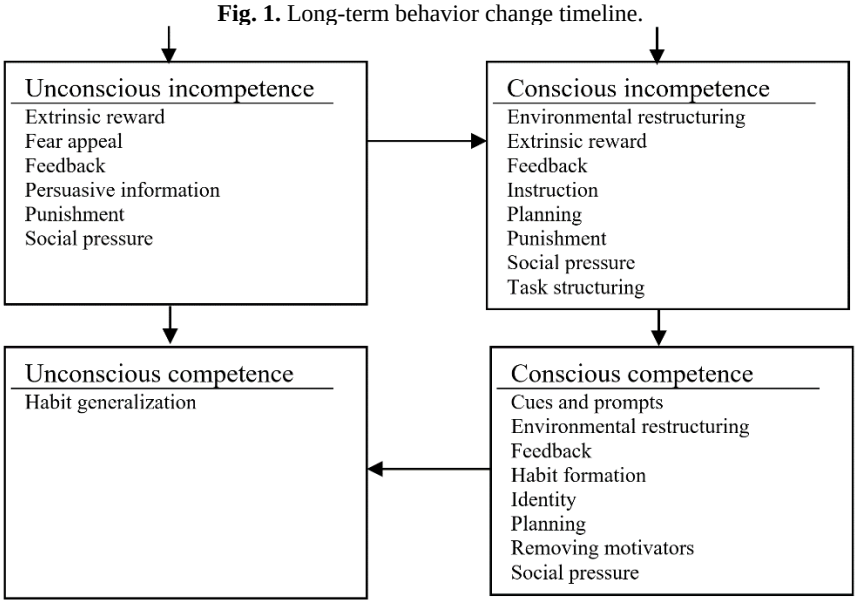
To reduce the risk of relapse, the user may start to identify with the new behavior (e.g. a non-smoker). Planning and feedback may still be required to maintain the behavior change. Behavior change techniques with an automaticity or proceduralization outcome [17] will be especially effective in transitioning to the final phase.

The final phase is characterized by *unconscious competence*, where the behavior change is governed by habitual action. In this phase, the risk of relapse of the user is greatly reduced. However, this does not mean that the behavior change is persistent. A prolonged change in context may disrupt the habit that governs the behavior change. This is a particular challenge for game-based interventions, which have to ensure that skills acquired in the game context transfer to and persist in real-life scenarios. In this final phase, habit generalization may therefore be beneficial.

While these phases suggest a strong linearity in the process of behavior change, this is not the intended message. For example, users that knowingly engage in behavior change will typically be consciously rather than unconsciously incompetent, and therefore start the process in the second phase. Through conditioning, users may also

go from unconscious incompetence straight to unconscious competence. In addition, at any point a user may relapse to an earlier phase.

Fig. 1. Long-term behavior change timeline.



6 Discussion

In this paper, we have taken a first step in creating a timeline for long-term behavior change by delineating what behavior change techniques are most likely to be effective in what phase of the behavior change. A behavior change intervention is more effective on the long run when it combines a variety of behavior change techniques that target motivation, capability, and opportunity. However, simply adding more behavior change techniques to an intervention does not guarantee its effectiveness will increase [37]. While some combinations of behavior change techniques show synergy, adding more behavior change techniques may reduce overall effectiveness. Unfortunately, it is currently poorly understood how different behavior change techniques interact. In addition, not all behavior change can be readily assessed.

To complicate matters, a particularly effective behavior change technique is tailoring [14], in which the intervention customizes itself to the needs of the user. Also, the effectiveness of behavior change techniques such as modeling as well as emphasizing personal susceptibility in fear appeals suggests that interventions that adapt to their user may be especially effective. Although it is known that different audiences have different needs, it is not clearly understood how the determinants of behavior and the effectiveness of behavior change techniques vary across audiences.

Behavior change is a complex interplay of motivation, capability, and opportunity, especially over longer periods of time. With the long-term behavior change timeline presented in this paper, we have taken a first step towards understanding how digital tools such as serious games need to be designed to ensure long-term effectiveness.

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