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Building Habits in the Digital Age: Incorporating Psychological Needs and Knowledge from Practitioners to Inform the Design of Digital Therapeutics

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Research Paper

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Abstract. Interventions for noncommunicable diseases (NCDSs) often require changing behaviors. In this regard, habitual behaviors (i.e., habits) are positively evaluated to foster behavioral changes. Forming habits is challenging but can be supported digitally. This paper reviews the requirements of forming habits and investigates how these requirements are implemented in habit apps. Based on the results, design principles are discussed for digital therapeutics. In contrast to conventional apps, digital therapeutics have a medical purpose and can be prescribed for the time it needs for a habit to form. The results reveal that conventional apps try to bind the user and ignore the state where the habit needs to be strengthened by decreasing technology use. In this regard, digital therapeutics reveal potential in supporting the formation of habits to prevent and treat NCDs.

Keywords: Behavioral Change, Digital Therapeutics, Habits, Habit Apps, Noncommunicable diseases

1 Introduction

Noncommunicable diseases (NCDs), such as diabetes, obesity, and cardiovascular diseases, are the most significant cause of death, accounting for 74% of all deaths worldwide (WHO 2020, 2023). Many of the deaths are lifestyle-related. For example, more than 20% of worldwide deaths are associated with dietary factors (e.g., high in sugar-sweetened beverages) increasing metabolic risks (e.g., high body-mass-index; Afshin et al. 2019). After the onset of chronic disease, therapy programs focus on limiting disease progression and positively influencing the disease trajectory by taking appropriate treatment steps. Thereby, it is crucial for the treatment success that the care plan is adhered to and lifestyle behaviors associated with the pathogenesis are changed (Aboumatar et al. 2022). The digital transformation in healthcare opens potential to support these behavioral changes with so-called “Digital Therapeutics” (DTx).

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DTx are software applications that, in contrast to conventional apps, treat, manage or prevent a concrete disease or disorder (DTx Alliance 2022) and that are designed for patients as end consumers (i.e., patient-facing; Sim 2019). From a broad IS perspective, DTx can be considered as instances of "virtual coaches" that promote health behavior change toward a certain goal (Fürstenau et al. 2023; Weimann et al. 2022). Recently, health insurance companies have begun reimbursing DTx, with Germany taking a pioneering role through the introduction of the "DiGA" (Gerke et al. 2020). While DTx holds potential for stimulating and maintaining health behavior changes, long-term evidence remains elusive (Beleigoli et al. 2019; Craig et al. 2021). In this regard, prior research indicates that conventional interventions focus on intentional psychological processes required to adopt new behaviors yet fall short in aiding the transition of these behaviors into automated, subconscious habits that seamlessly integrate into daily routines (Lakka et al. 2022; Vogelsang et al. 2022).

A habit is an automatically executed behavior in a specific context due to its consistent and repeated occurrence within that context (Lally et al. 2013). In contrast to overwhelming goals such as walking 10.000 steps per day, habits are manageable and seamlessly blend into daily routines. Habits are implemented by repeatedly performing a behavior in a context so that a cognitive link between behavior and context is created (Neal et al. 2006). For example, seeing a fruit basket (context) may foster healthy fruit intake (behavior). When the behavior is repeated in the same context, the cognitive link strengthens, leading to a strong, automatically executed habit (Gardner 2015). Information Systems (IS) in general, and DTx in particular, can be vital in forming habits by providing the necessary support for sustained adherence. While habit formation mechanisms have become increasingly popular in conventional "lifestyle-optimization" apps for the general healthy population, their use in professional medical care is still in its infants (Lakka et al. 2022; Stawarz et al. 2015). This paper aims to harness the potential of IS and DTx in successfully forming habits that tackle NCDs (Rippe 2018). In doing so, we follow the design science paradigm (Hevner et al. 2004; Peffers et al. 2007) to explore how habits can be formed. We contribute to the body of design literature for DTx by proposing design principles (DPs) for habit-based DTx and hence answer the following research question: *Which design principles could enhance the formation (i.e., implementation and strengthening) of habits within DTx?*

By following the design science procedure outlined in (Peffers et al. 2007) we conducted a literature review on literature in psychology and human-computer interaction (HCI) to determine meta-requirements (MRs) for implementing and strengthening habits (section 2). Additionally, we examined habit apps employing a content analysis to learn from conventional habit apps and hence add to the MR (section 3). Section 4 proposes the design principles, discusses limitations and future research.

2 Requirements for Implementing and Strengthening Habits

This section aims to provide a background on prior research in psychology and human-computer interaction (HCI) related to habit formation and its digital support to extrapolate MRs for effective app design. Previous research defines habits as a memory-based

tendency to automatically respond to a specific cue acquired through the repetition of the behavior in stable contexts (Verplanken et al. 2006, 2018; Wood et al. 2007, 2009). The first part of this definition characterizes habits as automatic behavior in response to a particular context. For example, the context of seeing a fruit basket in the kitchen may prompt the behavior of fruit intake. Once the link between the context and the behavior becomes strong, through constant repetition, the behavior is likely to be executed automatically (Gardner 2015). Although it is not inevitable, it now requires effort to resist and act in a way that is counter to the habit (Wood et al. 2009).

The second part of the above definition describes the process of how habits form. Prior psychology research details the habit formation process into four stages (Lally et al. 2013; Figure 1): In the first stage, a decision to take action is made. Typically, an intention is formulated for the new habit that serves as a foundation for its implementation. During the second stage, the intention transitions into action, enabling an initial assessment of the habit's advantages and disadvantages. This assessment informs the subsequent decision to maintain or abandon the habit. To solidify the habit, the behavior is repeatedly performed in the same context in stage three (Lally et al. 2010). In this stage, the focus shifts from defining and testing the habit to strengthening it. In the fourth stage, the new action is repeated in a fashion that is conducive to the development of automaticity, including creating salient cues, reducing behavioral complexity, and avoiding extrinsic rewards that have the potential to hinder the habit-formation process (Lally et al., 2013). In the following, we describe i) the individual stages of habit formation and ii) discuss digital strategies that have the potential to support these stages.

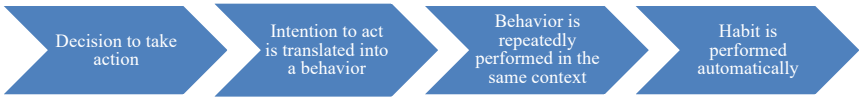

Figure 1. Stages to habit formation according to (Lally et al. 2010, 2013)

2.1 First Stage: Decision to Take Action and Formulation of an Implementation Intention

In the first stage, a decision is made to take action (Lally et al. 2013). To support decision-making for a potential habit, a typical strategy is information provision (Webb et al. 2010; Nilsen et al. 2012) aimed at providing data that can alter users' decisional balance (Pinder et al. 2018). Typically, information is related to statistics on positive or negative health outcomes. Information provision has demonstrated a (small) impact on behavior change, as shown in a meta-analysis (Anker et al. 2016).

MR1: Information should be provided to enable informed habit selection.

After choosing a habit, an implementation intention for this habit needs to be formulated to create a first mental association between the behavior and the context (Lally and Gardner, 2013). For example, an implementation intention might involve associating the context "**if** *I am on the bus for work"* with the behavior "**then** *I will get off one stop earlier and walk*".

MR2: The process of formulating an implementation intention should be supported to effectively link the context to the behavior.

To help remember the habit in a later stage, it is essential to feasibly describe context-specific cues. Typical contexts include physical settings (kitchen), time (9 a.m.), people (alone), prior behavior (getting up), internal state (being stressed), and combinations thereof (Ji et al. 2007). To facilitate remembering the habit, the context-specific cue should include all aspects as necessary to distinguish the context (Stawarz et al. 2020).

MR3: A detailed contextual specification should enable remembering the habit.

2.2 Second Stage: The Intention to Act is Translated into Behavior

After deciding on a habit and formulating its implementation intention, it must be translated into a behavior (Lally et al. 2013). The user can integrate this habit into their daily routine to assess the experience of executing it and determine if any modifications are required in the selected context (Stawarz et al. 2020). In this stage, digital strategies encourage repeated behavior, providing sufficient time to determine whether to sustain or abandon the habit and adjust and enhance the implementation intention (Stawarz et al. 2015). Furthermore, repeatedly executing the behavior in the context helps foster the mental association between the behavior and the contextual cues (Wood et al. 2007; Lally et al. 2010). In this stage, prior HCI literature highlights strategies to provide trigger events that serve as cues and help maintain repetition (Stawarz et al. 2014). Such digital strategies include visual cues or reminders on the smartphone's home screen. Typically, just-in-time reminders (Stawarz et al. 2015) are used when the system predicts that the user may be at risk of developing bad habits or is missing opportunities to execute good habits (Nahum-Shani et al. 2018; Pinder et al. 2018).

MR4: Trigger events should be used as cues to maintain repetition.

2.3 Third Stage: Repeating the Behavior Consistently in Response to the Context

After deciding to implement a habit and optimizing the implementation intention, the habit must be strengthened (Lally et al. 2013). This strengthening occurs when the behavior, prompted by a specific context, is consistently and repeatedly performed (Verplanken et al. 1999; Wood et al. 2009; Lally et al. 2013), allowing to strengthen the mental association established in the implementation intention. Once the habit is strengthened, the cognitive effort required to act decreases, and the habit becomes second nature (Lally et al. 2011). Alternatives (*staying on the bus*) become less accessible (Danner et al. 2007, 2008). Hereby, the repetition strategy of the previous stage should be phased out and abandoned at the end of this stage. In this stage, the use of reminders as trigger events is criticized as they might only maintain the habit at a superficial level (Stawarz et al. 2015). One argument is that the behavior is likely to be abandoned once

the technology fosters it is not used anymore (Pinder et al. 2018). To strengthen the habit, reminding should not be used as a trigger event sent at the moment of habit execution. Instead, it should reinforce the implementation intention (Stawarz et al. 2015). In this regard, notifications are sent, for example, in the morning (e.g., when I take the bus to work later, I will remember to get off a station earlier and walk) (Stawarz et al. 2015). This kind of reminder encourages the user to recall the behavior later when the context arises. The following two MRs on habit formation can be derived from this.

MR5: Reminders should be used to reinforce the implementation intention instead rather than solely functioning as trigger events.

MR6: Reminders should phase out so that users do not become reliant on notifications.

Nowadays, users receive many reminders and visual cues (Pielot et al. 2018). Therefore, solely using reminders and visual cues may be insufficient to prompt the repetition of habits or reinforce the implementation intention. Other digital strategies are consequently also needed for a complementary application with reminders. Overall, supporting the individual's internal self-regulatory processes plays a key role in stages two and three (Lally et al. 2013). According to Bandura's social-cognitive theory, self-regulation is a process consisting of three subfunctions: Self-monitoring, self-judgment, and the resulting self-reactions (Bandura 1991). Particularly self-monitoring support is a common ingredient of behavior change interventions and is considered in tandem with feedback (Michie et al. 2013). With regard to the stages of habit formation, self-monitoring is applicable across the second and third stages. In contrast, feedback is most applicable in the third stage when the actual behavior is executed (Lally et al. 2013). Self-monitoring captures information about behavior and often reveals previously unknown information to the user (e.g., visualize the number of steps during a day; Thaler and Sunstein 2009). According to Bandura (1991), feedback can stimulate self-regulation by providing information about "how one is doing" when monitoring alone is insufficient to get evidence of the individual progress. Obtaining feedback by being praised for executing the behavior (e.g., in the evening, when checking for habit adherence) can associate the behavior with a positive feeling and, with that, reinforce the behavior. Furthermore, praise can also be used to reinforce the implementation intention by repeating it, such as "*Congratulation, you have done your 7-minute workout after brushing your teeth this morning! Well done*.". To promote self-regulation, recent IS literature also discusses the concept of gamification, i.e., the application of game characteristics to non-game contexts (Deterding et al. 2011; Deterding et al. 2011). For example, to promote an individual's self-judgment and "intervention stickiness", apps include levels of difficulty or specific challenges (Hervas et al. 2017).

MR7: Facilitating self-regulation processes in the form of self-observation, self-assessment, and self-reactions should make an important contribution to translating the intention into the targeted behavior, but also to maintaining repetition (stage 2) and maintaining repetition and reinforcing the behavior (stage 3).

2.4 Fourth Stage: Reaching Automaticity and Abandoning Technology

In the fourth stage, the new habit is repeated in a fashion conducive to the development of automaticity (Lally et al. 2013). This stage includes creating salient cues for the activity, emphasizing consistency, reducing behavioral complexity, and avoiding extrinsic rewards that have the potential to hinder the habit-formation process (Lally et al. 2013). Hence, digital strategies used in the previous stages must be reduced and finally abandoned (Stawarz et al. 2014). This doesn't mean that the technology should not be used anymore, but that gamification, praise, and reminding should be avoided for the particular habit, which now reaches a higher level of automaticity. Instead, the technology may still be used to introduce new habits and to have an overview of the overall habits that have been implemented and strengthened. Such an overview may help the user to review their lifestyle annually or biannually and adjust accordingly, e.g., by altering existing ones. Furthermore, strong habits can serve as contextual cues for new habits. Using strong habits as a contextual cue for newer ones has been extensively discussed in the self-help literature as habit stacking (e.g., Clear 2018). In this regard, a new habit is added to another, serving as a contextual cue for the new one.

MR8: The habit that is about to gain automaticity should not be reinforced by technology anymore.

MR9: Strong habits should be used for habit stacking.

3 Content Analysis of Habit Apps

3.1 Design

To add knowledge of conventional habit apps to the requirements of section 2, this paper employs a content analysis according to Krippendorff (2018). To determine the sample, we used an API-based approach analog to (Catozzi *et al.* 2020; Richter *et al.* 2021) to investigate apps available on the Apple App Store for iOS devices. We refrained from including the Google Play Store as this platform does not support the API-based approach. To create an API query, the following components needed to be addressed: the basic search layer, the URL-encoded search term, the ISO country code (DE), the media entity (software), and the number of results (50) per search term. The following search terms were used: *Habit, Habit Tracking, Habit Tracker, Pattern Tracker, Pattern Tracking, Streak Tracker, and Streak Tracking.* Applying the search term resulted in a total of 320 apps. After removing duplicates, 149 apps remained. Furthermore, 29 apps that exhibited an app score of zero were excluded. Subsequently, one author manually reviewed the remaining apps towards their ability to form habits and their applicability for various purposes. Apps that were serving a specific purpose (e.g., weight loss, increased fitness) and those that were used to limit device functionality were not included in the investigation. Sixty-four apps were marked as suitable, of which three needed to be excluded due to technical problems and four due to a paid version only. Ultimately, 57 apps were identified and selected for examination.

Subsequently, we used the meta-requirements summarized in section 2 to approach the first set of categories to analyze the apps. In this stage, 20 apps were evaluated by downloading and trying the app to assess all features the application has to offer. Each app was assessed by at least two authors. In total, five authors engaged in evaluating the apps. This approach helped to discuss the evaluation results and to determine further categories. The remaining apps were evaluated after agreeing on a final set of categories and clarifying the evaluation procedures. Any uncertainties encountered during the evaluation process were discussed to ensure consistency.

3.2 Results

The analyzed apps were assessed based on their adherence to the MRs, with the degree of fulfillment being classified into three distinct levels: Full compliance, partial compliance, and non-compliance with the MRs. When considering the provision of information (**MR1**), we observed that only 28% (16) of the 57 apps partially adhere to this requirement. An approach commonly used to partially adhere to this MR was categorizing habits into goals to facilitate information (e.g., HabitMinder 2022). **MR2** addresses the formulation of an implementation intention, linking the context to the behavior. This can be incorporated into apps by allowing users to describe the behavior and associate it with a specific place, time, or another behavior as a contextual reference. Only 19% (11) of the 57 apps partially fulfill this requirement. For example, Focus Habits Streaks Progress (2023) employ a question-based approach to guide users in formulating their implementation intention, while Success Coach - Life Planner (2023) additionally provides a diary to reflect on the context's appropriateness.

Within **MR3**, we examined the capability of integrating multiple contexts for habit implementation. Out of 57 apps, 72% (41) offer the option to incorporate two contexts, while only seven apps provide the ability to add even more contexts. The most advanced apps in this regard also use location as context (Habit - Daily Tracker 2023) and even allow for incorporating Apple Health data into the habit implementation phase (Awesome Habits 2023). **MR4** emphasizes providing trigger events, such as reminders, to facilitate habit repetition. For most apps, 96% (55 out of 57) enable users to set up reminders for specific dates and times for each habit. Notably, apps like (Daily Habits - Habit Tracker 2021) go even further by allowing users to personalize their reminder texts. **MR5** examines whether reminders are employed to reinforce the implementation intention rather than being solely used as trigger events. However, after evaluating the 57 apps, no indications of this particular approach were found.

MR6 introduces the concept of gradually reducing reminders in order to foster habit strength. This aspect was only partially found in a single app (Better Habits of Health 2021). This app implements a living progress action score, which indicates the completion of a habit. Once a desired score is achieved, users can either conclude the habit technologically or restart it if necessary. In **MR7**, additional digital strategies aimed at promoting habit repetition and reinforcement were examined. Self-monitoring, for instance, was facilitated through various tools such as visual progress bars, experience points, and picture elements. These self-monitoring tools were employed by a significant majority of the apps (53 out of 57; 93%). Furthermore, gamification elements were

found in 88% (50) of the apps. An example of gamification can be seen in Flora (2023) where figurative elements, like a growing plant, are utilized to enhance user engagement. In terms of positive reinforcement, praise is used by 61% (35 out of 57) of the apps. One example is Rabit (2022), which offers users motivational messages containing famous quotes as positive reinforcement.

MR8 aims to minimize extrinsic stimuli for habit execution so that the habit can strengthen. However, during the content analysis, no instance of phasing out extrinsic stimuli (0 of 57) without requiring any action from the user were observed. It seems that the apps did not proactively incorporate mechanisms to gradually reduce stimuli. **MR9** centers around leveraging strong habits as a contextual framework for introducing new habits. The goal is to create a synergistic relationship between habits, where existing habits provide support for the development of new ones. Out of the 57 apps, only 18% (10 apps) were found to meet this MR. Notably, best practice apps like (North Star 2022) strive to induce routines or milestones to facilitate the integration of new habits. However, none of the apps use already-formed habits to stack new habits.

During the first phase of the content analysis, additional categories were identified that did not directly align with the MRs. One such category is **flexible habit management**, which facilitates habit implementation. It was found that 81% (46 out of 57) apps offered this feature. In this context, flexibility was considered present when users could define parameters such as time and frequency per week. Notably, Awesome Habits (2023) provides a skipping function for habits, allowing users more flexibility in their habit routines. In terms of **avoiding information overload**, gradually introducing a variety of habits was a helpful approach to habit implementation. However, it was observed that 89% (51 out of 57) of the apps display all habits at once without aiming to avoid information overload. Partial fulfillment was given when targets were displayed on a daily basis. Another way to prevent information overload was introduced by *The Fabulous* (2023), who avoids overload by introducing habits step by step as a journey. Related to MR7, the content analysis revealed the utilization of **social interaction** as a means to reinforce habits. Among the apps, 23% (13 out of 57) allow users to include their social contacts. Furthermore, 37% (21 out of 57) of the apps enable users to share their habit successes with friends, fostering a sense of accountability and support. Additionally, a habit community feature was found in 26% (15 out of 57) of the apps, allowing users to engage with a community of like-minded individuals. Noteworthy apps such as (Habitify, 2022) and (Coach.me, 2019) incorporate these social interaction functionalities. Additionally, 56% (32 out of 57) of the apps allow users to set a **habit focus**. Partial compliance in this aspect was observed when apps provided the ability to mark habits with colors or group them. Approximately 32% (18 out of 57) of the apps offer grouping proposals. Another possibility to categorize habits is by distinguishing them into build and quit habits, which is implemented by 30% (17 out of 57) of the apps. To improve **usability**, the three categories of personalizing i) behavior, ii) context, and iii) the general app appearance were found. Personalization of behavior is implemented by six apps through initial short questions about the users' personal goals or preferences. Context personalization is possible with 61% (35 out of 57) of the apps. Only 54% (31 out of 57) of the apps allow contextualized time and date, and 7% (4 out of 57) contextualize additional content (Grow, 2023). The general appearance of the

app can be personalized, for example, by different color schemes or language settings. 61% (35 out of 57) of the apps offer at least one or several options (e.g., Today 2022). Figure 2 provides an overview of the results of the content analysis.

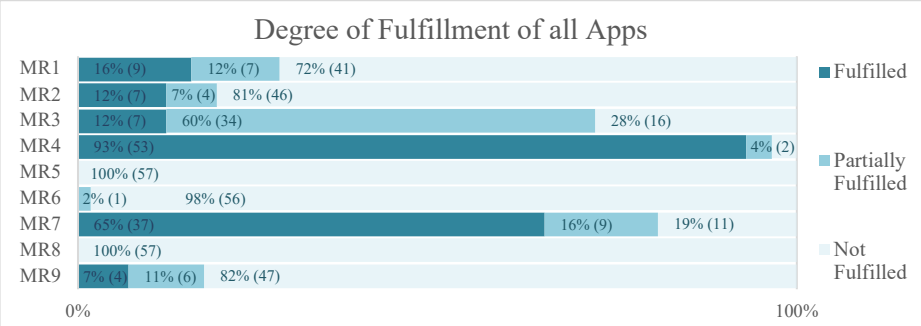

Figure 2. Overview of the content analysis results in regard to the meta-requirements (MR)

4 Discussion

This work summarizes prior research to form (i.e., implement and strengthen) habits. In accordance with a previous review of HCI research by Stawarz et al. (2015), our study has identified apps with the potential to support stages 1 and 2 of the habit formation process. However, none of the identified applications meet the requirements for strengthening habits at stages 3 and 4. Considering the proliferation of habit-forming apps since 2015 and the coverage of related topics in the self-help literature (e.g., Clear 2018; Wood 2019), we suspect the lack of technical support for habit strengthening is likely due to a lack of incentive. In fact, many habit apps follow a commercial interest, requiring the user to adopt the app continually (Krell et al. 2009). In contrast, forming habits, at some point, requires phasing out and abandoning technology (Stawarz et al. 2015; Pinder et al. 2018). Due to this contradiction, we also suspect that conventional habit apps may not be appropriate tools to implement and strengthen habits. With the rise of DTx, there is, however, a market that may allow filling this gap. To facilitate the design of DTx that have the potential to support implementing and strengthening habits, we now summarize design principles based on the MR and the insight we gained from using the conventional apps. These design principles are outlined in **Table 1**.

Stage 1 – Decision to act: Some apps investigated in the content analysis provided information on potentially beneficial habits to support the decision-making process on which habits to implement (Pinder et al. 2018; **DP1**). Beyond listing habits, some apps also categorized these habits into goals or journeys (**DP 4**). HabitMinder (2022) categorized habits into goals, while The Fabulous (2023) used journeys to reduce overload. When embarking on a journey (e.g., *mental fitness*), information for the next habit unlocks stepwise. In this regard, information overload by having too much information is reduced, and the user is guided to try out a new habit related to the selected journey one after another. Once the decision for a habit has been taken, an implementation intention

must be formulated (**DP2**). Such a formulation was possible in some apps (19%, 11 out of 57). However, hardly any app guided the user to link the behavior with the context in an implementation intention (Gollwitzer et al. 2006; Lally et al. 2013). For a precise specification of context (**DP3**) within the implementation intention, most apps allowed to specify time and date (72%, 41 out of 57), but only 11% (6 out of 57) of the apps included location (e.g., kitchen or bedroom as for example in Habio 2023). No app allowed to select prior habits (**DP 13**), or internal states (being stressed) as context. Combinations of contexts were supported partially in (Habio, 2023). The context may also vary for build or quit habits, so distinguishing these types of habits is important (**DP5**). Furthermore, this stage potentially benefits from personalizing the decision-making process of which habit to implement (**DP8**). In this regard, we found five apps that used questionnaires to narrow the selection of possible habits.

Table 1. Design principles for DTx; Stage 1 – Decision to act, Stage 2 – Intention to act is translated into behavior, Stage 3 – Behavior is repeatedly performed in the same context, Stage 4 – Habit is performed automatically; Origin MR-meta-requirement; CA-content analysis.

Design Principles for Habit-based DTx	Stages	Origin
DP1: Information should be provided to enable informed habitat selection.	1	MR1
DP2: The process of formulating an implementation intention should be supported to effectively link the context to the behavior.	1	MR2
DP3: A detailed contextual specification should enable remembering the habit.	1	MR3
DP4: Information overload should be avoided (e.g., by implementing a (habit-) journey or clear habit focus).	1	CA
DP5: Build (e.g., exercise in the morning) and quit habits (reduce coffee) should be distinguished.	1	CA
DP6: Flexible habit management should be allowed.	2-4	CA
DP7: Trigger events should be used as cues to maintain repetition.	2	MR4
DP8: Personalization should be enabled or offered at all stages.	1-4	CA
DP9: Comparison and feedback should be offered.	2-3	MR7, CA
DP10: Reminders should be used to reinforce the implementation intention rather than solely functioning as trigger events.	2-3	MR5
DP11: Reminders should phase out so that users do not become reliant on notifications (tapered reminding).	3	MR6
DP12: The habit that is about to gain automaticity should no longer be reinforced by technology.	4	MR8
DP13: Habit stacking options should be implemented by using strong habits.	4	MR9, CA

Stage 2: - Intention to act is translated into behavior: Once the habit is selected and an implementation intention is formulated, it needs to be translated into daily life. In this stage, digital support can provide trigger elements (**DP7**). Most apps use reminders via email or smartphone screen to trigger the habit. This stage may also profit from

flexible habit management (**DP6**). Some apps allow to detail habits as being due based on intervals or timeframes per day, week, or month or to skip habits in case of holidays or illness (e.g., Awesome Habits 2023). Furthermore, personalization may increase repetition in this stage by presenting users with customized reminders and notifications (**DP8**). Repetition may also be increased by providing comparison mechanisms (**DP9**). To effectively support self-regulatory processes, apps could provide mechanisms to enable a comparison with the user himself (self-comparison), other users (social-comparison), between groups (collective comparison), and/or to defined standard norms (Bandura 1991). Comparing the current behavioral performance or behavioral outcomes with these referential values also forms the foundation for providing dedicated feedback to the user via the app (Kramer et al. 2017). A special type of evaluative feedback is praise (positive feedback), which may be accompanied by (virtual) rewards such as trophies (Michie et al. 2013; Lehto et al. 2015). For addressing this DP, some of the analyzed apps leverage gamification design features such as leaderboards or social sharing (Habitify 2022) to stimulate a social comparison, but also badges or experience points (Daylio 2023) based on defined target norms. Particularly social comparison is a promising approach in the treatment of behavior-modifiable diseases (e.g., obesity or diabetes) where different strategies, such as upward, downward, or lateral comparison and comparison to other individuals or a group as a whole, underscore the need for personalization (see **DP8;** Arigo et al. 2021; Zhu et al. 2021).

Stage 3 - Repeating the behavior consistently in response to the context: In this stage, one strategy is to foster repetition as described in stage 2 (e.g., through **DP9**). Beyond fostering repetition, this stage also aims to reinforce the implementation intention (**DP10**). In this regard, reminders (**DP10**) and gamification (**DP9**) should be used to repeat the implementation intention so that the association between context and behavior can strengthen (Stawarz et al. 2015). To further allow the habit to strengthen, reminders as trigger elements should be phased out (**DP11**). Personalization in this stage may focus on finding an individual timeline to phase out reminders, e.g., by prompting notifications when the behavior hasn't been executed frequently and phasing out after the users have found their way back to the habit (**DP8**).

Stage 4 - Reaching automaticity and abandoning technology: To strengthen the habit, digital support must be abandoned so that the habit can integrate into daily life without relying on technology (**DP12**). However, technology may still help to implement and strengthen new habits. In this regard, the new habit may be stacked with a habit that is already strong (**DP13**).

This work has methodical limitations. For example, we focus on habit apps and not on to-do apps. While some to-do apps, such as (Todoist 2023), also allow the implementation of habits, TickTick (2023) explicitly focuses on implementing habits. We included these two apps as they have also been found using our search terms. However, we did not search for to-do apps. Furthermore, we excluded habits we could not test without paying for a subscription. When required, we entered a subscription and then canceled the subscription before payments became due. Based on this decision, we only

had a few days to explore the apps. A thorough investigation until the habits finally become strong may help investigate and ultimately weigh design principles. Furthermore, we excluded apps that only followed a specific focus (e.g., sleep, meditation) as we aimed to examine the mechanisms to implement and strengthen habits in general. Nonetheless, investigating apps with a specific focus may help formulate design principles that focus on quit habits. The paper also has thematical limitations. Firstly, the paper focuses on habit apps and their implementation in supporting behavior change for NCDs. While this focus allows for in-depth analysis, it may limit the generalizability of the findings to other types of interventions. Furthermore, concerning DP 12, it is worth critically reflecting on the usage of apps in general to reinforce habits. The content analysis reveals that apps foster reliance on technology to encourage continued usage. It would be valuable to compare the effectiveness of habit formation with and without technology, such as using hand-written habit scorecards (Clear 2018). This comparison would shed light on the role of technology in habit formation. This work is embedded in a broader project. After initially diving into the design of an effective habit app in Weimann et al. (2022), our goal is to bolster the development of habit-based DTx by a) offering effective DPs and b) establishing an open, AI-supported habit repository to aid in treating and preventing NCDs. This repository would be beneficial in particular to enhance stage 1 of the habit formation process.

5 Conclusion

This paper summarizes meta-requirements to implement and strengthen habits and executes a content analysis using conventional habit apps. Based on the requirements and insights from the content analysis, we formulated design principles for habit-based DTx. So far, conventional apps support mainly the first two stages of forming habits and hence help to decide on a habit (stage 1) and translate it into behavior (stage 2). However, for a habit to become strong, the behavior must be repeated consistently in response to the context without being triggered. Ultimately technology must be abandoned (Stage 3-4). So far, these two stages are rarely focused on by conventional apps. However, since DTx can be prescribed for the time, it needs for a habit to strengthen, these apps may contribute to forming habitual behavior that is directed toward long-term NCD prevention and treatment. From a theoretical perspective, the derived MRs and DPs provide a framework of the main “ingredients” of habit-based DTx and may facilitate deeper investigation of single aspects. On the practitioner side, our research could provide system developers and UX experts with a starting point for the conceptualization of novel habit-based DTx that may improve the self-management of NCDs.

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