International Journal of Human–Computer Interaction

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/hihc20

The Behavior Change Design Cards: A Design Support Tool for Theoretically-Grounded Design of Behavior Change Technologies

Chrysanthi Konstanti, Evangelos Karapanos & Panos Markopoulos

To cite this article: Chrysanthi Konstanti, Evangelos Karapanos & Panos Markopoulos (2021): The Behavior Change Design Cards: A Design Support Tool for Theoretically-Grounded Design of Behavior Change Technologies, International Journal of Human–Computer Interaction, DOI: 10.1080/10447318.2021.1990519

To link to this article: https://doi.org/10.1080/10447318.2021.1990519

Published online: 09 Nov 2021.

INTERNATIONAL JOURNAL OF HUMAN–COMPUTER INTERACTION
https://doi.org/10.1080/10447318.2021.1990519

The Behavior Change Design Cards: A Design Support Tool for Theoretically-Grounded Design of Behavior Change Technologies

Chrysanthi Konstanti[a], Evangelos Karapanos[a], and Panos Markopoulos[b]

[a]Department of Communication and Internet Studies, Cyprus University of Technology, Limassol, Cyprus; [b]Department of Industrial Design, Eindhoven University of Technology, Eindhoven, Netherlands

ABSTRACT

Despite a wealth of behavior change theories and techniques available, designers often struggle to apply theory in the design of behavior change technologies. We present the *Behavior Change Design (BCD) cards*, a design support tool that makes behavioral science theory accessible to interaction designers during design meetings. Grounded on two theoretical frameworks of behavior change, the BCD cards attempt to map 34 behavior change techniques to five stages of behavior change, thus assisting designers in selecting appropriate techniques for given behavioral objectives. We present the design of the BCD cards along with the results of two formative and one summative study that aimed at informing the design of the cards and assessing their impact on the design process.

1. Introduction

Behavior change support technologies are increasingly pervading all facets of human activity. From improving on dietary habits to managing personal expenses, coping with mental workload, enhancing physical activity, and reducing one's environmental footprint, such technologies are often seen as the way to personal improvement or even to addressing pressing societal challenges (Agapie et al., 2016; Li et al., 2010).

There is a wealth of related theories deriving from fields such as communication sciences, social psychology and behavioral economics which can inform the design of behavior change support technologies. However, applying behavior change theory to the design of behavior change technologies can be challenging, due to the vast amount of theories, models, and techniques available (Michie & Prestwich, 2010). As a result, prior studies have shown the majority of mobile apps lack theoretical content (*e.g.*, Azar et al., 2013; Conroy et al., 2014; Cowan et al., 2013). Designers can benefit from tools that will support them in recruiting such theories and applying them in the context of a design challenge.

Design cards have become a widely adopted design support tool in Interaction Design providing what Rogers (2004) calls *knowledge transfer* (*i.e.*, the translation of research findings from one discipline into another). It has been argued that design cards provide a number of benefits for the design process: they make the design process visible and less abstract, they communicate knowledge between the members of a group and increase creativity and idea generation, among others (Wölfel & Merritt, 2013). A recent survey by Roy and Warren (2019) examined 155 card sets and argued that they can aid the design process and provide information, methods, or good practice in a handy form. However, they point out the scarcity of empirical evidence for these benefits of cards and invite researchers to provide empirical support for their claims.

Designers of behavior change support systems can seek methodological guidance in several frameworks that have been proposed for design. Pioneering work by B.J.Fogg has integrated several theoretical and empirical considerations in a form that is actionable for designers and provided detailed guidance in his seminal book (Fogg, 2003) and his behavioral model (Fogg, 2009). Later, this approach was extended and restructured with the Persuasive Systems Design framework by Oinas-Kukkonen and Harjumaa (2009). While the latter is already significantly condensed and operationalized compared to the earlier treatment of the topic by Fogg, it is still material for studying rather than an encoding of design knowledge in a brief and actionable form to be used during design.

In this paper, we report on the development and evaluation of the *Behavior Change Design (BCD) Cards*. The BCD cards combine two behavior theoretical models, the Transtheoretical Model of Behavior Change (TTM) (Prochaska & Velicer, 1997) and the Behavior Change Techniques taxonomy by Michie et al. (2013) with the goal of guiding designers in a) identifying the behavioral antecedents that are likely to influence the uptake of the desired behaviors for different people at different stages of change, and b) translate those to concrete behavior change techniques, and in turn, to concepts of behavior change technology.

This paper makes the following contributions to the field of Human-Computer Interaction: a) whereas existing design card tools addressing the design of behavior change support systems lack a link to related theory, we contribute a new

CONTACT Chrysanthi Konstanti konstanti.chrysanthi@gmail.com Cyprus University of Technology, Limassol 3036, Cyprus

theoretically motivated design card tool, b) we show how elements of the Behavior Change Techniques taxonomy along with the stage-based model of TTM, can be made actionable in the domain of interaction design, c) we provide empirical evidence as to the efficacy of these design cards in guiding designers, d) we provide guidance on how to use the design cards effectively based on our experiment.

2. Background

2.1. The role of theory in HCI and the design of behavior change technologies

The field of Human-Computer Interaction has a long history of adopting theory from other established disciplines to describe the cognitive, social and organizational phenomena that surround the use of interactive technology (cf. Rogers, 2012). From the early cognitive modeling approaches such as the Model Human Processor and GOMS (Card et al., 1983), to the various different forms of theoretical knowledge, such as frameworks, principles and strong concepts, to name a few (cf. Carroll, 2003; Höök & Löwgren, 2012; Rogers, 2004), theory has played an instrumental role in the development of the field.

Not different to other HCI subdomains, the design of Behavior Change Technologies can leverage on decades-long efforts of empirical inquiry and theoretical development in the Behavioral Sciences. In the science of behavior change, one may identify two core forms of theoretical knowledge:

2.1.1. Theories of behavior and behavior change

A theory is "a set of concepts and/or statements with specification of how phenomena relate to each other [, and] provides an organising description of a system that accounts for what is known, and explains and predicts phenomena" (Davis et al., 2015, p. 327). Davis et al. (2015), in their review, identified 83 theories of behavior and behavior change. Theories of behavior, they suggested, "tend to be linear, and explain the reasons why behavior may occur by considering a number of predictors and their associations with one another and how these could influence the likelihood of a particular behavior" (p. 326). One example is the Theory of Planned Behavior (Ajzen, 1985). Theories of behavior change, on the contrary, "tend to be more cyclical and identify interactional and dynamic behavior change processes" (p. 326). One example is the Transtheoretical (Stages of Change) Model (Prochaska & Velicer, 1997).

2.1.2. Behavior change techniques

A Behavior Change Technique (BCT) is defined by Michie et al. (2013) as "an observable, replicable, and irreducible component of an intervention designed to alter or redirect causal processes that regulate behavior" (p. 82). Self-monitoring and goal setting are, for example, two behavior change techniques widely used by today's technology.

All in all, both forms of theoretical knowledge are valuable in the design of behavior change technologies. In fact, previous research has shown that technology-based interventions are most effective when they are theory-based (Morrison et al., 2012; Riley et al., 2011). Michie and Prestwich (2010) point out that theory helps in identifying key constructs, such as self-efficacy, that are hypothesized to be causally related to behavior. This, in turn, provides the means for selecting the appropriate behavior change techniques and helps to understand the reasons why the intervention was effective, or not. The standardization of behavior change techniques, on the other hand, allows the identification of which techniques contribute to effective interventions and supports the effective application of interventions from research protocols to practice (Michie et al., 2011a).

Despite the benefits of taking a theoretically grounded design process, recent studies have shown the majority of mobile apps to lack theoretical content. For instance, Cowan et al. (2013) scored 127 exercise apps on the degree to which they include theoretical constructs from four dominant theories: the health belief model (Becker, 1974), the theory of planned behavior (Ajzen, 1985), the transtheoretical model (Prochaska & Velicer, 1997), and the social cognitive theory (Bandura, 1991). Scores ranged from 1 to 28 on a 100-point scale with the average being 10/100. Azar et al. (2013) followed a similar methodology to assess the use of theoretical constructs among weight management apps and found an average behavioral theory score of 8.1/100. Riley et al. (2011) reviewed mobile health behavior interventions and found that the use of theory varied substantially per domain, with 1/20 of disease management interventions to be theory-based, 0/10 in treatment adherence, 7/12 in weight loss and 5/7 in smoking cessation. The use of theoretically and empirically supported behavior change techniques has also been found to be limited. For instance, Conroy et al. (2014) reviewed the descriptions of 167 top-ranked mobile apps and found that most apps employed fewer than four behavior change techniques. Similarly, Middelweerd et al. (2014) found an average of five among the 26 techniques present in the behavior change taxonomy of Abraham and Michie (2008) to be included in 64 physical activity promoting applications, with "self-monitoring," "providing feedback on performance" and "goal-setting" to be the most frequently used behavior change techniques. All in all, Yang et al. (2015) found only 39 out of the 93 behavior change techniques that are present in Michie et al.'s (2013) taxonomy, to be used in mhealth apps.

The lack of a theoretical basis in the design of behavior change technologies may be traced back to a number of different reasons. Firstly, design teams often lack behavioral science expertise. With an abundance of behavioral theories and according behavior change techniques, designers and researchers are "having a hard time deciding with confidence which of the theories and techniques to use in their design and research" (Michie & Prestwich, 2010). Moreover, the design of technological intervention further complicates the landscape as, through optimization and choice removal (*e.g.*, a heating system that turns on/off automatically), technology often increases the complexity and variety of unconscious strategies that designers can and may need to leverage on (Cash et al., 2017). Therefore, Secondly, practitioners tend to find academic writing style abstract and complex, while lacking details that are critical to the implementation of industry applications (Colusso et al., 2017). Thirdly, accessing

academic resources is also found difficult among practitioners because a) they may use incorrect search terms for finding relevant literature, b) they find it difficult to detect which articles merit attention given the large amount of academic resources, and c) they face cost barriers due to paywalls of online academic literature (Colusso et al., 2017). Furthermore, much of the literature on behavior change interventions is not specific to interaction design. For example, Mitchie's behavioral change wheel distinguishes between seven alternative policy categories conducive toward behavior change, among which communication could be considered as encompassing interaction design. Similarly, Bartholomew's intervention mapping approach by Bartholomew et al. (2015) details a structured approach to designing health interventions that do not address the concerns of interaction designers and is not easily consulted during design activities.

2.2. Design cards as a design support tool

One design support tool that has proven effective in transferring theoretical knowledge during design meetings is *design cards*. Design cards have been found to provide a number of benefits such as helping to kickoff and structure the design discussions, making theoretical knowledge accessible and providing a common vocabulary within the design team, supporting and emphasizing turn-taking, and supporting collaboration by being shared objects for discussion among team members (c.f. Halskov & Dalsgård, 2006; Hornecker, 2010; Lucero & Arrasvuori, 2010).

Prior work has demonstrated that design cards can be used anytime in the design process, starting at initial ideation, moving to the development of the ongoing concepts and finally the evaluation of the design concepts (Deng et al., 2014; Lucero & Arrasvuori, 2010; Lucero et al., 2016; Wölfel & Merritt, 2013). For instance, the Inspiration Cards by Halskov and Dalsgård (2006), are employed at the beginning of the design process. In doing so, they found an increase in idea generation and inspiration for user-centered design, while the cards worked as repositories for statements and arguments, using the cards as bookmarks for thoughts. The creators of Tango cards evaluated the tool in two design cases, an early-stage design activity of developing a tangible game and a late-stage design activity of redesigning a web-based game (Deng et al., 2014). The results showed that the cards made design knowledge accessible in both situations while these authors also suggest that the tool might be useful during a later stage design activity, such as the evaluation of a game using the cards. Design cards might also be useful when facing specific problems or looking for alternatives during the design activity. The IDEO Method Cards (2003) describe in a condensed form different methods that fit either in an early design stage or in evaluation and testing; therefore, they are meant to be used *as needed* in the design process. Additionally, cards are mostly used in specific situations, for instance, in workshops. However, while the duration of their use is limited to the duration of a short session (*e.g.*, $2^{1/2}$ hours), one may still refer back to the cards later in the design process when necessary (Lucero et al., 2013; Wölfel & Merritt, 2013).

In this study, we present the Behavior Change Design (BCD) cards, a card-based design tool developed to translate the knowledge of two behavioral models, the Transtheoretical Model of behavior change (TTM) and the Behavior Change Techniques Taxonomy (BCTTv1), and encourage the design community to engage with and develop theory-based behavior change technologies.

3. The BCD cards

For the development of the Behavior Change Design cards (BCD cards), we employed two well-established models. We chose the Behavior Change Techniques taxonomy (BCTTv1, Michie et al., 2013) because it is the first cross-behavior hierarchical taxonomy and the most comprehensive list of behavior change techniques (Wang et al., 2019) and because it has been used extensively for the design of technological interventions. The second model we chose is the Transtheoretical Model of Behavior Change (TTM, Prochaska & Velicer, 1997), and specifically the stages and the processes of change. Both models have been widely used across different behavioral domains and provide a vocabulary that is accessible to interaction designers. In the following sections we first elaborate on these two theoretical models, and then describe the design and development of the behavior change design cards.

3.1. Stages and processes of behavior change

According to the Transtheoretical Model (TTM) (Prochaska & Velicer, 1997), an individual moves through five stages when modifying behavior. In pre-contemplation, the individual is unaware or uninformed about the consequences of her behavior and resists changing it. Moving to contemplation, the individual becomes more aware of the pros and cons of changing her behavior, yet suffers from decision ambivalence. In the preparation stage, the individual already has a plan of action and is taking significant steps toward the behavior. In the action stage, the individual has made specific modifications in her lifestyle toward the behavior. Last, in the maintenance stage, the individual has maintained the behavior change for a while and intends to sustain the new behavior; works to prevent relapse to earlier stages.

The TTM also suggests *covert and overt activities people* can *use to progress through stages* (Prochaska et al., 2015), named as the ten Processes of Change. Empirical evidence has shown a systematic relationship between the five stages and the ten processes of change, suggesting that individuals in the early stages rely on more cognitive, affective and evaluative processes to move through stages, while individuals in later stages rely on commitments, conditioning, contingencies, environmental controls, and social support (Prochaska et al., 1992). For instance, for a person in the precontemplation stage, the process of *consciousness-raising* will increase awareness of the causes, consequences, and cures for problematic behavior. This may be achieved, for example, through media campaigns raising the importance of the behavior, and by providing feedback on one's behavior. In the action stage, the process of *contingency management* is more relevant. This process revolves around consequences for taking steps

in a particular direction, such as rewarding positive behaviors and reducing the rewards arising from negative behaviors. Reinforcement, incentives, and group recognition are, among others, procedures that increase the possibility of repeating the desired behavior. One should note that not all processes apply to every type of behavior. This implies that intervention designers need to identify which processes are relevant at each stage of change, for the behavior they wish to modify (Prochaska et al., 2015; Rakowski et al., 1998). Additionally to the ten Processes of Change, for people to progress through the stages they need a) *decisional balance* – a growing awareness that the "pros" of changing surpass the "cons," and b) *self-efficacy* – the confidence that they are able to maintain the changed behavior in situations where they may be tempted to relapse to their former unwanted behaviors (Prochaska et al., 2015).

The TTM model has gained extensive popularity among researchers, practitioners, and clinicians, and it has been used in a wide range of behavioral interventions, from physical activity promotion to smoking cessation, and others (see for example, Horowitz, 2003; Hutchison et al., 2009; Marshall & Biddle, 2001; Spencer et al., 2002, 2006). In addition, many of the concepts and ideas of the model are shared with other behavior change models, such as the Health Belief Model (HBM) (Rosenstock, 1974) and Bandura's (1977) Self-efficacy. The TTM has also been widely adopted in the HCI field. For instance, in a 10-month in-the-wild study of the adoption, engagement, and discontinuation of an activity tracker called *Habito*, Gouveia et al. (2015) found that users in intermediary stages were more likely to adopt a tracker (~50% adoption rate) than users in the early or late stages (~20% adoption rate). On the contrary, the results of a review study by Kersten-Van Dijk et al. (2017), suggest that personal informatics technology is mainly effective in the later stages (action and maintenance). While the two studies seem to disagree, or at least suggest a discrepancy between users' preferences and the support they receive from behavior change technologies, both are indicative of how TTM can inform design. All in all, the TTM is an informative model for the design of behavior change technologies as it deals with sustained behavior change, given that behavior change is a long – term process that requires preparation, change and subsequent sustainability of implemented behaviors (Kersten-Van Dijk et al., 2017).

Despite the extensive use of the model in various domains, it does not deal with how its concepts might be applied in the context of designing behavior change technologies. Therefore, for the design of the BCD cards, we focused on the constructs proposed by the TTM that involve "the acquisition of new information and insights of the sort that might be obtained through Personal Informatics (PI)" (see Figure 1). According to Kersten-Van Dijk et al.'s (2017) approach these are: consciousness raising, outcome expectancies, self-efficacy, and self-monitoring & contingency management. The construct of *consciousness-raising* is particularly relevant at the precontemplation stage and aims at increasing individuals' awareness of their behavioral problems, and especially of previously unknown issues. For instance, a tracker may automatically measure and provide insights into the user's heart condition. *Outcome expectancies* is most relevant at the first two stages, precontemplation and contemplation, and refers to making the advantages of the desired behavior more explicit. For instance, for a user that usually eats right before going to bed, a system may help her see the benefits of increasing the gap between bedtime and her last meal (*e.g.*, better sleep quality). *Contingency Management and Self-monitoring* is most relevant to the last two stages, those of action and maintenance: an individual is more likely to act and maintain a certain behavior if she keeps track of her behavior and the obstacles she faces and deals with them as they arise. For instance, providing informative and immediate feedback to the user with respect to the relevant behavior (*e.g.*, 180 calories left of today's meals consumption) is likely to influence her behavior. Finally, *self-efficacy* is an essential requirement for a person's change process that applies in all five stages of the TTM. It can be influenced by different sources of information, such as providing information about previous performance accomplishments, to give the feeling of confidence to the user that she is capable of doing the right thing.

Combining the TTM with the BCT taxonomy (Michie et al., 2013) can help designers think of the target audience in terms of personas (e.g., someone being in the precontem-

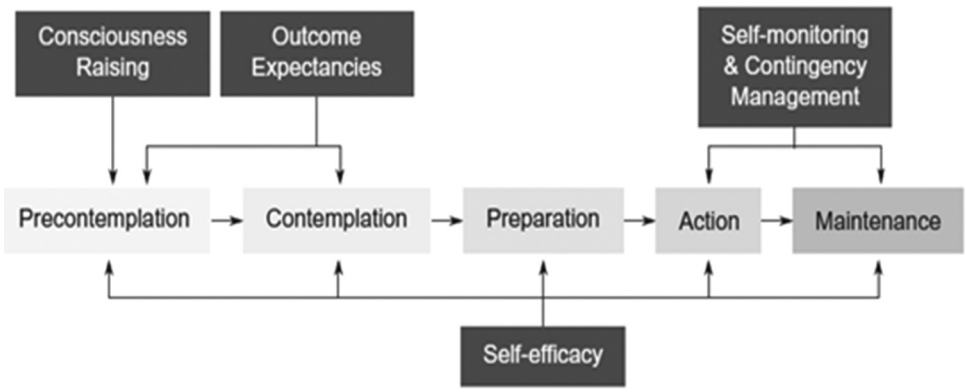

Figure 1. Overview of the stages of change from the Transtheoretical Model (Prochaska & Velicer, 1997) and information/insight-related processes of change that can aid progress through these stages. Figure from Kersten-Van Dijk et al. (2017, p. 275).

plation stage has no intention to increase her physical activity, yet), and structure the different behaviors in terms of their goal (i.e., the process in the language of the TTM). Prior work has shown that, in the case of technological interventions, while users may benefit from exposure to behavior change techniques, they may feel that the techniques are not relevant to their individual needs (Lee et al., 2017). The TTM has been shown to be a good model for contextualizing the use of different behavior change techniques as it helps structure the behavior change process in different phases (Cilliers et al., 2015; McClurg et al., 2015).

3.2. Behavior change techniques

Behavior change technologies can leverage decades of evidence about the efficacy and effectiveness of different behavior change techniques in the behavioral sciences. Michie and her colleagues, developed a structured approach to designing or updating behavior change interventions and strategies, the Behavior Change Wheel (BCW) (Michie et al., 2011b). The BCW lists common intervention functions (*e.g.*, modeling, education, training, etc.) which can be translated into specific techniques for changing behavior. Using a range of specific behavior change techniques, such as goal setting or providing feedback, one can develop a detailed intervention plan.

An attempt to list all the available behavior change techniques was a taxonomy of 93 behavior change techniques taxonomy, clustered into 16 categories, which can be used in multiple behavioral interventions (Michie et al., 2013). For each of the 93 techniques, the taxonomy provides a description with one (or more) examples explaining how the technique can be implemented in intervention design. For example, the technique *prompts/cues* is described in terms of how it can be used in the intervention: *"Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance."* Apart from the example provided, there are also notes, which highlight differences or similarities to other techniques.

The taxonomy was developed to guide physical intervention designs rather than the design of technological solutions. However, a considerable number of the 93 techniques can also be employed in the design of interactive technology for behavior change (Yang et al., 2015). Michie et al.'s (2013) taxonomy has been found useful by many researchers and designers, using it as a guide or a checklist for the development and the evaluation of behavior change interventions, both physical and digital, across a wide range of application domains (*e.g.*, Conroy et al., 2014; Dahlke et al., 2015; Helf & Hlavacs, 2016; Morrissey et al., 2016).

Michie et al.'s (2013) BCT taxonomy has been used in the field of Human-Computer Interaction as well. Many researchers attended to review and evaluate mobile applications for behavior change. For example, a four-week study by Stawarz et al. (2015) explored the influence of different types of positive reinforcement and cues on habit formation and conducted a review of 115 habit formation applications to investigate the use of relevant habit formation techniques derived from the BCT taxonomy. They found that existing apps focus on self-tracking and reminders, but do not support event-based cues. Alnasser et al. (2016) implemented 30 BCTs from Michie et al.'s (2013) taxonomy in the design of a weight-loss application. Within the app, users are encouraged to consider themselves as a role model for their children or family members (BCT 13.1: Identification of self as role model). They are also given professional advice on how to restructure their living environment to support the ease of making healthy decisions (BCT 12.1: Restructuring the physical environment). Graded weight loss goals are also included in the app as well as a graded step goal which increases the number of steps over time (BCT 8.7: Graded tasks; see Alnasser et al., 2016 for the full list of the implemented techniques).

3.3. The design of the BCD cards

The Behavior Change Design cards (BCD cards) consists of a total of 40 double-sided cards: one introduction card, five stage cards devoted to the five stages of behavior change (Prochaska & Velicer, 1997), 34 technique cards, adopted by the Behavior Change Techniques taxonomy (Michie et al., 2013), along with a "define the problem" exercise. For the development of the BCD cards, we followed a three-step process (see Figure 2). First, we clustered the 93 behavior change techniques proposed by the taxonomy into 34 new categories, each one representing a technique card in our deck. Second, we mapped each of the 34 techniques to the five stages of behavior change, signifying which stage(s) each group of techniques is most relevant to. Finally, we defined the layout and the content included in the BCD cards. We explain these three steps below.

3.3.1. Clustering the behavior change techniques

Michie et al.'s (2013) Behavior Change Techniques taxonomy was initially developed to guide health behavior change interventions, facilitated by medical practitioners. However, while the taxonomy has been used lately in the design of interactive technology, we suggest that not all the techniques are relevant to technological interventions. Therefore, we decided to exclude those techniques that seemed irrelevant to this cause. All 93 techniques were discussed by the first two

Figure 2. The Behavior Change Techniques (BCTs) selection procedure.

authors until reaching consensus. We ended up excluding 9 out of 93 techniques (*e.g.*, "Pharmacological Support"); see Appendix A, Table A1 for the list of excluded techniques and the reasons for exclusion.

Next, we found many BCTs presenting similar strategies, but differentiating against one or more dimensions. For instance, *Goal setting (behavior)* and *Goal Setting (outcome)* are essentially the same technique, only differing in terms of what the goal is – a behavior (*e.g.*, walk 3 miles a day), or a desirable outcome (*e.g.*, lose 0.5 kg over a week). Similarly, *social support* is split into three different techniques in Michie et al.'s (2013) taxonomy with respect to whether it refers to "practical," "social" or "unspecified" support. Other techniques were found to be similar in scope, yet differing in their implementation. For instance, *Behavioral Contract* is a written commitment regarding the behavior to be changed, while *Commitment* is the verbal analogy. For all those cases, we decided to group them while preserving the information on the backside of the card. For instance, the type of goal (*i.e.*, behavior or outcome) was inserted on the backside of the card as a design consideration (*i.e.*, "how will you guide the user in setting an appropriate goal?"; what type of goals are you designing for: behavior (e.g., steps) or outcome (e.g., weight loss)?"). While, to our knowledge, there are no studies on the appropriate size of a card deck to effectively facilitate discussion and group thinking, we observed that it is common for design card decks to consist of 20 to 50 cards and we felt that including all behavior change techniques from Michie et al.'s (2013) taxonomy would considerably increase complexity with no corresponding gain regarding to how well designers-users of the cards would be informed. Lucero et al. (2016) suggest that too few cards may negatively affect the creativity of the output, while too many cards may cause confusion and a waste of time when participants are reviewing their options (cards) during the design process. We thus ended up with a total of 34 technique cards in our deck (Appendix A, Table A2).

This process was done iteratively by the first two authors until the structure was judged to be complete. After the classification of the 83 techniques into the 34 groups was complete, an independent researcher was given the definitions of the 34 groups and the definitions and examples of the 83 selected techniques as given by Michie et al. (2013). He was then asked to classify each of the 83 into the new 34 groups; each technique was used only once. An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among raters. There was substantial agreement between the two raters classifications, $\kappa = 0.74$ ($p < .000$). To ensure that no information was left behind during the merging procedure, we translated the definitions and examples provided by Michie et al. (2013), into guided questions and hints, and included them on the back-side of each card. For instance, when merging the techniques *Avoidance* ("Advice on how to avoid exposure to specific social and contextual/physical cues for the behavior, including changing daily or weekly routines") and *Distraction* ("Advise or arrange to use an alternative focus for attention to avoid triggers for the unwanted behavior"), we used the definition of the first and added on the back-side of the card a number of questions that prompt designers to think of the combination of the two techniques (e.g., "What triggers the unwanted behavior? Social cues such as smoking with friends? Physical cues such as being at a pub? Emotions and thoughts?," "When is the right time to distract from these cues?"). Those questions worked either design considerations, or as examples from specific domains, or as steps in implementing the strategy.

3.3.2. Mapping the behavior change techniques to the stages of behavior change

One can think of the five Stages of Behavior Change as *periods in time*, or as *mental states* implying a set of tasks that need to be done in order to move to the next stage. A hierarchical relationship can be defined between the stages, the processes and behavior change techniques. For instance, in the precontemplation stage, consciousness raising is particularly important, which may be facilitated by techniques such as "*information about consequences*" and "*social comparison.*" Moreover, a technique may be applicable in more than one stage, but needs to be designed differently for the different stages. For instance, considering goal setting, one would naturally expect that a person will set a goal as soon as she decides that her behavior needs to be changed and she is ready to take action. This places her in the Preparation Stage. This means that the "Goal Setting" technique can only be designed for a person that belongs in one of the last three stages: Preparation, Action, and Maintenance. Nonetheless, the goal-setting feature can be designed differently in each stage: in the preparation stage we can help the user set an appropriate goal, in the action stage we can focus more on feedback and gradually support increasing the goal, and in the maintenance stage we can assist in providing adjustments to the goal to prevent possible relapse.

Following this rationale, the first two authors mapped each of the 34 *techniques* to one or more of the five stages of behavior change. This process was done iteratively and on the basis of the definitions of the TTM's stages and processes of change, as well as the definitions and examples provided by the BCTs taxonomy. While we did not create separate design cards for the processes of change, this information was inserted as design considerations on each of the *stage cards* in our card deck (see section 3.3.3), as we found the processes to support the ideation around each stage of the behavior change process. For the full classification of BCTs against the stages of behavior change, see Appendix A, Table A3.

3.3.3. Information architecture of the BCD cards

The BCD cards consist of five *Stage* cards, 34 *Technique* cards and one *Define the Problem* card, approximately 13 × 9 cm in size. All cards are two-sided and combine text with images to support glanceability and quick communication, following the recommendations by Wölfel and Merritt (2013), Halskov and Dalsgård (2006), and Lucero and Arrasvuori (2010).

3.3.3.1. The stage cards. The front side of each Stage card (Figure 3) presents the title and a description of the stage, while the backside lists a number of design considerations relevant to this stage and the processes involved. Initially, all *stage* cards were color-coded in shades of blue, from light blue

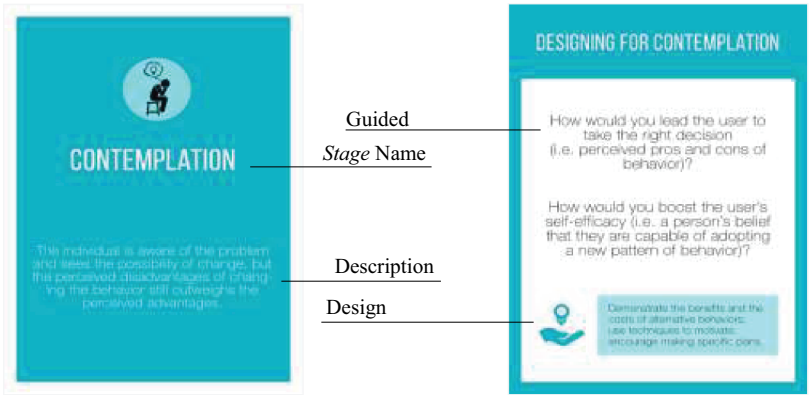

Figure 3. A stage card (left: front side, right: backside).

(Pre-contemplation) to dark blue (Maintenance), as we wanted to give the feeling of the gradual transfer from one stage to the other. However, participants in our formative evaluation studies faced difficulties in differentiating the stages and mapping them to appropriate techniques. Thus, the latest version of the cards presents each stage with a discrete color, in an effort to make the cards more memorable and the technique-stage mapping easier.

3.3.3.2. The technique cards. Each of the 34 behavior change techniques is presented in a card, along with a brief description, an example, and design considerations. Design considerations serve to stir up discussion and group interactions, and their role has been shown to be particularly important (Deng et al., 2014; Hornecker, 2010). In the first version of the cards, while the backside presented the design considerations and a pictured example. However, participants in our formative studies focused primarily on the technique description and the example in their effort to gain a first understanding of the technique. We thus reorganized the material, placing the example on the front side along the description, and the design considerations and hints on the backside of the card (see Figure 4). The front side also included colored tabs representing the stages to which the featured technique is deemed relevant. For instance, in the example provided in Figure 5, *goal setting* is deemed relevant to the preparation, action and maintenance stages.

3.3.3.3. The "define the problem" exercise. In our second formative study (see section 4.2) we observed that participants lack focus, drifting toward different directions as they generate ideas. We thus decided to include an exercise that would assist participants in defining the problem they wish to solve and remaining focused on this during their later design inquiry. Michie et al. (2016) suggest that the first step in designing a behavior change intervention is to define the behavioral problem. This can be done by specifying the target behavior and identifying what needs to be changed. The *"define the problem"* exercise was initially a two-sided card where both sides consisted of a series of guided questions. During the evaluation of the BCD cards (see section 5) we found participants using only the front side of this card and "forgetting" the questions on the backside. Therefore for the latest version, we decided to create a one page *"define the problem"* exercise providing the possibility to designers to write down the responses on the paper describing the

Figure 4. A technique card (left: front side, right: backside).

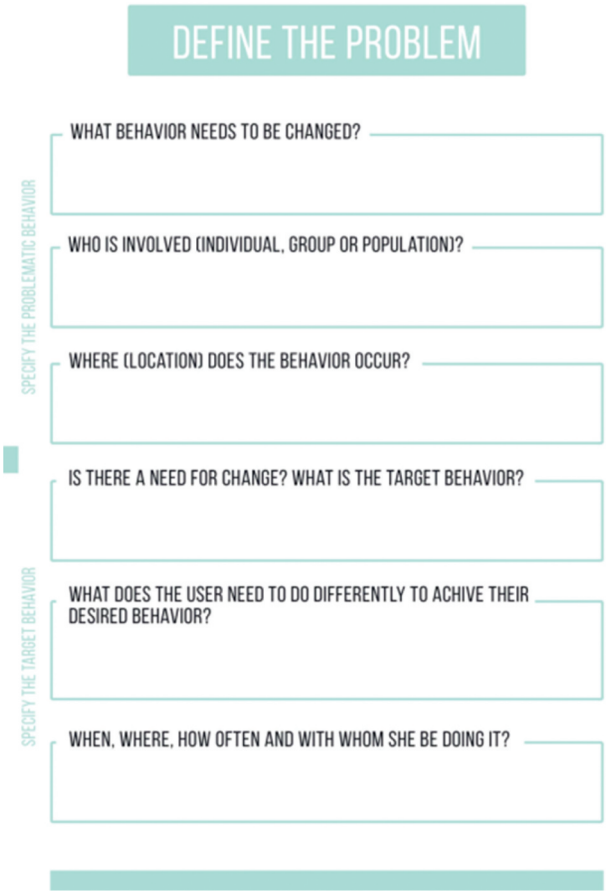

Figure 5. The *Define the Problem* exercise.

behavior to be changed and the target behavior and discuss the initial possible solutions to achieve this new behavior. This exercise is proposed for use at an early stage of the design process where a group of designers hasn't yet agreed on what the design brief should be.

3.3.3.4. Beta version. We created a *beta version* of the tool and conducted two formative studies with the goal of informing the design of the cards. The beta version consisted of 29 cards: one intro card (*i.e.*, describing the general content), five *stage cards* describing the five stages of behavior change and *23 technique cards* describing each of the behavior change techniques. All cards were two-sided. The *stage cards* were colored in different hues of purple to give the feeling of the gradual transfer from one stage to the other. On the front side of each of the *stages cards*, a description was provided. On the backside questions related to the processes of change and possible design directions. The front side of each of the *technique cards* included the description of the technique and hints (on some of the techniques cards) while the backside included questions and one pictured example with verbal explanation. Moreover, each of the *technique cards* indicated a bar of five tabs at the bottom – each one representing one of the five stages. Specific tabs were colored – to the same color as each stage card – indicating in which stages that specific technique can be applied. The beta version was used in the two formative studies described in the next section.

4. Formative studies

Two formative studies were carried out in order to gain an initial understanding of the function of the BCD cards and to inform their further development.

4.1. Formative study I

The goal of the first study was to inquire into the overall experience with the BCD cards and find the best possible ways of using them in the design process.

4.1.1. Participants

A total of 22 students (12 male and 10 female) worked on two different design cases, "Oral Hygiene" and "Open Office Annoyance," as part of their course assignment in Design for Behavior Change, in the Master's program of [Anonymized for Review]. Eight groups of either two or three students worked independently on their design cases in a 30-minute-long design session. Participation in the design exercise was optional and the students used the cards in their benefit as it was related to their final assignment for the course.

4.1.2. Study procedure

After a short presentation on the BCD cards, with *no specific instructions* on how to use them, students were invited to use the deck in their design inquiry. At the end of the session, students were asked to fill in a questionnaire regarding their overall experience with the cards and provide recommendations for improving the cards. More specifically, they responded to questions such as "To what extent did you use the design cards?," "How helpful were the [descriptions of the techniques]/[questions]/[examples and pictures] on the cards?" using 5-point Likert scales (1 = Not helpful at all to 5 = extremely helpful). Additionally, they elaborated in free text as to whether and how the cards helped them apply theoretical design principles in their design case, what information they missed on the cards, what parts of the cards they liked, what they did not like, and what they would like to change on the cards. Finally, we held a five-minute interview with each group of students, to discuss and better understand their responses to the questionnaire.

4.1.3. Findings

Overall, the cards were judged to be useful during the design sessions by the majority of the students (91%, N = 20/22; mean = 4.41, SD = 0.8). Among the factors which were named as "things they found helpful" (*i.e.*, descriptions, questions, and examples), description were chosen as the most helpful (mean = 3.95; SD = 0.72) when using the cards, followed by the questions (mean = 3.55; SD = 1.47) and the examples (mean = 3.27; SD = 1.49) on the cards.

During the first informative study we observed that at some times participants struggled to warm up and engage with the

Table 1. Instructions regarding the use of the BCD cards given to participants during the second formative study.

(1) Describe in one sentence the problem you are trying to solve.
(2) For each of the *stages*, write down the main challenges that need to be addressed.
(3) Pick one of the challenges. Review the *Behavior Change Techniques cards*, and select a few that have the potential to address this challenge (Hint: not more than 2). Discuss how you would modify. Provide this information on a poster.
(4) Choose a new challenge from a different stage and repeat step 3.

process, asking questions such as *"what do we have to do?"* or *"where do we start; from here [showing a stage card]? ."* We also found that some participants would get confused during the design process: *"now, what do we have to do with these [showing the technique cards]?."* To address these problems, we created a set of instructions (see Table 1) on how to use the cards that we deployed and tested during the second formative study.

4.2. Formative study II

Based on our findings in the first formative evaluation, for this second evaluation, we adapted the context and procedure of using the BCD cards. We conducted a workshop with the aim to evaluate whether providing instructions on how to use the tool would provide a better structure for the design process. We also assessed the overall function of the BCD cards, their potential in supporting theoretically grounded design, and students' experiences with the cards.

4.2.1. Participants

The second formative study consisted of an $1^{1/2}$ hour-long workshop with 25 students (7 male, 18 female) following the [Anonymized for Review] at the [Anonymized for Review]. Students worked in teams of two to four. They had been previously asked to decide on a behavioral problem they wanted to design for, as part of their course's requirements. Participation in the design workshop was optional and no incentive was provided.

4.2.2. Study procedure

Students worked on a wide range of behavioral problems, from motivating type 2 diabetes patients to adhere to their treatment plan, children aged 12–18 years old lacking the motivation to study to adhere to their study schedule, and patients with a one-hand disability to use their affected hand in their daily life, among others. After a short presentation of the BCD cards, participants were asked to follow a 4-step exercise (see Table 1) when using the tool and created a poster elaborating on their ideas and how they used the tool in the design process. They were also asked to complete a 4-item self-efficacy questionnaire, inspired by Bandura (1977; See Appendix B, Figure B1), before and after the design activity, along with the questionnaire used in the first formative study that was only completed after the design activity.

4.2.3. Findings

In this study, 87,5% (N = 21/24, one did not answer) found the BCD cards overall useful in the design procedure (Mean = 4.08; SD = 0.584), while almost all participants found the descriptions (96%, N = 24/25; Mean = 3.92; SD = 0.812) and questions (92%, N = 23/25; Mean = 3.52; SD = 0.714) as the most helpful element on the cards, followed by the examples and pictures 58.3% (N = 14/25; Mean = 3.08; SD = 1.139).

We found a significant increase in participants' self-efficacy after the design session (pre: Mean = 41.70, SD = 20.297; post: Mean = 64.67, SD = 10.59; t (24) = −4.615, p = .000). We had no means of knowing whether this is due to the BCD cards, or to other factors such as the experience they gained from the design activity. A constraint that was obvious when using the BCD cards was that participants generated many interesting ideas, often unrelated to their design case, yet this often resulted in confusion and loss of focus. This might happen because of the exposure to much information and different techniques that can solve a problematic behavior. However, they tended to generalize their ideas and not focus on the specific target audience and problematic behavior they initially discussed. Therefore, the later improved version of the cards was extended with a card named "Define the problem" (see section 3.3.3).

5. Evaluating the efficacy of the BCD cards

We conducted a user study in order to evaluate the efficacy of the BCD cards as a design support tool. More concretely, we wanted to inquire into the benefits that the cards bring to the design process, if at all, and into designers' overall appraisal of the cards, in terms of their usefulness and ease of use. Moreover, we wanted to understand whether using the BCD cards enhances designers' feeling of being creative and capable of designing for behavior change.

5.1. Method

The study followed a simple between-subjects design study with two conditions: *with* and *without* the BCD cards. Both groups were given a brief introduction to the goal of the study. We then provided the following design brief and asked participants to develop their design solutions:

> According to the World Health Organisation (WHO), 28% of adults, aged 18+, are insufficiently physically active with physical inactivity being a key risk factor for chronic noncommunicable diseases, such as diabetes, heart diseases, and cancer. Health recommendations on physical activity for adults suggest that an active person should: do at least 150 minutes of moderate-intensity physical activity per week (WHO), walk 10000 steps per day and to take breaks from sedentary activities at least every 30 minutes. However, maintaining sufficient levels of physical activity is increasingly challenging, as people's daily work and living environments are increasingly sedentary. Your task is to design technology for adults 18+, to support them in increasing their daily physical activity levels with the aim to reduce the risk of developing chronic diseases.

Each team consisted of two participants. They worked on the design task for approximately 60 minutes. After reading the

brief, participants in the experimental group (with the BCD cards) followed instructions on how to use the cards. Participants in the control group were asked to follow the brief, and design their solution using the blank wireframe templates. The outcome of each creative session was a design rationale, which described the proposed solution along with an elaboration on why and how the solution would address the problem provided.

Before the design sessions, participants in both groups completed a pre-study questionnaire, rating the extent to which they were familiar with any behavior change theories and/ or techniques, as well as their self-efficacy beliefs when designing for behavior change. After the design session, participants in both groups completed again the self-efficacy beliefs questionnaire, as well as a validated scale (i.e., the Creativity Support Index; Carroll et al., 2009; see section 5.1.2 Measures), to self-report on how creative they felt during the design activity. Participants in the experimental group additionally completed the Perceived Usefulness and Ease of Use Questionnaires scales from the Technology Acceptance Model (Davis, 1989; see section 5.1.2 Measures). Some of the participants of the experimental group participated, on a voluntary basis, in a 15-minute follow-up semi-structured interview discussing their overall experience with and appraisal of the BCD cards. Each interviewed participant received a €10 voucher as compensation.

5.2. Participants

A total of 29 participants joined the study (15 in the experimental and 14 in the control condition). All participants (12 male and 17 female, median age = 21), were undergraduate students of the Design for All course at the [Anonymized for Review], with a background in Graphic or Multimedia design. They had worked together as part of their studies and chose their own partner for this study. Moreover, participation was optional and students did not have previous collaboration with any of the authors. Participants' prior exposure to behavior change theory was measured through a single question: *"Rate the extent to which you are familiar with any behavior change theories and/ or techniques."* Most participants were unfamiliar with behavior change theory, yet we found a significant difference in the responses across the two groups (experimental: mean = 1.73, SD = .96; control: mean = 2.93, SD = 1.27; $t(27) = -2.87$, $p < .01$).

5.3. Measures

5.3.1. Perceived creativity of the design process

The Creativity Support Index (Carroll et al., 2009) was completed by all participants across the two conditions (with and without cards), in order to assess whether the BCD cards increased the perceived creativity of the designers. Participants used the Beta CSI version of the tool, and the index for each participant was computed manually. This score is the result of an equation between participants' responses to a) six statements, such as "I was very engaged/absorbed in the activity – I enjoyed it and would do it again," using 10-point likert scales and b) a comparison of each of the six factors against the other five to assess the relative importance of these factors to each participant for the activity under study. The internal reliability of the questionnaire was good (Cronbach's alpha = 0.82).

5.3.2. Self-efficacy

participants in both groups completed a self-efficacy questionnaire, before and after the design process, reporting their self-efficacy beliefs in relation to behavior change design. We created a 10-item questionnaire (see Appendix B, Figure B2) following the guidelines of Bandura (2006). Participants responded to each of the statements using a numerical scale that ranged from 0 (Can not do at all) to 100 (Highly can do). The internal reliability of the instrument was good to excellent (Cronbach's alpha: pre = 0.887, post = 0.909).

5.3.3. Perceived usefulness and ease of use of the BCD cards

Participants of the experimental condition were asked to complete the six-items Perceived Usefulness (PU) and Perceived Ease of Use (PEU) questionnaires of the Technology Acceptance Model (Davis, 1989), using seven-point scales. Internal reliability was good for both Perceived Ease of Use (Cronbach's alpha = 0.856) and Perceived Usefulness (Cronbach's alpha = 0.895).

5.4. Findings

The objective of the third study was to evaluate the efficacy of BCD cards when designing for behavior change and to examine how the cards' features supported or constrained the design process. We summarize below our findings, using a combination of questionnaires, observation and interview data.

All in all, we found the BCD cards to bring a number of benefits to the design process.

The cards supported the design process by *kicking off ideation* and helping participants generate ideas believe they would not have thought of otherwise. As some participants mentioned: *"[the cards] helped think about principles that I otherwise would have missed"* [P4], *" … sometimes they gave me the inspiration to think of a solution for my design case, like the rewards technique"* [P15]. Participants often commented that the cards helped them in structuring and guiding their thinking: *"the cards help you to reason from strategy to idea instead of coming up with random ideas, which you will have to verify afterward"* [P4]. The cards often acted as *"reminders of ways that you can use to achieve behavior change"* [P21], while the stage of change helped participants in framing the problem and challenged them to see the problem from a different point of view:

> It was nice to think with a different perspective towards the problem" [P11] "they helped me to see the problem from another perspective, due to the different steps" [P20],

> with the first cards [stage of change cards] you can determine in what stage you want to work on, and with the second cards [technique cards] you can pick in what way you want to solve the problem [P2].

The design considerations placed on the backside of the cards were judged as *"helpful questions [that helped to] start thinking"* [P22]. These design considerations often became the focal point of discussions, generated further questions, and helped participants deepen their understanding of a particular behavior change technique and its application in their situation.

Moreover, we found that the physicality of the cards helped in making the design process visible, provided a shared vocabulary among group members, and helped participants in deciding which strategies are most suitable for their design context. As some participants mentioned: " … *Here we can move the cards and be more efficient […]. We all talk about the same precise stage/element*" [P3], "*it helped to make it more visible, and it is something tangible to fall back on. It helps in making clusters and keeping an overview*" [P16], " … *it was useful to have a good overview of the design principles in order to make connections between them*" [P18].

On average, participants found the BCD cards *easy to use* (mean = 4.94, SD = 0.85) and *useful* (mean = 4.83, SD = 1.14) for the design of behavior change technologies. Participants highlighted as an advantage the fact that no prior knowledge was necessary in order to use the cards, and that they made the two theoretical models easy to understand: "*the cards were very helpful because your grasp of the theory does not have to be good to make use of it in your design case*" [P6], "*I like that we were able to use the cards without prior knowledge*" [P5].

Next, we expected that when using the Behavior Change Design cards, participants would feel more creative and would rate their experience during the design session as a more creative one, as compared to participants in the control condition; 25 out of 29 participants of the study completed the CSI questionnaire (experimental condition: N = 15; control condition: N = 10). Our hypothesis was confirmed, as we found a statistically significant difference between the two groups (experimental: mean =69.82, SD = 11.68; control: mean = 61.6, SD = 29.81, t(23) = 0.971, $p < .001$).

Finally, we also expected that the Behavior Change Design cards would strengthen participants' self-efficacy beliefs regarding the design of behavior change technologies. All 29 participants, in both the control and the experimental condition, responded to the self-efficacy questionnaire before and after the design activity. As expected, we found a statistically significant increase in self-efficacy beliefs for the experimental group (pre: Mean = 59.6, SD = 12.94; post: Mean = 71.63, SD = 10.23); t (27.97) = −2.59, $p < .05$; but not for the control group (pre: Mean = 68.86, SD = 12.94, post: 76.86, SD = 14.1, t(25.8) = −1,56, $p > .05$). However, no statistically significant difference was observed in post-session self-efficacy ratings between the two groups (just the t(26.03) = −1.05, $p = .303$).

6. Discussion and conclusion

Prior work has emphasized the need for design support tools that make behavioral science theory accessible during design meetings (Colusso et al., 2017; Michie & Prestwich, 2010). Toward this end, this paper described the design, development and evaluation of the Behavior Change Design (BCD) cards. The BCD cards were grounded on two well-established theoretical models of behavior: the Transtheoretical Model of behavior change (Prochaska et al., 2015; Prochaska & Velicer, 1997) and the Behavior Change Techniques Taxonomy (BCT taxonomy, Michie et al., 2013). By condensing Michie et al.'s (2013) BCT taxonomy to a set of 34 behavior change techniques that are applicable to the design of digital interventions, and presenting these in a tangible format, the BCD cards provide an easily accessible repertoire of theoretically and empirically grounded behavior change techniques for interaction designers. Further, using Prochaska and Velicer (1997) Transtheoretical Model of behavior change, and particularly the stages and processes of change, the BCD cards provide a way to structure designers' efforts, inviting them to tailor their intervention to particular stages of change and to consider the specific challenges and the purpose the intervention can serve in each stage. By mapping the 34 techniques to the five stages of change, we support designers in selecting the behavior change techniques that are most appropriate to a given stage.

Following Roy and Warren (2019) call for more empirical evidence on the assumption that design cards support knowledge transfer tools during design activities, we employed the BCD cards in an experimental study that aimed at inquiring into: a) the benefits that the cards brought to the design process, if at all, b) participants' overall appraisal of the cards, in terms of their usefulness and ease of use, and c) the experiential effects of using the BCD cards in terms of experienced creativity and participants' self-efficacy beliefs, regarding designing for behavior change.

All in all, we found the cards to bring a number of benefits to the design process. The cards helped design teams in kicking off ideation and coming up with ideas that would not have been thought of, otherwise, and facilitated collaboration by providing a shared vocabulary and acting as tangible reminders of ideas that emerged during the design process. The stage of change cards supported teams in framing the problem and guided their thinking process, while the design considerations placed on the backside of each technique card became the focal point of discussions and helped participants deepen their understanding of particular techniques and how these apply in their situation. Quantitative data further supported this view as they revealed that participants who used the BCD cards experienced their design session as a more creative one, as compared to participants in the control condition, who did not have access to the BCD cards. With respect to self-efficacy beliefs, we found a statistically significant increase in perceived self-efficacy for participants in the experimental condition, after completing the design session, but not for those in the control condition. However, post-session self-efficacy did not differ between the two groups. This may be an artifact of the small sample size of the study, or the between-subjects experimental design employed. As no participant experienced both conditions, participants may have been judging their perceived self-efficacy to different standards (e.g., the efficacy of other participants in their team). While the BCD cards may have supported participants' ability to design for behavior change, they might have, at the same time, overwhelmed them by the sheer amount of information provided during a limited period of time. Understanding and measuring the

experiential consequences of design support tools is thus of critical importance.

Toward this end, this paper also contributed with the development and assessment of a self-efficacy scale (see Appendix B, Figure B2) for the context of behavior change design, measuring designers' perceived efficacy in different facets of the behavior change design process, including identifying and articulating the problem in behavioral terms, making appropriate use of behavior change techniques, designing creative solutions, and communicating effectively all design decisions. The scale was developed by observing participant's activities in two formative studies and was found to have satisfactory internal reliability. As there is a growing interest in developing behavior change technologies and related design support tools, this scale can be useful in assessing the experiential effects of these tools.

One should highlight the need for fine tuning of design cards during their creation. Our formative studies revealed a number of deviations from our expectations in terms of participants' behavior. Participants would often glance at part of the card, skipping important information, while confusion about terms and definitions were often raised. The formative studies led us to revise and reorganize material and to add new cards that helped in structuring the design process. Not surprisingly, creating design cards should also be subject to a user-centered design process.

One should also note a number of limitations in the current studies that require further exploration. First, our quantitative analyses opted to inquire into interim outcomes of the BCD cards, and in particular, self-efficacy and experienced creativity. While one would naturally assume increased self-efficacy or experienced creativity to reflect also stronger outcomes of the design process, such as more creative ideas, and ideas with stronger theoretical grounding, this may not always be true. One could also even hypothesize a reverse effect, as the sheer amount of information may overwhelm designers and disturb the design process. For instance, Daalhuizen et al. (2014) compared a systematic to a heuristic method, and found that despite its benefits, the systematic method introduced higher time pressure to designers, it reduced their motivation and was perceived to require higher effort than simply using a set of heuristics. Dorst (2008) argues that assessments of design tools should focus not just on enhancing the efficiency and the effectiveness of the design process but also on the design content, the design context and the designer's needs and existing practices. While we have provided evidence regarding the benefits the BCD cards bring to the design process, it is less straightforward to lay claims regarding the efficacy or effectiveness of the resulting solutions in changing behaviors. Such behavioral outcomes depend on a large number of design and implementation decisions pertaining to various aspects of the user experience affecting the adoption of the technology and its ability to deliver the intended intervention. One could conceive of studies that would seek to establish a causal link between the use of the cards and behavior change outcomes by controlling for these extraneous variables. For example, we could imagine implementing and comparing empirically a large number of concepts developed with and without the within constrained technological settings (e.g., one example is Gouveia et al.'s, 2016, rapid prototyping of different physical activity tracking concepts as watchfaces on Android smartwatches and their comparative week-long field trial), the impact of other factors could be controlled. However, such an approach would lack external validity and would not do justice to the wicked nature of design problems and the contextualized nature of design processes. A more fruitful direction for future research would be the use of BCD cards in real-world design projects, where the patterns of use and the value that practitioners reap from using the cards are assessed by qualitative means. Second, while the current studies assessed the capacity of the BCD cards to support the initial phases of the design cycle, and particularly in relation to ideation, one could further explore their potential to support late stages, during idea evaluation and refinement.

Acknowledgments

We would like to express our sincere gratitude to [Anonymized for Review] who inspired our work on the Behavior Change Design cards, [Anonymized for Review] and [Anonymized for Review] for their contribution to the graphic design of the cards, and lastly, all participants from the three studies.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology*, *27*(3), 379. https://doi.org/10.1037/0278-6133.27.3.379

Agapie, E., Avrahami, D., & Marlow, J. (2016). Staying the course: System-driven lapse management for supporting behavior change. In *Proceedings of the 2016 CHI conference on human factors in computing systems* (pp. 1072–1083).

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl, & J. Beckmann, (Eds.), *Action Control: From Cognition to Behavior* (pp. 11–39). Berlin: Springer-Verlag.

Alnasser, A., Sathiaseelan, A., Al-Khalifa, A., & Marais, D. (2016). Development of 'Twazon': An Arabic App For Weight Loss. *JMIR Research Protocols*, *5*(2), e76. https://doi.org/10.2196/resprot.5497

Azar, K. M., Lesser, L. I., Laing, B. Y., Stephens, J., Aurora, M. S., Burke, L. E., & Palaniappan, L. P. (2013). Mobile applications for weight management: Theory-based content analysis. *American Journal of Preventive Medicine*, *45*(5), 583–589. https://doi.org/10.1016/j.amepre.2013.07.005

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, *50*(2), 248–287. https://doi.org/10.1016/0749-5978(91)90022-L

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-efficacy Beliefs of Adolescents*, *5*(1), 307–337. https://books.google.com.cy/books?hl=en&lr=&id=P_onDwAAQBAJ&oi=fnd&pg=PA307&dq=Guide+for+constructing+self-efficacy+scales&ots=rjLJt8EguU&sig=1PlNr0gBEUrwz-MbSEKsUGSK6AM&redir_esc=y#v=onepage&q=Guide%20for%20constructing%20self-efficacy%20scales&f=false.

Bartholomew, L. K., Markham, C., Mullen, P., & Fernandez, M. E. (2015). Planning models for theory-based health promotion interventions. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health*

behavior: Theory, research, and practice (pp. 359–388). John Wiley & Sons.

Becker, M. H. (1974). The health belief model and personal health behavior. *Health Education Monographs*, *2*(4), 324–473. https://doi.org/10.1177/109019817400200407

Card, S. K., Moran, T. P., & Newell, A. (1983). *The psychology of human-computer interaction*. L. Erlbaum Associates.

Carroll, E. A., Latulipe, C., Fung, R., & Terry, M. (2009). Creativity factor evaluation: Towards a standardized survey metric for creativity support. In *Proceedings of the seventh ACM conference on creativity and cognition* (pp. 127–136).

Carroll, J. M. (Ed.). (2003). *HCI models, theories, and frameworks: Toward a multidisciplinary science*. Elsevier.

Cash, P. J., Hartlev, C. G., & Durazo, C. B. (2017). Behavioural design: A process for integrating behaviour change and design. *Design Studies*, *48*(1), 96–128. https://doi.org/10.1016/j.destud.2016.10.001

Cilliers, F., Schuwirth, L., & Van der Vleuten, C. (2015). 13 health behaviour theories: A conceptual lens to explore behaviour change. *Res Med Ed*, *8*(1), 141. https://doi.org/10.1002/9781118838983.ch13

Colusso, L., Bennett, C. L., Hsieh, G., & Munson, S. A. (2017). Translational resources: Reducing the gap between academic research and HCI practice. In *Proceedings of the 2017 conference on designing interactive systems* (pp. 957–968 doi:10.1002/9781118838983.ch13).

Conroy, D. E., Yang, C. H., & Maher, J. P. (2014). Behavior change techniques in top-ranked mobile apps for physical activity. *American Journal of Preventive Medicine*, *46*(6), 649–652. https://doi.org/10.1016/j.amepre.2014.01.010

Cowan, L. T., Van Wagenen, S. A., Brown, B. A., Hedin, R. J., Seino-Stephan, Y., Hall, P. C., & West, J. H. (2013). Apps of steel: Are exercise apps providing consumers with realistic expectations? A content analysis of exercise apps for presence of behavior change theory. *Health Education & Behavior*, *40*(2), 133–139. https://doi.org/10.1177/1090198112452126

Daalhuizen, J., Person, O., & Gattol, V. (2014). A personal matter? An investigation of students' design process experiences when using a heuristic or a systematic method. *Design Studies*, *35*(2), 133–159. https://doi.org/10.1016/j.destud.2013.10.004

Dahlke, D. V., Fair, K., Hong, Y. A., Beaudoin, C. E., Pulczinski, J., & Ory, M. G. (2015). Apps seeking theories: Results of a study on the use of health behavior change theories in cancer survivorship mobile apps. *JMIR mHealth and uHealth*, *3*(1), e3861 doi:10.2196/mhealth.3861.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: A scoping review. *Health Psychology Review*, *9*(3), 323–344. https://doi.org/10.1080/17437199.2014.941722

Deng, Y., Antle, A. N., & Neustaedter, C. (2014). Tango cards: A card-based design tool for informing the design of tangible learning games. In *Proceedings of the 2014 conference on designing interactive systems* (pp. 695–704). ACM.

Dorst, K. (2008). Design research: A revolution-waiting-to-happen. *Design Studies*, *29*(1), 4–11. https://doi.org/10.1016/j.destud.2007.12.001

Fogg, B. J. (2009). A behavior model for persuasive design. In *Proceedings of the 4th international conference on persuasive technology* (pp. 1–7).

Fogg, B. J. (2003). *Persuasive technology: Using computers to change what we think and do*. Morgan Kaufmann Publishers.

Gouveia, R., Karapanos, E., & Hassenzahl, M. (2015). How do we engage with activity trackers? A longitudinal study of Habito. In *Proceedings of the 2015 ACM international joint conference on pervasive and ubiquitous computing* (pp. 1305–1316).

Gouveia, R., Pereira, F., Karapanos, E., Munson, S. A., & Hassenzahl, M. (2016). Exploring the design space of glanceable feedback for physical activity trackers. In *Proceedings of the 2016 ACM international joint conference on pervasive and ubiquitous computing* (pp. 144–155).

Halskov, K., & Dalsgård, P. (2006). Inspiration card workshops. In *Proceedings of the 6th conference on designing interactive systems* (pp. 2–11).

Helf, C., & Hlavacs, H. (2016). Apps for life change: Critical review and solution directions. *Entertainment Computing*, *14*(1), 17–22. https://doi.org/10.1016/j.entcom.2015.07.001

Höök, K., & Löwgren, J. (2012). Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *19*(3), 1–18. https://doi.org/10.1145/2362364.2362371

Hornecker, E. (2010). Creative idea exploration within the structure of a guiding framework: The card brainstorming game. In *Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction* (pp. 101–108).

Horowitz, S. M. (2003). Applying the transtheoretical model to pregnancy and STD prevention: A review of the literature. *American Journal of Health Promotion*, *17*(5), 304–328. https://doi.org/10.4278/0890-1171-17.5.304

Hutchison, A. J., Breckon, J. D., & Johnston, L. H. (2009). Physical activity behavior change interventions based on the transtheoretical model: A systematic review. *Health Education & Behavior*, *36*(5), 829–845

IDEO. (2003) . *IDEO method cards: 51 Ways to inspire design*. William Stout Architectural Books.

Kersten-Van Dijk, E. T., Westerink, J. H., Beute, F., & IJsselsteijn, W. A. (2017). Personal informatics, self-insight, and behavior change: A critical review of current literature. *Human–Computer Interaction*, *32*(5–6), 268–296. https://doi.org/10.1080/07370024.2016.1276456

Lee, J., Walker, E., Burleson, W., Kay, M., Buman, M., & Hekler, E. B. (2017). Self-experimentation for behavior change: Design and formative evaluation of two approaches. In *Proceedings of the 2017 CHI conference on human factors in computing systems* (pp. 6837–6849).

Li, I., Dey, A., & Forlizzi, J. (2010, April). A stage-based model of personal informatics systems. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 557–566).

Lucero, A., & Arrasvuori, J. (2010). PLEX cards: A source of inspiration when designing for playfulness. In *Proceedings of the 3rd international conference on fun and games* (pp. 28–37).

Lucero, A., Dalsgaard, P., Halskov, K., & Buur, J. (2016). Designing with cards. In P. Markopoulos et al. (Eds.), *Collaboration in creative design* (pp. 75–95). Springer.

Lucero, A., Holopainen, J., Ollila, E., Suomela, R., & Karapanos, E. (2013). The playful experiences (PLEX) framework as a guide for expert evaluation. In *Proceedings of the 6th international conference on designing pleasurable products and interfaces* (pp. 221–230).

Marshall, S. J., & Biddle, S. J. (2001). The transtheoretical model of behavior change: A meta-analysis of applications to physical activity and exercise. *Annals of Behavioral Medicine*, *23*(4), 229–246. https://doi.org/10.1207/S15324796ABM2304_2

McClurg, D., Frawley, H., Hay-Smith, J., Dean, S., Chen, S. Y., Chiarelli, P., Mair, F., & Dumoulin, C. (2015). Scoping review of adherence promotion theories in pelvic floor muscle training–2011 ics state-of-the-science seminar research paper i of iv. *Neurourology and Urodynamics*, *34*(7), 606–614. https://doi.org/10.1002/nau.22769

Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011a). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy. *Psychology & Health*, *26*(11), 1479–1498. https://doi.org/10.1080/08870446.2010.540664

Michie, S., Atkins, L., & Gainforth, H. L. (2016). Changing behaviour to improve clinical practice and policy. In *Novos Desafios, Novas Competências: Contributos Atuais da Psicologia. Braga: Axioma-Publicações da Faculdade de Filosofia* (University College London) (pp. 41–60).

Michie, S., & Prestwich, A. (2010). Are interventions theory-based? Development of a theory coding scheme. *Health Psychology*, *29*(1), 1. https://doi.org/10.1037/a0016939

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J., & Wood, C. E. (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. https://doi.org/10.1007/s12160-013-9486-6

Michie, S., Van Stralen, M. M., & West, R. (2011b). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*(1), 42. https://doi.org/10.1186/1748-5908-6-42

Middelweerd, A., Mollee, J. S., Van der Wal, C. N., Brug, J., & Te Velde, S. J. (2014). Apps to promote physical activity among adults: A review and content analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *11*(1), 97. https://doi.org/10.1186/s12966-014-0097-9

Morrison, L. G., Yardley, L., Powell, J., & Michie, S. (2012). What design features are used in effective e-health interventions? A review using techniques from critical interpretive synthesis. *Telemedicine and e-Health*, *18*(2), 137–144. https://doi.org/10.1089/tmj.2011.0062

Morrissey, E. C., Corbett, T. K., Walsh, J. C., & Molloy, G. J. (2016). Behavior change techniques in apps for medication adherence: A content analysis. *American Journal of Preventive Medicine*, *50*(5), e143–e146. https://doi.org/10.1016/j.amepre.2015.09.034

Oinas-Kukkonen, H., & Harjumaa, M. (2009). Persuasive systems design: Key issues, process model, and system features. *Communications of the Association for Information Systems*, *24*(1), 28. https://doi.org/10.17705/1CAIS.02428

Prochaska, J. O., DiClemente, C. C., & Norcross, J. C. (1992). In search of how people change: Applications to addictive behaviors. *American Psychologist*, *47*(9), 1102. https://doi.org/10.1037/0003-066X.47.9.1102

Prochaska, J. O., Redding, C. A., & Evers, K. E. (2015). The transtheoretical model and stages of change. *Health Behavior: Theory, Research, and Practice*, *97–121*(1). https://doi.org/10.4278/0890-1171-12.1.38.

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion*, *12*(1), 38–48. https://doi.org/10.4278/0890-1171-12.1.38

Rakowski, W., Ehrich, B., Goldstein, M. G., Rimer, B. K., Pearlman, D. N., Clark, M. A., Velicer, W. F., & Woolverton, H., III. (1998). Increasing mammography among women aged 40–74 by use of a stage-matched, tailored intervention. *Preventive Medicine*, *27*(5), 748–756. https://doi.org/10.1006/pmed.1998.0354

Riley, W. T., Rivera, D. E., Atienza, A. A., Nilsen, W., Allison, S. M., & Mermelstein, R. (2011). Health behavior models in the age of mobile interventions: Are our theories up to the task? *Translational Behavioral Medicine*, *1*(1), 53–71. https://doi.org/10.1007/s13142-011-0021-7

Rogers, Y. (2004). New theoretical approaches for human-computer interaction. *Annual Review of Information Science and Technology*, *38*(1), 87–143. https://doi.org/10.1002/aris.1440380103

Rogers, Y. (2012). HCI theory: Classical, modern, and contemporary. *Synthesis Lectures on Human-centered Informatics*, *5*(2), 1–129. https://doi.org/10.2200/S00418ED1V01Y201205HCI014

Rosenstock, I. M. (1974). Historical origins of the health belief model. *Health Education Monographs*, *2*(4), 328–335. https://doi.org/10.1177/109019817400200403

Roy, R., & Warren, J. P. (2019). Card-based design tools: A review and analysis of 155 card decks for designers and designing. *Design Studies*, *63*(1), 125–154. https://doi.org/10.1016/j.destud.2019.04.002

Spencer, L., Adams, T. B., Malone, S., Roy, L., & Yost, E. (2006). Applying the transtheoretical model to exercise: A systematic and comprehensive review of the literature. *Health Promotion Practice*, *7*(4), 428–443. https://doi.org/10.1177/1524839905278900

Spencer, L., Pagell, F., Hallion, M. E., & Adams, T. B. (2002). Applying the transtheoretical model to tobacco cessation and prevention: A review of literature. *American Journal of Health Promotion*, *17*(1), 7–71. https://doi.org/10.4278/0890-1171-17.1.7

Stawarz, K., Cox, A. L., & Blandford, A. (2015, April). Beyond self-tracking and reminders: Designing smartphone apps that support habit formation. In *Proceedings of the 33rd annual ACM conference on human factors in computing systems* (pp. 2653–2662).

Wang, Y., Fadhil, A., & Reiterer, H. (2019). Health behavior change in HCI: Trends, patterns, and opportunities. *arXiv Preprint arXiv:1901.10449* (1).

Wölfel, C., & Merritt, T. (2013). Method card design dimensions: A survey of card-based design tools. In *IFIP conference on human-computer interaction* (pp. 479–486). Springer.

Yang, C. H., Maher, J. P., & Conroy, D. E. (2015). Implementation of behavior change techniques in mobile applications for physical activity. *American Journal of Preventive Medicine*, *48*(4), 452–455. https://doi.org/10.1016/j.amepre.2014.10.010

About the Authors

Chrysanthi Konstanti is a PhD candidate in the Department of Communication and Internet Studies of the Cyprus University of Technology. Her research focuses on theory-driven behavior change design, and she seeks to encourage the design community to engage with and develop theory-based behavior change technologies.

Evangelos Karapanos is Associate Professor in the Department of Communication and Internet Studies of the Cyprus University of Technology, where he leads the Persuasive Technologies Lab (http://persuasive.cut.ac.cy). He has a keen interest in longitudinal field trials of interactive technology, with an emphasis recently on behavior change technologies.

Panos Markopoulos is a computer scientist working in the field Human Computer Interaction. He studied in the National Technical University of Athens and was awarded a PhD in Computer Science at Queen Mary University of London. He is a Professor of Industrial Design at the Eindhoven University of Technology.

Appendices

Appendix A

Table A1. List of excluded behavior change techniques from Michie et al.'s (2013) taxonomy, along with reasons for exclusion.

Excluded Technique	Definition	Reason for exclusion
10.7 Self-incentive	Plan to reward self in future if and only if there has been effort and/or progress in performing the behavior	As the technology enables monitoring of one's behavior, *self-incentive* is replaced by technology-supported reward and incentive provision.
10.9 Self-reward	Prompt self-praise or self-reward if and only if there has been effort and/or progress in performing the behavior	Same as 10.7.
11.1 Pharmacological support	Provide, or encourage the use of or adherence to, drugs to facilitate behavior change	The technique needs to be facilitated by a medical practitioner.
11.2 Reduce negative emotions	Advise on ways of reducing negative emotions to facilitate performance of the behavior	Given current technology, facilitating and monitoring the outcomes of this technique is challenging. The technique is more relevant to traditional interventions facilitated by a medical practitioner.
12.6 Body Changes	Alter body structure, functioning or support directly to facilitate behavior change	Same as 11.2.
15.2 Mental rehearsal of successful performance	Advise to practise imagining performing the behavior successfully in relevant contexts	The technology enables monitoring of one's behavior and may suggest alternative contexts to perform the behavior. The imagination of such contexts can be prompted but not monitored by the technology.
15.4 Self-talk	Prompt positive self-talk (aloud or silently) before and during the behavior	Same as 11.2.
16.1 Imaginary punishment	Advise to imagine performing the unwanted behavior in a real-life situation followed by imagining an unpleasant consequence	Same as 11.2.
16.6 Imaginary reward	Advise to imagine performing the wanted behavior in a real-life situation followed by imagining a pleasant consequence	Same as 11.2.

Table A2. The 34 technique categories, each representing a *technique card* in the BCD cards deck, and the techniques included in each of the categories. BCTs' numbers and names are as originally provided in Michie et al.'s (2013) taxonomy.

Technique Category	BCTs per category
Goal Setting	1.1 Goal Setting (behavior)
	1.3 Goal Setting (Outcome)
Problem Solving	1.2 Problem Solving
Action Planning	1.3 Action Planning
Review Goals	1.5 Review behavior goal(s)
	1.6 Discrepancy between current behavior and goal
	1.7 Review outcome goal(s)
Commitment	1.8 Behavioral Contract
	1.9 Commitment
Surveillance	2.1 Monitoring of behavior by others without feedback
	2.5 Monitoring outcome(s) of behavior by others without feedback
	6.3 Information about others' approval
Feedback on Behavior	2.2 Feedback on behavior
	2.6 Biofeedback
	2.7 Feedback on outcome(s) of behavior
Self-Monitoring	2.3 Self-monitoring of behavior
	2.4 Self-monitoring of outcome(s) of behavior
Social Support	3.1 Social Support (unspecified)
	3.2 Social Support (practical)
	3.3 Social Support (emotional)
Information about antecedents	4.2 Information about antecedents
	4.3 Re-attribution
	4.4 Behavioral Experiments
Information about consequences	5.1 Information about health consequences
	5.2. Salience of consequences
	5.3 Information about social and environmental consequences
	5.4 Monitoring of emotional consequences
	5.5 Anticipated regret
	5.6 Information about emotional consequences
	16.3 Vicarious consequences
Skills Training	4.1 Instruction on how to perform a behavior
	6.1 Demonstration of the behavior
	8.1 Behavioral practice/rehearsal
Social Comparison	6.2 Social Comparison
Prompts/cues	7.1 Prompts/cues
	7.2 Cue signaling reward
Reduce prompts/cues	7.3 Reduce prompts/cues
	7.5 Remove aversive stimulus
Satiation	7.6 Satiation
	11.4 Paradoxical instructions
Exposure	7.7 Exposure
Associative learning	7.8 Associative learning
Behavior substitution/Create alternatives	8.2 Behavior substitution (Create alternatives)
	8.4 Habit reversal

(*Continued*)

Table A2. (Continued).

Technique Category	BCTs per category
Habit formation	8.3 Habit formation
Graded tasks	8.7 Graded tasks
Overcorrection	8.5 Overcorrection
Generalization of a target behavior	8.6 Generalization of a target behavior
Credible source	9.1 Credible source
Pros and cons	9.2 Pros and cons
	9.3 Comparative imagining of future outcomes
Rewards	10.1 Material incentive (behavior)
	10.2 Material reward (behavior)
	10.3 nonspecific reward
	10.4 Social reward
	10.5 Social incentive
	10.6 nonspecific incentive
	10.8 Incentive (outcome)
	10.10 Reward (outcome)
	14.4 Reward approximation
	14.5 Rewarding completion
	14.6 Situation-specific reward
	14.7 Reward incompatible behavior
	14.8 Reward alternative behavior
Restructuring the environment	12.1 Restructuring the physical environment
	12.2 Restructuring the social environment
	12.5 Adding objects to the environment
Reducing Exposure to cues for the behavior	12.3 Avoidance/ reducing exposure to cues for the behavior
	12.4 Distraction
Self-Identification	13.1 Identification of self as role model
	13.4 Valued self-identity
	13.5 Identity associated with changed behavior
	15.1 Verbal persuasion about capability
Framing/Reframing	13.2 Framing/Reframing
Punishment	10.11 Future punishment
	14.1 Behavior cost
	14.2 Punishment
	14.10 Remove punishment
Reduce Rewards	7.4 Remove access to the reward
	14.3 Remove Reward
	14.9 Reduce reward frequency
Focus on past success	15.3 Focus on past success
Incompatible beliefs	13.3 Incompatible beliefs

Table A3. The 34 technique categories, classified to the five stages of behavior change.

Technique	Stages of Behavior Change*
Goal Setting	PR, AC, MA
Problem Solving	PR, AC, MA
Action Planning	AC, MA
Review Goals	AC, MA
Commitment	PR, AC, MA
Surveillance	AC, MA
Feedback on Behavior	AC, MA
Self-Monitoring	AC, MA
Social Support	AC, MA
Information about antecedents	PCO, CO, PR, AC, MA
Information about consequences	PCO, CO
Skills Training	PR, AC
Social Comparison	PCO, CO, PR, AC, MA
Prompts/cues	AC, MA
Reduce prompts/cues	MA
Satiation	AC, MA
Exposure	PR, AC, MA
Associative learning	PR, AC, MA
Behavior substitution/Create alternatives	PCO, CO, PR, AC, MA
Habit formation	PR, AC, MA
Graded tasks	PR, AC, MA
Overcorrection	AC, MA
Generalization of a target behavior	AC, MA
Credible source	PCO, CO, PR, AC, MA
Pros and cons	CO
Rewards	AC, MA
Restructuring the environment	PR, AC, MA
Reducing Exposure to cues for the behavior	PR, AC, MA
Self-Identification	PCO, CO, PR, AC, MA
Framing/Reframing	PR, AC, MA
Punishment	AC, MA
Reduce Rewards	MA
Focus on past success	AC, MA
Incompatible beliefs	PCO, CO, PR, AC, MA

(*Continued*)

Table A3. (Continued).

* PCO = Pre-Contemplation; CO = Contemplation; PR = Preparation; AC = Action; MA = Maintenance

Appendix B

Please rate in each of the blanks on the column how certain you are that you can design for behavior change.
Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all				**Moderately can do**					**Highly certain can do**	

	Confidence (0-100)
I can design for behavior change.	_____
I can apply behavior change methods to my design.	_____
Make use of the Transtheoretical Model of behavior change.	_____
Make use of Behavior Change Techniques.	_____

Figure B1. Self-efficacy Questionnaire used in the second formative study before and after the workshop session.

Please rate in each of the blanks on the column how certain you are that you can design for behavior change.
Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all				**Moderately can do**					**Highly certain can do**	

	Confidence (0-100)
Design technologies for behavior change.	_____
Describe a problem in behavioral terms.	_____
Develop design solutions for behavior change needs.	_____
Objectively select best design solution/concept.	_____
Justify design decisions and solutions.	_____
Design for different stages in behavior change.	_____
Implement different behavior change techniques to designs.	_____
Communicate project details in writing.	_____
Work effectively in a team.	_____
Manage my time efficiently to accomplish activities.	_____

Figure B2. Self-efficacy Questionnaire used in experimental and control conditions before and after the design sessions.