

DIY Digital Interventions: Behaviour Change with Trigger-Action Programming

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Fig. 1. Participants conceptualising their DIY digital behaviour change interventions.

Whether it is sleep, diet, or procrastination, changing behaviours can be challenging. Individuals could design and build their own personalised digital interventions to help them reach their goals, but little is known about this process. Building upon previous research we propose the Behaviour Change with Trigger-Action Programming (BC-TAP) model which describes how individuals could bridge the gap between their current and desired behaviour through the creation of ‘Do-It-Yourself’ (DIY) digital interventions. We conducted a

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two-day participatory workshop based on the BC-TAP model with 28 participants. Participants articulated plans to change a behaviour of their choice and represented these plans in mobile device automations. After using their interventions for up to three weeks, participants reflected on their experience. Our findings report opportunities and challenges at each stage of the process. While formulating a digital proxy for certain behaviours was challenging, both failures and successes facilitated participants' awareness of their behaviour, and their ability to change it.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; **HCI theory, concepts and models**.

Additional Key Words and Phrases: wellbeing, behaviour change, self-reflection, end-user programming, trigger-action programming, computational thinking, automations, implementation intentions

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1 Introduction

To realise the best possible health and wellbeing outcomes, people sometimes have to change and adapt their behaviours. Many digital behaviour change interventions (DBCI) and wellbeing applications have been designed to support people in changing their behaviour, such as step counters to increase physical activity and screen time caps to reduce screen time (for a review, see [6, 41, 67]). Despite their widespread availability, research has shown that these generic applications often fail to have a significant effect on the targeted behaviour [6]. Generic DBCIs often do not account for the complexity of people's behavioural goals, or the way they can change over time [1, 47]. As a result, interventions are often unable to sustain an effect on the target behaviour and may be abandoned entirely by users [6].

Rather than download a generic DBCI, it has been suggested that people could design and implement their own digital interventions [35, 53, 56]. Self-designed interventions created by an individual for themselves could be intimately adapted to that person's daily routine and their physical and social environments. By designing their own 'just-in-time' interventions, people could have greater control over when and where an intervention activates [5, 32, 35]. Furthermore, if an individual detected that their personalised intervention was failing to have the desired effect, they could proactively adapt it through further iterative changes, in a process of self-experimentation [26, 35]. Hence, through a dynamic process of self-reflection and intervention iteration, a person can work towards closing the gap between their current and desired behaviour.

Unlike downloading a generic app, directing the process of creating a behavioural intervention requires the user to reflect on themselves and their current and desired behaviour. They must consider the aspects of behaviour they want to change, how they want to achieve that change, and what are they willing to do to achieve it. Furthermore, they must translate these goals into a computational form, through some form of end-user programming. Through making a personal investment into the development of the intervention, the individual could channel their self-agency [48] and show greater engagement with the final intervention [68]. There is early evidence for this 'IKEA effect' in the self-assembly of personalised interventions using trigger action programming (TAP) in the context of social media addiction [52, 54].

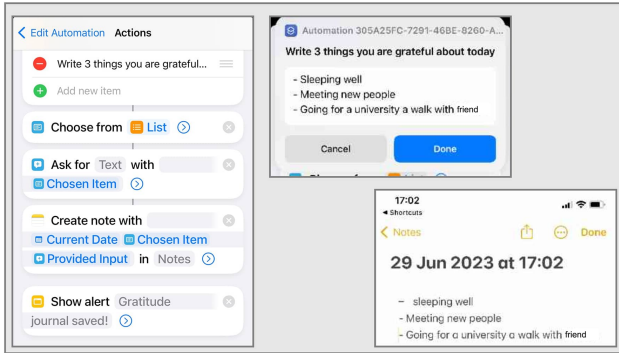
Early research has explored the DIY approach to DBCIs in the context of reducing social media usage [53] and improving sleep behaviours [36]. In these studies, the researcher determined one or more of the following aspects of the intervention; the target behaviour, the design of the intervention, the implementation of the intervention, and the metrics of evaluation. However,

when taking a ‘Do-It-Yourself’ (DIY) approach in everyday life, users would have to direct all these aspects themselves. In this study, we utilised a participatory design approach to demonstrate how people navigate the full cycle of conceptualising, implementing, and evaluating a DIY DBCI.

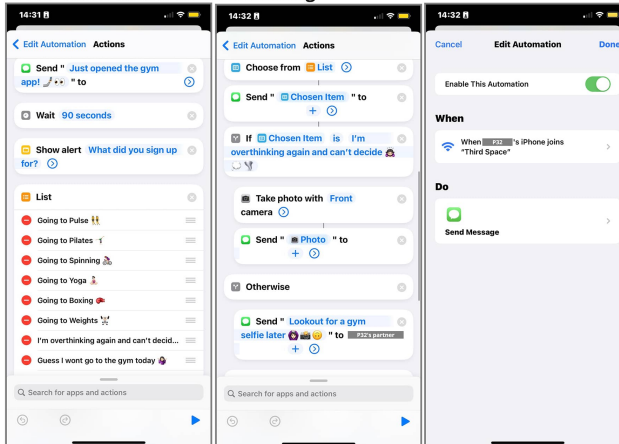
This paper contributes the following:

- A new participatory design approach which guides people to identify their target behaviours, simplify them, and translate them into trigger-action programming sequences. This DIY approach is summarised in the Behaviour Change with Trigger Action Programming (BC-TAP) model shown in Figure 4, which builds upon previous models of behaviour change [1, 3, 47].
- An empirical account of the opportunities and challenges faced by 28 individuals at each stage of the DIY process. We describe the different types of interventions built by participants (Figure 2), and how the DIY approach can engage users in self-reflection, even when the interventions do not work as expected.

1. TAP Intervention for Gratitude



2. TAP Intervention for Overthinking



3. TAP Intervention for Social Media Use

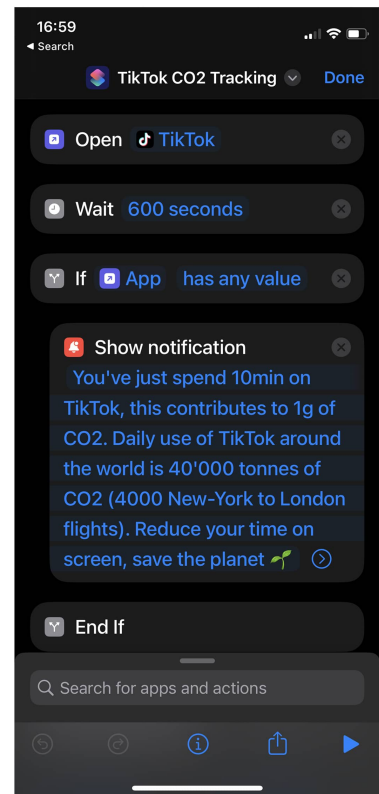


Fig. 2. Participants created their personal digital behaviour change interventions using Trigger-Action Programming (TAP) tools, such as iOS Shortcuts. This figure shows the TAP interventions created by participants during the workshop; 1) targeted at increasing overthinking; 2) targeted at decreasing overthinking; and 3) targeted at decreasing time spent on TikTok.

Our exploratory approach highlights the discursive and generative properties of the BC-TAP model and points to many areas for future research and practice [31, 59]. The participants' designs reflected the peculiarities of their individual lives and goals; they incorporated songs, selfies, local routes, restaurants, and loved ones within their interventions, in a way they believed to be most effective in influencing their behaviour. Despite this high level of personalisation, DIY DBCIs were not all equally successful in influencing participants' behaviours. However, our findings show that these failures have the potential to trigger self-reflection, further design iteration, and eventually improve alignment between the users' needs and their technological tools. By integrating participatory design, behaviour change theory, self-experimentation, and trigger-action programming, we propose a DIY approach to DBCIs that could empower people to bridge the gap between their current and desired behaviours.

2 Background

Sometimes people struggle to perform the healthy behaviours they want to perform. This difference between an individual's desired behaviour and their actual behaviour has been called the 'intention-behaviour gap' [63]. An inability to achieve desired behaviour change can lead to reduced well-being and worse health outcomes [12]. This gap has been identified across many different behaviours, including exercise routines [13, 57], eating habits [45, 46, 62], sustainability behaviours [23], privacy [58], technology use [7, 42], and many others.

Correspondingly, there is a vast range of behaviour change applications addressing exercise and diet [7, 34, 61], mental health [2, 14], digital detox [55], sleep [49], and many others. Many of these interventions combine behaviour monitoring (e.g. step counts, sleep and diet tracking) with 'just-in-time' reminders aimed to trigger desirable behaviours in the user. For example, many mobile devices will monitor the users' screen time, offering reminders when they get close to their daily time cap, and even blocking certain applications after the time limit has been met. However, these interventions are not always effective in changing people's behaviour, with some users finding these interventions too restrictive, easy to ignore, and others deleting them entirely [6, 28, 29, 55]. Generic DBCI's often fall short of sustainably changing user's behaviour as they fail to adapt to individuals' fluctuating intentions, circumstances, and levels of motivation [1]. In the following section, we account the design of DBCIs may be informed and improved by behavioural science.

2.1 Informing Technology Design with Behaviour Science

Behaviour scientists and HCI scholars have developed multiple frameworks describing behaviour change to inform the design of DBCIs [18, 19, 51]. One of the earliest of these frameworks was Fogg's Behaviour Model, also known as the B=MAP model, which posits that behaviour (B) is determined by three factors which must converge at the same moment: Motivation (M), Ability (A), and Prompt (P) [17]. Other models include Wendel's 'behaviour change process' [69], and the COM-B model of behaviour, which posits Capability (C), Opportunity (O) and Motivation (M) as core determinants of behaviour (B) change [40].

These frameworks point to common drivers and obstacles of behaviour change, which could be useful for designers of DBCIs, but which also require learning new terminology and approaches that could complicate or even disrupt the design process. To address this hurdle, researchers have created behaviour change theories design cards, which can be used throughout design sprints and prototyping phases [10, 22, 37]. Colusso et al. [10] showed how designers can use these cards to identify when and where to place behaviour change interventions within the user journey, allowing a more targeted, justified ideation process.

While these existing behaviour change theories, approaches, and frameworks can improve the efficacy of interventions overall, they cannot account for the full complexity and idiosyncrasies of

individual behaviour. An intervention that works for one person at one time may not work for someone else, or for the same person but at a different time. The extent to which behaviour change goals fluctuate and evolve has been well documented in research into personal informatics, which we summarise below.

2.2 The Complex Evolution of Individual Behaviour Change Goals

While a DBCI may provide one solution or metric addressing one particular behaviour, an individual may have multiple behaviour change goals, some of which are qualitative rather than quantitative, and these goals often change over time. Hence, there can be a mismatch between what a DBCI offers at one time, and what the user needs over their entire behaviour change journey, which could last months or years [1].

Through personal informatics (PI), users can choose to record and track certain behaviours over time, such as the number of steps they walk, their weight, their heart rate, or their sleep. Many DBCIs offer PI features, as understanding current behaviour can be critical to understanding how to change it, and in what direction. In the context of fitness tracking, Niess and Woźniak [47] presented the Tracker Goal Evolution model, which describes how users have to translate their (often implicit) eudamonic and hedonic needs (such as 'feel well') into explicit qualitative goals (such as 'spend more time outside'), and then into quantitative goals ('go for a 30-minute walk every day'). Through this process of quantification, goals must be simplified and can lose their original importance or meaning to the user over time.

It is almost inevitable that a DBCI will become misaligned with a user's needs, because people's behaviour change goals evolve extensively over time. These moments of misalignment can actually be an opportunity for reflection, which is critical to behaviour change [3]. Agapie et al. [1] proposed the Longitudinal Goal-Setting Model, which describes how a successful therapeutic journey supports people to select between and adapt to their many behaviour change goals. To do so, they must engage in descriptive, dialogic and transformative reflection to identify, explain and challenge their current behaviours [15].

With goals fluctuating in this way, generic DBCIs often become irrelevant and are abandoned over time. This abandonment can lead to a lapse in a quantified track record and a subsequent feeling of failure [1]. More importantly, not all goals can be meaningfully quantified in the first place. Hence, while goal quantification can be associated with gamification and increased engagement, it may also have negative consequences in the long term, due to the changeable complexity of behaviour change and goals.

Acknowledging this changeability, research has suggested that people could embark on a process of self-experimentation and transformative reflection, through which they trial different approaches to achieving their goal, evaluating and iterating until they find something that works for them individually [26, 27, 56]. Technology can help users track and isolate different triggers (e.g. for a chronic disease [26]), but the metrics collected by an application, the scales used, and the restricted reporting times do not suit every individual's complex needs. As a result, Karkar et al. [26] argues that self-experimentation systems should empower "particular users [to] choose designs appropriate to their individual situations". Furthermore, this research highlights the methodological challenges when deploying a self-experimentation approach. With sample sizes of just one person, and each participant taking different approaches and aiming for different outcomes, quantifying the effect of self-experimentation approaches is challenging [27, 31]. Alternatively, we propose that qualitative methods based on thematic analysis and self-report can accommodate the range of experiences elicited during a self-experimentation study, facilitating a richer understanding for both users and researchers.

The work summarised above acknowledges people's ability to monitor and reflect on their behavioural data, and to apply insights from this to self-experiment with their behaviours. The research summarised in the next paragraph suggests that people may also be able to conceptualise and build their own interventions which correspond and adapt directly to their changing behavioural needs. Hence, people do not just change *themselves* through transformative reflection and self-experimentation, but also the *technology* they are using.

2.3 Psychological and Digital Toolkits for Behaviour Change

Acknowledging the diversity and ever-changing nature of an individual's behaviour change goals, an alternative approach could be to provide psychological and technological 'toolkits' that people can use and adapt to address their differing goals over time.

One such psychological technique teaches people to create 'implementation intentions', which are if-then statements which specify the desired action in a particular context [21]. For example, 'if I am leaving the house, *then* I will make sure to take my keys'. To form an implementation intention, a person has to plan and rehearse the 'when', 'where' and 'how' they will achieve an intention, which increases the feasibility and salience of fulfilling an intention. Implementation intentions have been shown to improve health-related behaviour change in exercise, diet, smoking, alcohol consumption and sleep, amongst others [39, 64]. The implementation intention technique is highly versatile and adaptable to many behaviours and over time.

Digital toolkits offer individuals a large amount of control over what their devices do, and when and where they do it. Rofarello et al. [43] provided Android users with an app with a choice of over 14 types of digital wellbeing interventions, including self-monitoring features alongside time-based blockers. In the FeelHabits system, users set their own intentions (or 'usage rules') for enforcing control over or increasing awareness of their usage at a device- or app-level across multiple devices [44]. These studies found that participants appreciated the ability to design and set personalised interventions. However, these studies were focused just on digital wellbeing (e.g. screen time), rather than behaviour change generally. Furthermore, users could not utilise all their devices' capabilities for the design of their digital intervention (e.g. sending messages to friends, taking photos, setting timers or diverting to an alternative app or web page).

Recent developments in trigger-action programming (TAP) software have made a greater number of mobile features accessible for end-user programming. An example of TAP software is iOS Shortcuts¹, as shown in Figure 2. These interfaces allow a user's mobile device to automatically detect certain events or 'triggers' (such as entering a particular location or opening an app), and subsequently deliver a sequence of 'actions', such as a sending notification or message, setting a timer, vibrating the phone, or redirecting to another app. This repertoire of triggers and actions can be utilised by users to formulate different configurations of context-aware digital automations. Ur et al. [66] found that over 100,000 individuals have already shared individually crafted programs for smart-home automation, on the website 'If-This-Then-That' (IFTTT).

Purohit et al. [52] investigated how the co-creation of digital interventions can be achieved using iOS Shortcuts. Guided by the researcher, ten users constructed a pre-designed digital intervention on their personal device using iOS Shortcuts and then trialled it for two weeks. The findings suggest that co-creation can offer users a positive sense of agency as well as a sense of accomplishment, and reduce privacy concerns. Furthermore, the intervention reduced the time users spent online compared to their baseline. However, the automations described in Purohit et al. [52, 54] were designed by the researcher, not the individual participants. Targeting improved sleep hygiene, Lee et al. [35] guided users to design their 'just-in-time', home-based digital interventions, which had a

¹<https://support.apple.com/en-gb/guide/shortcuts/welcome/ios>

positive effect on sleep behaviours over seven weeks. However, the applications were written, built and installed by the researcher, not by the participants themselves. The participants in these studies could not choose which behaviour to target or what strategy to take. Applying a participatory design method [24, 65], our study required the participants to choose the target behaviour and encouraged them to utilise the full repertoire of their devices' capabilities when designing their final TAP interventions.

The work described above suggests that a) behavioural science can inform the design of DBCIs, b) current DBCIs may promote self-reflection, but struggle to adapt to the way goals change as a result of this reflection, and c) people could potentially prefer and benefit from designing their own DBCIs. In our study, we integrate these findings to suggest that users can become designers of their own behaviour change interventions, using TAP to create automations which intervene in their behaviour as and when they see fit. To explore the challenges and opportunities in this approach, we developed a participatory design protocol through which 28 participants identified a gap in their current and desired behaviour, formulated an implementation intention to close it, and then translated this into a programming sequence of triggers and actions on their personal mobile devices. They then trialled their interventions for up to three weeks in their everyday lives. We encapsulate the three stages in this approach in a model shown in Figure 4.

3 Developing a DIY Approach to DBCI Design

Preparatory Activities			Workshop Activities		Debrief Activities	
Model Stage	Behavioural Context		Specific Context	Computational Context	Post-workshop Evaluation	In-the-Wild Evaluation
Activities	Behaviour Reflection Table	TAP Tutorial	Session 1	Session 2	Post-workshop Survey	Debrief Session
Day	Day -14 to -1		Day 0	Day 1	Day 4-10	Day 19
N	28 participants		27 participants	25 participants	15 participants	9 participants*

Fig. 3. Study Protocol. * The nine participants acted as representatives for their teammates who had shared their experiences prior to the debrief session.

The idea that people who use technologies should play a critical part in their design is a core aspect of participatory design (PD) and participatory prototyping [16, 65]. Participatory methods engage users in the design process, either through ethnography, prototyping, and feedback [4]. A key goal of participatory design is to achieve mutual learning between participants and researchers; in the case of this study, the participants discovered new behaviour change strategies and TAP, and the researchers discovered the challenges and opportunities faced by individuals taking a DIY approach to DBCI. To achieve this end, we developed a two-day participatory design workshop where 28 individuals would design and implement their DIY interventions using TAP.

Acknowledging that creating a personal DBCI in just two days is a demanding task, we designed a protocol which subdivided the process into more manageable sub-tasks. Inspired by the PD 'Future Workshop' [24], our protocol guided participants through various activities, including preparatory activities, workshop activities, and debrief activities (as shown in Figure 3.) We encouraged the participants to work together throughout the study, as collaborative group work has been shown

to reduce the cognitive load of creative brainstorming and problem-solving tasks [30, 33], and increase creativity in PD [4].

3.1 Approaching a Model of Behaviour Change with Trigger-Action Programming (BC-TAP)

Our focus was particularly on the notion of how DBCI's need to *approximate* people's current and desired behaviour, in terms of how they 'identify' the former and can 'enable' the latter through meaningful interventions.

More specifically, these approximations take place on several levels or in several steps, which could broadly be summarised as:

- (1) To start off, a person needs to determine what current behaviour they intend to change and the desired behaviour they would like to achieve.
- (2) They then need to identify common situations in which the current behaviour arises and what they can do to change the behaviour in such a situation. This can be achieved by formulating 'implementation intentions' through IF-THEN pairings.
- (3) A person then needs to think about how the underlying IF-THEN pairing can be represented by the technology, given its sensing and acting capabilities.

To systematise and visualise the different stages and levels of abstraction involved in designing TAP DBCIs, we represent them in what we refer to the BC-TAP model, shown in Figure 4, which expands upon previous models of goal-directed behaviour change [1, 47].

The Behaviour Change with Trigger-Action Programming (BC-TAP) model, depicted in Figure 4, describes the thinking and development processes our participants went through to conceptualise, design and build a DBCI. As our study was interested in examining the steps of abstraction and approximation people undertake and how this leads to the design and revision of their DBCIs, the BC-TAP model is used as a high-level framing for this inquiry and its findings.

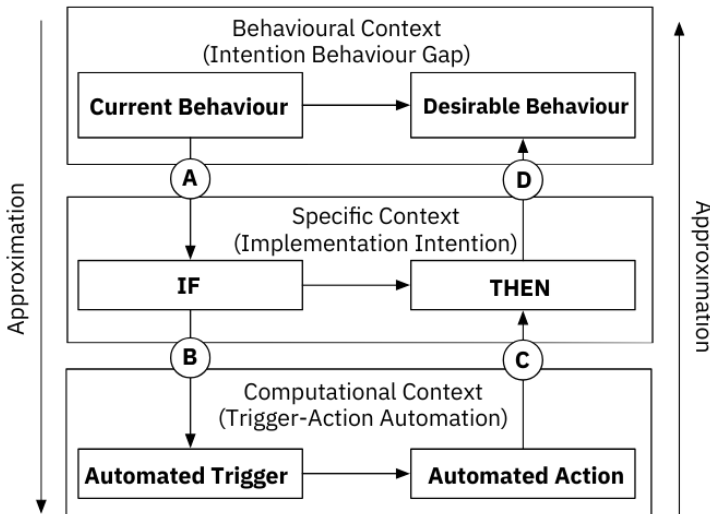


Fig. 4. Behaviour Change with Trigger Action Programming (BC-TAP) Model

There are three key phases to the BC-TAP model; the behavioural context, the specific context and the technological context.

The *behavioural context* includes the ‘intention behaviour gap’, which outlines the difference between the current behaviour, and the desired behaviour. Participants reflected on the behavioural context throughout the protocol, particularly in the preparatory and evaluation phases. The *specific context* describes the ‘if-then’ statement, also known as an implementation intention, which provides a specific plan for changing this behaviour. Participants formulated the specific context of their interventions in the first workshop exercise, described in [section 3.4.1](#). The *computational context* outlines the Trigger-Action Automation, made up of an automated trigger and an automated action. Participants formulated the computational context of their interventions in the second workshop exercise, described in [section 3.4.1](#).

In the downward approximation (Paths A and B), the system approximates the original behavioural context to end up with a highly specific automated trigger, losing some of the complexity of the original behaviour. The downward approximation requires people to abstract their behaviour in meaningful ways so that it can be translated into a computational trigger. In the upward approximation (Paths C and D), the automated action targets a very specific short-term or immediate behaviour that acts as a proxy for the overall behaviour. By moving through these paths of approximation repeatedly, we propose that the user can change their behaviour and their technologies in a dynamic process.

Thus, the BC-TAP model is a representation of how people could bridge their intention-behaviour gap, by first creating an implementation intention, and then a trigger-action sequence executed automatically by their device. In the following sections, we describe the protocol through which we guided our participants to follow the BC-TAP model to create and use a DIY intervention of their own.

3.2 Participants

We recruited 28 participants for this study (10 male and 18 female, between the ages of 23 and 42). All participants were PhD students attending a three-day summer school focused on HCI for wellbeing held at the University of Bremen, Germany. To take part in the summer school, the participants had to submit an application which asked about their motivation to take part and their research interests. The participants came from a diverse range of educational backgrounds including psychology and cognitive sciences, computer science and engineering, design and digital arts, and business and management studies. A breakdown of the participants’ demographics can be found in [Table 1](#).

Though our participants were provided food and/or accommodation during the summer school, they were not directly remunerated for their participation in this study. Participants could withdraw from the study at any time, with no consequences.

After an assessment, this study was exempted from formal review by the Ethics Committee of the University of St Gallen, Switzerland.

3.3 Preparatory Activities

Before the workshop, we engaged the participants in preparatory activities which were delivered through a digital MIRO whiteboard and completed collaboratively and independently. The participants engaged in two key preparatory activities. The first was to engage in a collaborative ‘Behaviour Reflection’ exercise described in the next sub-section. Secondly, participants were asked to complete a tutorial in TAP, so to practice the technical skills required for the workshop.

3.3.1 Behaviour Reflection Table. Before attending the workshop participants were invited to consider two to three behaviours they would like to change, hence identifying the behavioural context shown in [Figure 4](#). They were then asked to add their chosen behaviours to a collective

Dimension	Sub-dimensions	Participants
Gender	Male	10
	Female	18
Bachelor's Subject	Psychological and Social Sciences	5
	Computer Science and Engineering	13
	Arts and Humanities	7
	Natural Sciences	1
	Other	3
Previous experience with TAP software	Never heard of TAP before	11
	Had heard of TAP, but had never used it	10
	Had previously used TAP	7

Table 1. Participant demographics. (*For gender, no participants identified as non-binary or declined to answer)

MIRO board (available in the supplementary materials) and answer several questions about each to explore them in greater depth. The questions were informed by the main components of existing behaviour change models: COM-B [40] and Fogg's Behavior Model [17]). Through considering these questions, participants built a richer understanding of the intention-behaviour gap, by covering the contextual behavioural factors, and associated experiences, as well as the strategies or tools for changing the behaviour.

Participants were also asked to vote for the top two behaviours they would wish to address in the workshop by placing a star with their participant number next to it. We used these votes to create groups with similar interests for the workshop.

3.3.2 Automation Tutorials. Next to the Behaviour Reflection Table in the MIRO board, we placed links to tutorials for trigger-action programming. These tutorials were provided to introduce participants to mobile device scripting applications ahead of the workshop. We provided tutorials for both iOS and Android devices.

3.4 Workshop

The participants took part in a workshop which was split into two two-hour long sessions on two consecutive days. Four researchers facilitated the workshop sessions by following a slide deck (available in the supplementary materials). While the preparatory activities focused on establishing the behavioural context in the BC-TAP model shown in Figure 4, the workshop activities focused on supporting participants to navigate paths A, B, C and D, so as to identify the specific and computational contexts relevant to closing the intention-behaviour gap. We sorted participants into nine groups of three people, each focusing on a different target behaviour. During the workshop, one participant decided to pivot from the target behaviour of *Checking in with a Friend* to focus on the behaviour of practising *Gratitude*. Hence, the 10 target behaviours considered and designed for in the workshops were those selected by the participants themselves to either support and increase (S/I), or reduce (R).

- (1) Checking in with a Friend (S/I)
- (2) Eating Regularly (S/I)
- (3) Exercising (S/I)
- (4) Meditation (S/I)
- (5) Self-compassion (S/I)
- (6) Sleeping (S/I)

- (7) Gratitude (S/I)
- (8) Social Media Use (R)
- (9) Overthinking (R)
- (10) Procrastination (R)

3.4.1 Workshop Session 1. On each table, groups were provided with sheets of A2 paper, 12 trigger and 12 action cue cards, coloured post-notes, and pens. The facilitators then introduced two group exercises; 1) Defining Implementation Intentions and 2) Creating Trigger-Action pairings using the cue cards shown in Figure 6.

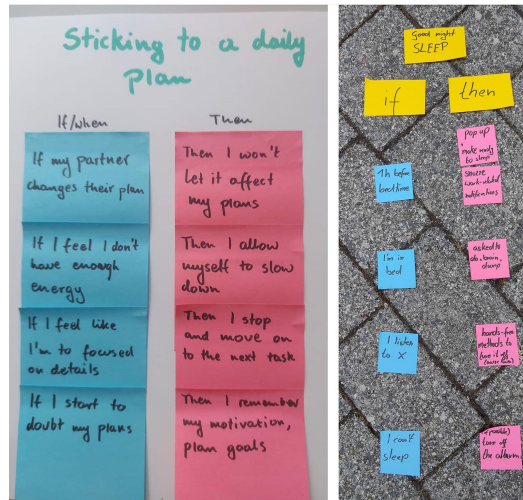


Fig. 5. Groups defined their target behaviour using if-then statements. From left to right: *Overthinking Group*; *Sleeping*

Exercise: Defining Implementation Intentions. To find specific contexts relevant to the behaviour context (paths A and D in Figure 4), participants articulated an ‘if-then’ statement [21, 63, 64].

Using post-it notes on a sheet of A3 paper, participants were given 20 minutes to come up with as many ‘if-then’ statements for their behaviour as possible, as shown in Figure 5. For the target behaviour of sleeping, examples could include “**If** I am in bed... **Then** I will not go on social media”, or “**If** it is after 1pm... **Then** I will not drink caffeine.”

Exercise: Creating Trigger Action Pairings. To find computational “proxies” for these specific contexts (paths B and C in Figure 4), participants were instructed to represent these if-then statements in ‘trigger-action’ pairs. They were provided with cue cards, shown in Figure 6, which represented nearly all the triggers and actions available in iOS Shortcuts and Android alternatives. These cue cards represent a palette of mobile device functionalities, encouraging participants to engage with the full repertoire of their devices’ capabilities when conceptualising their digital interventions. Within 30 minutes, the participants matched their statements with triggers and actions and collectively chose the three most interesting or exciting pairs to present to the rest of the groups.

3.4.2 Workshop Session 2. The second and final workshop session focused on implementing the designs for digital interventions, conceptualised in the previous session. In this workshop, the participants fully implemented paths B and C in the BC-TAP model shown in Figure 4.

Particular time		Particular date		Set timer or alarm		Create calendar event	
Connect to Wi-Fi		Particular location		Create a document		Navigate somewhere	
Battery level		Night / Focus mode		Play music		Take a screenshot	
Sound detected		Incoming message		Record a sound		Send a message	
Opening an application		Closing an application		Open an application		Close an application	
Connecting to Bluetooth		Outgoing message		Open a link		Notification / Ask for input	

Fig. 6. Participants were provided with ‘Trigger’ and ‘Action’ cue cards, which correspond to the Input and Output functionalities available in iOS Shortcuts. The left columns in blue show the ‘trigger’ cue cards, and the right columns in pink show the ‘action’ cue cards.



Fig. 7. Groups then translated their if-then statements into triggers and actions available in scripting tools. The trigger-action pairings for the *Sleeping* group is shown.

The participants spent 90 minutes building their interventions on their personal mobile devices, personalising as they pleased. Facilitators were available to help troubleshoot and guide the building of the interventions if needed.

When built, participants were required to populate a table on the MIRO with images of the if-then statements, trigger action pairings, and screenshots of the final intervention design produced throughout the workshop. Groups were invited to explore this collective MIRO board and presented their final interventions to the whole group in a three-minute pitch.

3.5 Debrief Activities

After finishing the workshop, we asked participants to fill out a survey which asked them about their experience in the workshop, as well as their perceptions of the intervention they created. These questions were posed as statements, which participants could then indicate their agreement with on a five-point Likert scale ranging from ‘Strongly disagree’ to ‘Strongly agree’. The survey was created using Microsoft Forms, and can be found in the supplementary materials. 15 participants completed the post-workshop survey.

In the weeks after the workshop, we asked participants to use their interventions as they wished, in their daily lives. It was critical to evaluate the interventions within the participants’ real lives, to see how they adapt to the complexity and stubbornness of current behaviours [60]. We were interested to see if any of the participants had adapted their interventions, or created new ones.

We held a focus group three weeks after the workshop to understand if and how the participants perceived the self-designed interventions to be supporting their intended behaviour change (path C and D in the BC-TAP model (Figure 4).

While all the participants were invited to attend the debriefing focus group, we asked that they ensure at least one ‘representative’ per group was present. Before the debrief session, we encouraged the participants to reflect on their experience with their intervention and share this with their representative.

We chose to hold a focus group rather than individual interviews for several reasons. As the participatory workshops were collaborative, we decided a collective debrief session could emulate and capture the comparative, exploratory nature of designing DIY interventions together. Participants could compare their post-workshop experiences with others, and highlight similarities and differences. They continued to populate the MIRO board together, further enriching this shared artefact for our analysis and their own reflection.

Nine participants attended the debrief session on Zoom, representing seven of the ten groups and their target behaviours; Eating Regularly, Exercising, Overthinking, Procrastination, Gratitude, Sleeping and Social Media Use. During the session, the participants were asked to collectively populate and discuss another part of the MIRO board containing a table which asked them about how their intervention worked or could be improved, and their future approach to behaviour change.

4 Analysis

Our protocol populated three main data sources for our analysis; the MIRO board which scaffolded the whole participatory process, the video recording of the debrief session, and the post-workshop survey responses.

4.1 Coding the MIRO Board

Throughout the protocol, the participants collectively populated two tables in the MIRO board; the Behaviour Reflection Table, described in [subsubsection 3.3.1](#), and the final Workshop Table, described in [subsubsection 3.4.2](#). A PDF of the MIRO board with both tables can be found in the supplementary materials.

To make sense of the participants’ collaborative, iterative thinking, we started by analysing their final interventions and worked ‘backwards’ from there to derive the context for these interventions.

In the following section, the interventions thus also serve as a starting point to investigate the preceding phases of conceptualisation and ideation (preparatory and workshop activities) and the following application and use of the intervention (debrief activities).

Two researchers coded participant groups' final intervention ideas (consisting of If-Then statements and Trigger-Action pairs). Both researchers coded the interventions using open coding. Next, a coding tree was established through iterative discussion with all authors. Following this, the codes for all interventions were revised by one author using the agreed coding tree. We identified six ways in which participants approximated their behavioural context with automated triggers (path B): time, environment, body, digital, social and literal. These themes are reported in [subsection 5.2](#). We identified four ways in which participants tried to bring about certain behaviours with automated actions (path C), via *Suggestion*, *Encouragement*, *Simplification* or *Restriction*. These themes are reported in [subsection 5.3](#).

4.2 Coding the Debrief Session

The recording of the debrief session was automatically transcribed by Zoom, and then manually cleaned by the lead author. Two researchers then separately coded the transcript in Nvivo 12 using *reflexive thematic analysis* [9] – taking an *inductive* (bottom-up data-driven coding), *semantic* (meaning is explored at the surface level), *experiential* (analysis aims to capture people's own understanding and experience), and *essentialist* (analysis aims to capture reality as expressed within the data) approach. Using affinity diagramming [38], codes were then integrated and organised to generate themes through iterative discussions between the same researchers.

The researchers organised their codes into two key themes and various sub-themes.

- (1) Designing Digital Interventions
 - a. Descriptions of Intervention Designs
 - b. Descriptions of Experience in the Study
- (2) Living with DIY Digital Interventions
 - a. Awareness of Behaviours
 - b. Awareness of Motivation
 - c. Breaking and Creating Habits

While quotes from the first two sub-themes are used to support the results from the analysis described above, the last three sub-themes are described independently in [subsection 5.4](#).

5 Findings

We organise our findings to address each stage of the BC-TAP model respectively, from Path A to Path D. This follows the participants' journey from identifying a behaviour they would like to change, encapsulating this in an 'if-then' statement with their groups, translating this into a trigger-action programming sequence, and iterating on the rules and conditions of this automation in the following weeks. Rather than describing each individual's design process, we have identified key themes reflected in the process of approximating behaviour contexts and activities with triggers and actions, and the interventions developed themselves. We use examples and quotes from particular groups and participants, and overall survey responses, to support our findings.

5.1 Approximating the Intention Behaviour Gap into Implementation Intentions (Path A)

In the pre-workshop exercises described in [subsection 3.3](#), our participants were encouraged to think broadly about the behaviours they wanted to change, enriching the behavioural context ([Figure 4](#)). Participants were also encouraged to think about strategies for improving their behaviour,

and how they could evaluate the effectiveness of these strategies. Hence, they developed a greater understanding of the intention-behaviour gap and how they could close it. In the post-workshop survey, 12 (80%) participants agreed with the statement "The MIRO board helped me to reflect on the behaviours I would like to change."

The process of discussing behaviours with others was evaluated positively by participants. In their survey responses, 11 (73%) of participants disagreed with the statement "I would have preferred to work alone during the workshop tasks", and 12 (80%) agreed with the statement "My group worked effectively together." Through collaboration, the participants could compare their behaviour to that of others, which made it more engaging than reflecting alone. In the debrief session, P15, described *"really enjoy[ing] discussing with someone"*, and that comparing different goals between group members *"was already a fun part of thinking about what that means in your life"*.

Participants then created pragmatic plans to address the gap between their current behaviour and desired behaviour in the form of implementation intentions (path A in Figure 4). This process requires decomposition of the target behaviour into precise contexts ('if') and activities ('then'). The groups' implementation intentions varied in their specificity. For example, both the *Overthinking* group and the *Checking in with a Friend* group articulated an 'if'-statement as "feeling low in energy", while the *Meditation* group wrote "if I am in work flow". These more ephemeral, internal cues were harder to approximate in a digital representation, as described in the following section.

However, during the process of approximating 'if' and 'then' contexts into the system 'triggers' and 'actions', the groups revised their implementation intentions to be more specific. Reflecting this, the *Checking in with a Friend* group re-wrote their intention implementations twice, with the second set of iterations titled "more practically", as shown in Figure 8. Between these two iterations, an 'if' statement was specified from "If my social battery is low" to a more clearly defined context – "If I have only work events in my calendar".

Similarly, the *Social Media Use* group rephrased their implementation intentions to be more concrete. Their initial statement, "If I am bored", evolved into several different contexts: "If I've been scrolling for more than 15 minutes"; "If I see content that triggers me"; "If I am already in front of a screen"; and "If I feel the need to post". This process shows how the feeling of 'boredom' can be broken down and differentiated into numerous distinct behavioural contexts, which are more detailed in location, timing, and precise desires or triggers. In the post-workshop survey, 12 participants (80%) agreed with the statement "Creating if-then statements was helpful for thinking about behaviour change".

In the debrief session, multiple participants described the intensive thinking and reflection as key benefits of the DIY approach to behaviour change. P19, from the *Eating* group, said that *"the thinking preparation required [you] to sort of really understand what is the behaviour and why it is important for you to change it on a personal level"*. P8 added further detail to this idea:

So before I start this intervention, I really just have, well, a super rough idea. Oh, I need to be more fit, just the idea of being fit... without thinking about: Oh, how can I be fit? How do you define it and what kind of status means fit and or, you know, in what schedule and also the time span, how long do you want to achieve your goal? So so many things I didn't think about." P8, Exercising

5.2 Approximating Specific Context with Automated Triggers (Path B)

Following the articulation of their intentions and plans for behaviour change, our participants had to translate an implementation intention into a trigger-action automation. The 'if' component was approximated by contextual triggers (Path B in Figure 4), sensed by a mobile device, and the 'then'

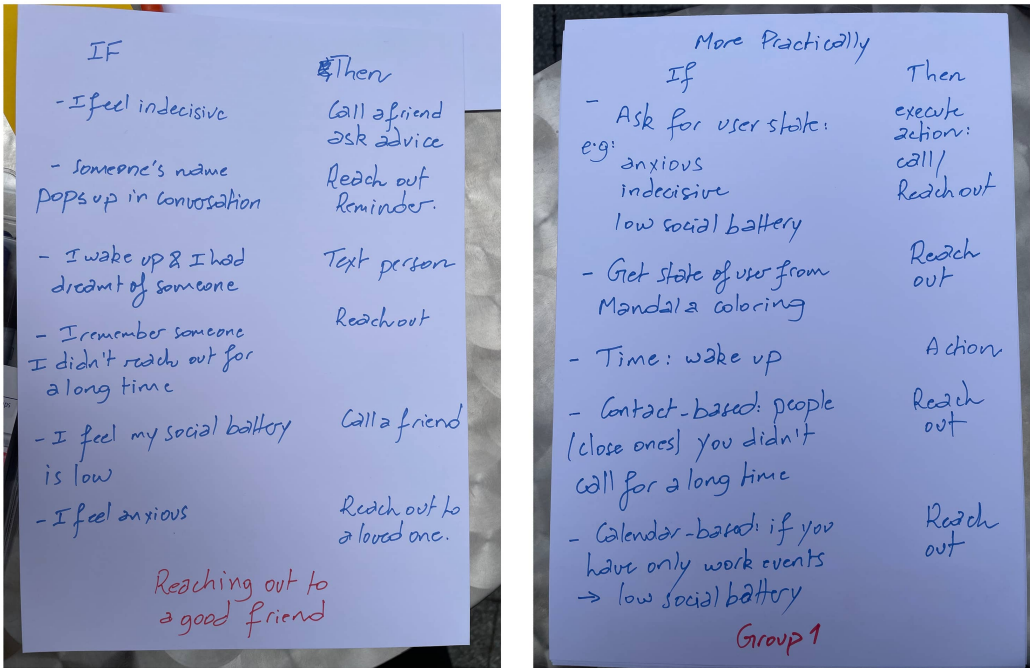


Fig. 8. When asked to think about how they would find “digital proxies” for their behaviour plans, the Checking in With A Friend group rewrote their implementation intentions to be more ‘practical’ and specific.

component was approximated by automated actions available within the programming interface (described later in [subsection 5.3](#)).

Overall, 10 (67%) participants agreed with the statement “The application was a useful tool to target the behaviour”. While it was relatively straightforward to define a suitable trigger for some behavioural contexts, it was much less trivial for others. For example, digital behaviours, such as spending time on a social media app, can be easily approximated with the digital trigger of opening that particular app. However, many of the participants’ ‘if’ statements referred to more intangible, internal states. Of the three participants who disagreed with the statement above, two were targeting *Self-compassion* and one was targeting *Procrastination*. In such cases, participants had to identify tangible parameters of more abstract feelings and emotions, such as certain associated activities, people, times and locations.

The final interventions designed by our participants deployed many different triggers to approximate certain contexts. We describe the following types of triggers with examples; time, environment, body, digital, social and literal articulation.

5.2.1 Time contexts and triggers. Many groups identified *time* as a trigger for certain behaviours. For many, this involved a particular time, such as 8.30 am, to proxy when they wake up, or 9 pm, to proxy going to sleep. While simple and regular, people often do many different activities at the same time of day, so the trigger cannot adapt well to changes in routine.

Alternatively, other groups utilised time relative to another event as a trigger. For example, the *Checking in with a Friend* group conceptualised a trigger which detected how much time has

passed *since* contacting a particular friend. The *Procrastination* group used the trigger of time *until* a deadline.

Several groups wanted to use the density of events within a calendar time frame as a trigger. Both the *Meditation* group and the *Checking in with a Friend* group thought the number of events in the calendar could approximate having 'low social battery', or 'busy times'. The *Exercising* group conceived that a gap in the calendar, such as a cancelled meeting, could act as a trigger for a time to exercise.

5.2.2 Environmental contexts and triggers. Several groups envisioned that their *location and environment* could act as triggers for their automation. The *Meditation* Group conceptualised an automation triggered by being in their local park. Furthermore, they used sound detection to detect if their dog barked, adding further contextual detail.

The *Procrastination* group wanted to reduce their use of certain apps while at work, and hence wanted their work location to act as a trigger. They saw connecting to their work Wi-Fi as a close proxy for this. Similarly, the *Eating* group envisioned shopping for food as an important context for their target behaviour and subsequently thought that detecting their location as being at the grocery store was an appropriate trigger.

The *Exercising* group thought it could be possible to use weather as a trigger; good weather could trigger a reminder to walk to their next destination, rather than take public transport.

5.2.3 Bodily contexts and triggers. Several groups wanted to pick up on *internal, bodily contexts* to trigger their automation. The *Self-compassion* group thought that they could proxy feelings of stress and hurt by triggers such as an elevated heart rate or poor posture. During the debrief session, P15 from the *Eating* group described finding it "*hard and challenging.... to think about the complexity of eating regularly, and how to capture a shortcut. For me, eating regularly doesn't mean that I eat at certain or specific times, but that I eat when I'm hungry.*".

5.2.4 Digital contexts and trigger. Some participant used *events that occurred on their phone* as a trigger for their automation. For example, the *Social Media Use* group and the *Procrastination* group used the opening of the Instagram application to trigger their automation. The *Sleep* group conceived that low battery levels could be used as a proxy for it being time to go to sleep.

5.2.5 Social contexts and triggers. *Social and interpersonal factors* were sometimes perceived as critical for behavioural contexts. For example, the *Overthinking* group identified that their rumination could be triggered by their partner changing their plans. In the debrief session, P5 discussed how their exercise routine (which was the focus of their overthinking) was largely determined by their partner.

"When I go to the gym, it also depends on my partner because we are going together. I don't really like to go by myself and just hang around by myself. So if he's not going, then I'm also not going." P5, *Overthinking*

Even though participants were creating interventions on their individual, personal mobile devices, they imagined ways to integrate social contexts as a trigger. As already discussed, the *Checking In With a Friend* group conceptualised a trigger which detected how much time has passed *since* being in contact with a particular friend, as well as a lack of social calendar events. Other examples could include the detection of close proximity to a friend's phone, or having shared tickets to an event.

5.2.6 Literalising contexts as a trigger. Rather than find a contextual proxy, some groups envisioned they could *articulate their mental state and behaviour context*, and literally input their intention into the system. For example, the *Overthinking* group suggested that when feeling low energy, they

could simply say "*time to slow down*" and use voice detection to translate this into a trigger for an automation.

5.3 Approximating Specific Behaviours with Automated Actions (Path C)

While an automated trigger has to capture the specific context of behaviour, an automated action has to bring about a particular behaviour. This process is described in paths C and D in the BC-TAP model. This section describes Path C, where the automated action tries to initiate a response or an activity in the user. Different people and different behaviours will respond differently to particular interventions. For example, while one person may only require a simple notification to make them go for a walk, another person may need a route generated for them, with an expected duration, and a friend to accompany them.

The number of different features available in TAP tools means that there are many ways to nudge an individual towards a behaviour. Reflecting on this diversity in the debrief session, P8 described Shortcuts as providing "*many different methods to achieve our goals*". Some of these methods may be more effective than others, depending on the target behaviour and the individual's preferences. When considering the statement "I believe my intervention would change my behaviour if I used it", six (40%) participants agreed, while five (33%) disagreed, with the rest being neutral. In the following section, we describe the different types of interventions, and how they may succeed or fail in nudging someone's behaviour.

We coded the different actions into four different types of action: *Suggestion*, *Encouragement*, *Simplification* and *Restriction*. The first three of these actions map closely onto the different 'Prompts' for behaviours described in the B=MAP model of behaviour change [17]: Signal, Spark and Facilitator, respectively.

5.3.1 Suggestion as an action. *Suggestion* refers to an automated action that involves sending a notification, reminder, or prompt to perform an activity. Importantly, this action merely presents a message or information and does not technically require the user to respond in a particular way. For example, the *Checking in with a Friend* group thought that their device could provide a reminder to call a friend. The *Exercising* group envisioned a notification to take a walk instead of the bus, or a suggestion to take an active work break when there was a gap in their calendar. The *Social Media Use* group envisioned a notification popping up after 10 minutes of using social media, suggesting that they close the app.

Users have a high level of control over how to respond to these suggested actions; they are free to act upon or ignore the suggestion. In the debrief session, several participants mentioned ignoring their intervention's suggestions (P5, P10, P14).

"I treated them as normal alarms when I wake up so I would just turn it off ... So at this point it didn't work because I didn't take it like seriously." P5, Overthinking

5.3.2 Encouragement as an action. *Encouragement* refers to an automated action which raises the individual's motivation to perform an activity e.g., through inspiration or social consequences. The *Eating* group envisioned that the automation could show them pictures of recipes to inspire them to cook. They also designed an automation which played a particular song which could motivate them to "listen" to their bodies' current hunger and energy levels.

In the debrief session, P32 in the *Overthinking* group described an intervention which automatically sent their partner a message, if they hadn't yet decided on a gym class to attend. Perceiving that they would like to make it "*more interesting*" for their partner, they then decided to add an "*unflattering selfie*" to this message. These social consequences act as an encouraging factor to engage with the intervention and the behaviour it is trying to bring about.

Compared to suggestion actions, these actions are explicitly designed to motivate or persuade them and hence may be harder to resist or ignore. However, P32 said "*it was really up to [them] to not lie*" when responding to their intervention; participants could still decide whether to entertain the positive elements or bear the "*embarrassing*" consequences designed into their automation.

5.3.3 Simplification as an action. *Simplification* refers to an automated action that raises the individual's ability to perform an activity by making it easier to perform. Primarily, these interventions would break down the behavioural activity into simpler sub-actions, and/or provide the means to achieve these sub-actions. For example, the *Eating* group created an intervention which pre-populated a healthy shopping list when it detected they were in a grocery store. The *Meditation* and *Sleeping* groups both designed an intervention which opened a blank document to support their reflection on the past day. The *Overthinking* group designed an intervention which generated a local route for a walk and would begin playing relaxing music to support the user in slowing down.

These interventions give the user a plan of action to achieve their behavioural outcome and utilise the system to make it easier to fulfil that action e.g. through opening a document or generating a navigation route.

5.3.4 Restriction as an action. *Restriction* refers to an automated action that blocks or prevents the individual from performing an activity. The *Meditation* group designed an automation which automatically turned off smartphone applications to help them 'be in the moment'. Restriction actions afford users less control than other action types, as the system is reducing their autonomy by blocking access to certain features. While many groups envisioned restrictive interventions, four participants desired a more strict intervention, which they couldn't bypass so easily.

"It would have been better if, instead of just showing a notification that it has been 10 min, the app will close automatically after 10 min." P21, Social Media Use

5.4 Approximating Behavioural Outcomes with Automated Actions (Path D)

Engagement (or lack of engagement) with an intervention is critical to its impact on a user's behaviour (path D in Figure 4). The participants reflected on the effect, or lack thereof, of their interventions in their everyday lives over three weeks. This longitudinal, in-the-wild approach is critical to understanding how DIY digital interventions may be able to adapt to the complexity of established and changing routines and break the stubbornness of real-life habits [1, 60].

We found that through both using *and not using* their interventions, the participants reported a) a greater awareness of their behaviours, b) their motivation to change them, and c) initial signs of breaking and creating habits. As observed by Bentvelzen et al. [3], the mismatch between a user's preferences and their well-being intervention can provide a moment for self-reflection and re-alignment. Importantly, the BC-TAP model suggests that users could channel this reflection into adjusting their intervention so that it better matches their needs. In the post-workshop survey, eight (53%) participants agreed with the statement "I will continue to change and improve my intervention in the future", while six disagreed. We describe a process of iterative 'conditioning' below, demonstrating how some participants adjusted their interventions to their specific behavioural context, while others didn't feel that had the skills or the motivation to do so.

5.4.1 Awareness of Behaviours. Several participants described their interventions as increasing awareness of their behaviour, a demonstration of descriptive reflection [1, 15]. For P22, they reported that "*the direct feedback worked really well*" to remind them that they had spent 10 minutes procrastinating on the social media app: "*Otherwise I just don't see, and time flies.*"

Participants recalled gaining an extra awareness of the timing and frequency of their unwanted behaviours, even if they did not engage with the automated action or perform the desired activity.

"Every day, at 9PM, I received a notification to write in my gratitude journal. But it didn't work, because every day I was there, but I was watching something, I was working on something, and I never actually paid attention to the notification, so just realised in the current set up, the current timing, it doesn't really work for me." P10, Gratitude

"I realised how often I actually end up in this in a situation where I don't go to sleep... I usually just wiped [the notification] away, so it was not effective for me personally, but it helped me with reflecting on how often I was actually in the situation." P14, Sleeping

Both P10 and P14 both found that they were often doing other things at the time they had set as a trigger for their intervention. This reveals the 'brittle' nature of their trigger – at the same time each day, the participants experienced changing desires and behaviours that they prioritised over fulfilling their target behaviour. Hence, the failure of a self-designed intervention can reveal the complexity of one's real-life behaviour with greater granularity.

'Conditioning' with new trigger-action sequences. During the trial period, some participants noticed that their intervention did not work as they had expected, and formulated new automations which captured more of their behavioural complexity.

One participant envisioned that *"instead of [their intervention] having a hard cut, to make it a bit more progressive"* (P22, Procrastination). To achieve this, they made their intervention have three sequential stages of actions after being on Twitter for a certain amount of time; first, they receive a reminder to break down their tasks for the day, then, after an additional minute, a productivity app fades in, and then after another 30 seconds, the Browser window with Twitter fades out.² The progressive stages of this intervention use passing time to 'condition' the actions of the intervention, and better adjust it to the user's needs.

Participant 32 said they had *"made quite a few changes over the past couple of weeks"*. These changes involved adding different 'if' statements to their automation, as shown in the second automation in Figure 2. For example, they expanded their intervention through another iOS shortcut which messaged their partner if they connected to the gym Wi-Fi.

Originally a member of the *Exercising* group, during the trial period, Participant 8 realised that they did not need their intervention as they *"already have the routine of going to the sports center"*. Revising their goals, they created a new intervention to encourage productivity ahead of an upcoming deadline.

Iterating the trigger-action automation requires skill and effort. P10 mentioned that in the future they would like to reduce the barrier to iterating their automation, by developing *"more hands-on experience with Shortcuts, so that [they] can implement changes immediately and effortlessly when [they] need to."*

To be motivated to engage with and iterate their intervention, a person needs to remain motivated to change their behaviour. The following sections describe how living with the self-designed interventions increased participants' awareness of their motivation, or lack thereof, to engage with the automation or to change their behaviour generally.

5.4.2 Awareness of Motivation. Reflecting on why the intervention failed to work for them, several participants mentioned motivation as an obstacle. P10 described realising that they were not yet committed to regularly reflecting on gratitude.

²P22 created this intervention using an additional automation application called 'Shortery', available on Mac.

"I am not close to really believing [that] I should be doing these things every day and it will eventually help me. So I still feel some distance between me and the behaviour." P10, Gratitude

Several participants (P5, P19, P21) felt that the impulse or motivation to change one's behaviour should 'come from inside', rather than from technology. Reflecting on their previous experience with quitting smoking, P21 said:

"I don't think technology would have helped me with that. It's really needed to come from me and do it by myself." P21, Social Media Use

This may be due to a lack of social motivation given by the technology: P5 said that they "need someone to like push [them] into this direction", and that they "don't really care about this technology", so it cannot give them the "social input" they need. This was particularly because P5's exercise routine was largely defined by their partner, which provided a stronger source of social motivation than the digital intervention.

On the other hand, P19 recognised that behaviour change is inherently challenging, and this made them feel more determined to persist with the DIY approach.

"I think, one of the reasons I gave [TAP] a go for longer, just so that I can recognise that, you know, this is the behavior I'm trying to work on, and in order to do so, it is not going to be sort of smooth sailing from the get go, to try and shift certain behaviors." P19, Eating

5.4.3 Breaking and Creating Habits. The breaking of old habits and the creation of new habits is an important aspect of behaviour change [50], and is one of the outcomes of transformative reflection [15]. Regular behavioural habits are more likely to be repeated, and hence, make a significant contribution to broader, long-term behavioural outcomes.

Describing the effect of their intervention on *Social Media Use*, P21 reflected on how the reminder had helped them automatically 'know' when 10 minutes had passed. This instinctive knowledge suggests the creation of a new habit, reducing the strength of the old habit of staying on social media for longer than 10 minutes.

"Just having it every 10 min was helping, and after a while, I kind of knew it was 10 min, and I could close it without seeing the notification, which was good." P21, Social Media Use

P32 described 'spill-over' effects of their intervention on their wider routine. Their intervention targeted overthinking behaviour in the context of choosing a gym class. They found that by quickly choosing which gym class they would take each day, led them to develop a more structured weekly routine.

"Because it's helped me be more deliberate about deciding on which class to pick, I found that I just ended up starting to develop a routine, like, Monday, I know I'm doing this class... like Tuesday, I'm taking this class. And then I found that it actually started influencing how I schedule things around it. And it actually helped me become a little bit more structured with my days." P32, Overthinking

P14 found that their bedtime intervention failed to stop their Instagram usage, partly because it required them to be on their phone, which increased their likelihood of going on Instagram. Subsequently, they decided to "switch to an analog" alternative, and created the new habit of turning to a book before bed, rather than activities on their phone.

"I also started reading again... I think that's the most effective thing – to just not open up the laptop or the smartphone and just grab my book and read... So maybe I shouldn't focus too much on the automation, but more on enjoying my book." P14, Sleeping

6 Discussion

With generic DBCIs often failing to accommodate people's complex and changing behaviour change goals [6, 28, 29], previous research has highlighted the need for DBCIs which can accommodate multiple goals which change over time [1, 47]. Taking this, along with the evidence that people prefer to personalise their interventions [43] and can benefit from building interventions themselves [35, 52], our research provides a new method and early evidence in which people demonstrate their ability to conceptualise, build, and trial their own DBCIs on their mobile devices.

6.1 DIY personalisation and iteration require significant motivation

As in the Tracker Goal Evolution Model [47], the BC-TAP model describes how people must approximate their abstract, qualitative goals with specific technological goals. However, the BC-TAP approach suggests that people can even design and determine how these technology interventions detect and act upon their behaviour. The participants created highly idiosyncratic interventions, such as sending an unflattering selfie to a loved one, playing a favourite song, or generating a walking route in the local vicinity. DIY digital interventions can embrace the constellation of people, places, and media which matter most to an individual and their behavioural goals. Our participants also played with different levels of restriction and control in their interventions, with some preferring complete blocking of their undesired behaviours, and others preferring automated actions which encouraged or simplified their target behaviour [29].

Some of our participants became more aware of their behaviours, such as the opening of a social media app (descriptive reflection), and the reasons for these behaviours, such as a lack of motivation or reliance on others in their motivation to exercise (dialogic reflection). Our participants also demonstrated moments of transformative reflection, by reporting a change in their routines, or taking a new approach to changing their behaviour, such as reading before bed [1, 15]. Critically, with a DIY approach, if it becomes clear that the system's actions are not triggering the desired behaviour, the individual has the opportunity to change the intervention, their behavioural goals, and their understanding of themselves. Hence, the DIY approach suggests that reflection can also be directly channelled into changing a DBCI, pointing towards the potential for a dynamic adaptation between an individual's goals and their DBCIs.

The DIY approach may also evoke a feeling of psychological ownership [11] and the 'IKEA effect', where the individual places higher value on something they have built themselves [52]. On the other hand, the DIY approach also requires extensive investment and effort from the individual. For some participants, this effort acted as a barrier to creating, iterating or even engaging with their DIY interventions. While some participants ignored their intervention or found that it didn't work as expected, others reflected on these failures to identify the 'missing ingredient' required to change their behaviour, whether that be social accountability, internal motivation, or a completely analog approach to behaviour change (such as reading a book before bed). Hence, the DIY approach follows the advice in Karkar et al. [27] that single-case experimentation tools should be "prepared to fail and designed for failure".

6.2 The future of the DIY approach to DBCIs

There are multiple avenues to build upon, improve, and extend the DIY process for DBCIs, for research and for end users. First of all, further research is needed to get a better understanding of which behaviour change goals DIY approaches might be most suitable for. Most participants in this study found it easier to find automated triggers for digital behaviours, such as social media use, or online procrastination, than for offline and/or embodied behaviours, such as sleeping and eating, or more ephemeral psychological states, such as feeling overwhelmed or practising gratitude. As

well as identifying which behavioural goals may be best suited to the DIY approach presented in this paper, future research could also look to improve and extend the TAP protocol and resources (toolkit, tutorials etc.) so to make them more adaptable to any behaviour change goal.

For example, future TAP protocol or tutorials could provide people with relevant information and inspiration to build their interventions to address a specific behaviour, as done in Lee et al. [35]. Before creating their designs, the participants in this study were taught several strategies for improved sleep, including reduced caffeine consumption and napping [35]. Future research could combine the BC-TAP approach with more evidence-based advice for behaviours such as stress management, diet, or exercise. Secondly, TAP toolkits could be expanded to include an even greater palette of features for DIY design. For example, making it possible for a TAP sequence to force an application to close, easing the need for self-discipline, which some participants in our study found challenging (e.g. see [subsubsection 5.3.4](#)). Beyond the smartphone, sensing and actuation devices, such as wearable devices, IoT devices, or even brain-computer interfaces [70] could be made available for trigger-action programming and allow a more direct approximation of bodily and mental triggers and actuation. However, with an increasing feature set, it is also important to help users navigate the options available to them. Future research could look to develop and improve the TAP tutorials and Trigger-Action cue cards to aid users when engaging with this complexity.

Finally, our work suggests that people could also benefit from creating and implementing digital interventions with their peers. Thus, DIY digital intervention initiatives could be tailored to and conducted in existing communities, such as schools, workplaces, maker spaces, support groups, or gyms, and facilitated by behavioural professionals. This would also help address the challenge that, in contrast to many DBCI apps, DIY digital interventions cannot be easily downloaded and installed, and therefore such initiatives might help raise awareness of the approach, provide support and guidance, and foster its impact.

However, as it might sometimes be too time-consuming, expensive, and too complicated logistically to get people to get together and build DBCIs with peers in such workshops, this raises the question how to scale the DIY approach with personalised and context-aware guidance and support. One opportunity is to develop conversational assistants and interactive tutorials that might use generative AI to provide structured yet highly personalised guidance for users hoping to change their behaviour using DIY DBCIs (see for example [25]). These assistants could not only provide relevant ideas on what might characterise current and desirable behaviour but also ‘brainstorm’ with the person, elaborating on how a current behaviour could be recognised by a device and which actions could foster the desired behaviour. However, while this may make it easier for an individual to create a DBCI with TAP, this could undermine the potential privacy benefits of the DIY approach, as well as the psychological ownership and IKEA effects [52]. Future research should thus examine how the advantages of using natural language assistants and tutorials based on generative AI might compare to these potential disadvantages [20].

6.3 Methodological Limitations

It has been argued that, for HCI research, it is more important to assess the users’ experiences of an early-stage technology, than to ascertain a clinical effect [31]. The large body of research which approaches BC through a quantitative lens has left some of the opportunities and considerations related to individualisation and adaptation of DBCIs unexplored. Furthermore, the challenges of quantitatively evaluating single-case, self-experimentation approaches for wellbeing are well documented [26, 27]. Hence, in line with our goal to better understand how people would create and adapt their own personalised interventions, we refrain from a quantitative assessment and instead present a qualitative account of the process by which our participants identified behaviours

to change, and conceptualised, built and evaluated their personalised interventions. Furthermore, quantification of behaviour change is a design choice, and we wanted to see what participants would create with TAP without being forced or primed to quantify their behaviour in some way. As the findings showed, some participants changed how they defined their desired behaviour, which would make quantitatively measuring success difficult.

Our participants include a highly educated sample of PhD students, with at least some familiarity and experience in computing and interaction design. While TAP is more accessible than other programming languages, a degree of technical ability is still required for the BC-TAP approach. While this study proposes a method to facilitate the creation of DIY interventions, future work should assess how people without a technical background may create and evaluate their own digital interventions for behaviour change.

The in-the-wild trial period lasted three weeks with the aim to get insights into sustained use and adaptation of the interventions and changes in behaviour. Nevertheless, three weeks may not be long enough to understand long-term use and lasting changes in behaviour.

There was considerable participant attrition after the in-person workshop, with just over half of the participants completing the post-workshop survey, and a third attending the debrief session. This drop-out could have biased the results to some extent. For example, a participant's enjoyment or success during the process of creating their DIY intervention may affect their motivation to continue using their intervention and participate in the study. Future research must balance the benefits of sustained participation due to compensation structures with the effect of demand characteristics, which could also bias results. Larger sample sizes will be important in this process, as well as identifying and standardising meta-measures such as self-efficacy, which are independent of the behaviour change goal itself [8]. This is critical as people's behaviour change goals are constantly changing, and the BC-TAP approach hopes to support this process, rather than stifle it.

7 Conclusion

Changing behaviour can be critical to achieving desirable health and wellbeing outcomes. Rather than rely on generic digital behavioural interventions, which often fail to adapt to individuals' changing needs and goals, we show that individuals can conceptualise, build, and evaluate their own digital interventions. We contribute the novel BC-TAP model describing the stages of designing DIY digital interventions and explore the opportunities and challenges of this alternative approach using participatory design. While our early findings suggest the DIY approach may work better for certain people and behaviours than others, more research is required to uncover its full potential. Our approach and empirical findings can inform future research and initiatives focused on empowering people to change their individual intention-behavior gap, and get to know themselves better along the way.

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