Episodic Future Thinking as Digital Micro-interventions

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Abstract. Micro-interventions are quick focused behavioural interventions aimed at matching users' current capacity for engagement. Mobile devices are powerful, interactive, and sensor-rich platforms for delivering micro-interventions and for determining when and where to do so. This paper presents a novel smart-phone based approach to micro-interventions based on established 'Episodic Future Thinking (EFT)' research. The paper both presents the background for EFT-based micro-interventions and the design of an 'EFT' smartphone application implementing this. The approach and technology were evaluated in a feasibility study including 14 participants using the system for 14 days. Results demonstrate the feasibility of implementing EFT as micro-interventions, with participants willing to use the application, providing positive feedback and constructive suggestions. The paper concludes with a thorough discussion of the implications for smartphone-based EFT delivered as micro-interventions and how these can be used as part of a larger behaviour change and health improvement initiatives.

Keywords: Micro-interventions · mHealth · Delay Discounting · Episodic Future Thinking

1 Introduction

Self-management of a chronic illness is for many a long, arduous journey spanning decades of uncertain health outcomes and worries, where faraway consequences of smaller repeated gratifying behaviours seem less relevant. However, forgoing such seemingly minor gratifying behaviours, like being less sedentary, can have a large impact on long term health [26]. This underlying discounting of future outcomes has therefore been suggested as a therapeutic target for preventing transition from pre-diabetes to type 2 diabetes [18]. Despite the transition being largely

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avoidable through lifestyle changes and weight loss, the uptake in prevention programs remains low [27]. Similar discounting of the future has been shown to correlate with poorer self-management outcomes in type 2 diabetes [11].

The human tendency of discounting the future can be assessed via the method of 'delay discounting', a behavioural economic trans-disease process measuring the extent to which people prefer smaller immediate rewards over larger delayed ones [19]. One intervention shown to be effective at reducing delay discounting is Episodic Future Thinking (EFT) [60]. In EFT a person mentally projects him/herself into the future though a personal vivid and sufficiently detailed episodic future event [51]. This can be facilitated by first asking the person to imagine one or more attractive future events, for instance "*I am playing football with the grandchildren on a summer day*", and associate these with a created audio cue, that can then afterwards be used to recall the future event.

Recent research has shown EFT to be effective in reducing delay discounting in relation to multiple areas like the risk of type 2 diabetes [51], overeating [47] and cigarette smoking [54]. A potential way of increasing the accessibility of EFT is through scalable and cost effective digital means. Mobile health (mHealth) applications present one such technology [44], and individual components of EFT have previously been demonstrated in a digital setting.

Such components of EFT delivered as a digital intervention can be broken into 3 primary tasks 1) a *generation task* [51] creating a cue representing an episodic future 2) a *projection (or review) task* where a person pre-experiences the episodic future and 3) an *assessment tasks* where the delay discounting is measured. It can be argued that the first two of these tasks are *micro-interventions*, given their short duration and positive impact on in-moment behaviours [8,47] whereas the third task simply acts as an assessment component. Micro-interventions are defined as resources that can be quickly consumed, intended to have an immediate positive effect on targeted symptoms [24], and can include both just-in-time (JIT) [43] and ecological momentary interventions (EMI) [6].

However, despite the increased accessibility of self-guided real world digital health interventions, research suggests uptake in real world settings remains low [9,23,42]: A recent meta-analysis looking at attrition and dropouts rates across app-interventions found these to be as high as 43% across studies [42]. Another recent study related to popular mental health apps found user retention as low as 3.9% after just 15 days [9]. This could indicate a lack of acceptance by users or a failure to address the specific, and often evolving, user needs [21]. Alternatively, it could be that patients' experiences and needs might not always align with clinical judgement [59] used to create the interventions, or it could be that users might not want to invest much effort into these, despite being interested in their effects [8]. This highlights a need to consider the larger context for delivery of mHealth applications like EFT, taking into account intervention timing, differences in population [22] and personal preference [50], which in turn implies tackling *personal context* and larger *therapeutic perspectives* while meeting peoples' capacity to engage with the interventions. The idea of leveraging several different micro-interventions in combination through a larger narrative that aims to achieve an overall outcome has been coined *micro-intervention care* [8].

This paper presents an approach to embed EFT-based micro-interventions into a mHealth application, aiming to support micro-interventions both standalone and as part of a larger narrative. The EFT-based micro-intervention approach is based on a theoretical engagement into the theory behind EFT combined with a thorough design process, involving a wide range of chronic patients engaged in focus groups, formative usability testing, and an initial feasibility study of the mHealth application.

We therefore explore how EFT might be implemented as micro-interventions. We further look at users' experiences with EFT as micro-interventions i.e., the facilitators and barriers and we discuss the potential areas and use-cases where EFT may be used as part of micro-intervention narratives. We designed an application to deliver EFT as a number of micro-interventions in a human-centred design process and implemented the design in Flutter for Android and iOS using a pre-existing mobile sensing framework for mHealth applications, and ran a 2 week single-arm feasibility study involving 14 participants. The users overall gave positive feedback, although engagement varied with less than half completing the full 2 week period. In this paper, we include the design and the results from the study, and discuss their implications for future design considerations.

2 Theoretical Background and Related Work

Both delay discounting and EFT are areas with significant contemporary research, and micro-interventions are an emerging field of research with increasing interest in recent years. The following sections provide background knowledge on the core concepts of delay discounting, EFT and micro-interventions.

2.1 Delay Discounting

Delay discounting is a measure of the perceived difference in value of an immediate reward when postponed to the future. As humans, we often prefer gratifying behaviours or rewards now rather than later, and to have more rewards rather than less [46]. From a health perspective this might translate to preferring pleasurable behaviours here and now, rather than taking in-moment actions for a larger reward impacting long term health. Delay discounting stems from behavioural economics and describes the extent to which we prefer immediate gratification against future larger gratifications or rewards [35]. Mazur suggests delay discounting to be described by a hyperbolic mathematical model:

$$V = A/(1 + kD)$$

where V represents the perceived present subjective value, A is the actual value, D is the delay and k is the delay discounting coefficient [19,39]. Persons with higher values of k therefore perceive the subjective value of a reward to drop significantly when delayed, resulting in distant outcomes being considered of lesser value. Persons with higher values of k thus prefer smaller rewards soon, and may e.g., be inclined to consume high caloric food rather than foregoing this with a benefit of a better long term health [58]. High delay discounting has been associated with obesity and the inability to delay gratification [14]. This also translates to other behavioural areas related to health, such as smoking [54], engaging in lifestyle changes halting the transition to type 2 diabetes [51] and engagement in diabetes self-management [11], and in other behaviours such as different forms of addiction [2]. Epstein et al. further suggests delay discounting as a potential target for prevention of prediabetes to type 2 [18] while showing a relationship between high discounting and multiple health related behaviours such as lower adherence to medication, diet quality, physical activity and HbA1c[1] [19].

Delay discounting can be assessed through a series of choices usually presented in the form of money, i.e., "Would you prefer $20 now or $200 in 6 months". Depending on the exact method either the less immediate or the greater delayed reward is adjusted according to the user's reply. Alternatively, the delays or both amounts are adjusted. Eventually a tipping point is reached where a subject changes opinion between rewards, also known as the indifference point [38], which can be used to calculate the overall discounting rate, expressed through the discounting coefficient, k.

Several methods are used in common practice, such as the adjusting amounts task [19] or the Kirby Delay-Discounting Questionnaire [32] although several variations of delay discounting measures exist [38]. The Kirby Delay-Discounting Questionnaire e.g., consists of 27 questions that present immediate values, fixed delays and uses shorter time periods (7–186 days) whereas the adjusting amounts task deals with longer periods of time (1 day - 25 years) and can be based on either $100 or $1000. The adjusting amounts task e.g., starts with $50 now versus $100 later for a given time period, and for each choice the subject takes, the amount now is adjusted by 50% depending on that choice e.g., if $50 is chosen over $100, the amount now is adjusted to $25. Similarly the amount may be adjusted to $75 if the delayed amount is chosen, with these choices being repeated another 4 times until indifference is reached, and it then repeated across 6 time periods.

2.2 Episodic Future Thinking

Episodic Future Thinking (EFT), which is a growing area of research in both cognitive neuroscience and psychology [49], refers to the ability to imagine one's personal future.

In EFT, one projects oneself forward into the future in order to pre-experience an event [4], e.g., "I am sitting outside enjoying the warm spring weather, in a few moments I will be going on a walk to enjoy the park". EFT is a type of prospective thinking and is thought to reduce impulsiveness by increasing the perceived

[1] Average blood glucose over 2–3 months, also known as the Hemoglobin A1 test.

value of delayed outcomes, thereby encouraging decisions with long-term benefits [56]. A recent meta-analysis supports EFT's effects on delay discounting across studies, noting positive EFT events are more effective than neutral or negatively toned future events [60]. EFT's ability to reduce delay discounting and impulsiveness has been shown in a number of contexts [10,14,15,47,51,54]. Dassen et al. for example showed EFT to be effective in reducing discounting rate and snacking, suggesting it as effective also in reducing the need for immediate gratification [15]. Similarly, O'Neill et al. found that EFT significantly reduces energy intake when carried out in a public food court [47], indicating effectiveness of EFT as ecological momentary interventions. This is further backed by Hollis et al. showing EFT to impact in-moment ecological decisions made in grocery shopping [28]. Additionally, Sze et al. shows that online-administered EFT can reliably reduce delay discounting and demands for fast foods [56]. In studies related to chronic disease [17] and substance abuse [3] EFT has shown equally effective in reducing delay discounting. Stein et al. found EFT reduced delay discounting to directly affect self-administration of cigarettes [53,54] and reduce delay discounting in persons at risk of type 2 diabetes [51].

The use of smartphones in EFT has often been limited and mainly focused on the delivery of audio cues. The study by Sze et al. makes use of an online web-based system compatible with desktops, tablets and mobile devices allowing participants to access their cues on smartphones [55]. Generation of cues was handled with a case manager at an introductory session using separate open-source software and a laptop to facilitate recording [55]. In a later study Sze et al. further showed the feasibility of using an online self-guided generation task for audio cue creation [56]. Similarly, O'Neill et al. leverages participants own smartphones to deliver the studies audio cues, with none-compatible phones replaced by an iPod where cue generation is handled through a moderated EFT cue-development interview and is recorded using a recorder [47].

2.3 Micro-interventions

Fuller et al. defines micro-interventions as quick resources that can be easily consumed and should have an immediate positive impact on targeted symptoms. Micro-interventions can be both just-in-time (and just-in-time adaptive interventions) [20] or ecological momentary interventions EMI [41] by nature [24]. These micro-interventions can consist of a single event [25], repetitions [16], variations [20] and sequences of events [24].

One convenient way to look at micro-interventions can be found in the conceptualization by Baumel et al. describing the core components of micro-interventions [8]. An important distinction presented in this work is that of the micro-interventions themselves and the micro-intervention care. Micro-intervention care consists of individual micro-interventions as steps in a therapeutic process linked together in a coherent therapeutic narrative maintained by a "hub" [8]. A hub refers to an entity (or multiple entities including systems in combination) that recognises an individual's state and context, recommending relevant interventions and creating and maintaining a therapeutic narrative [8].

This narrative is driven by conceptual models, determining how/when a digital micro-intervention should be used in the therapeutic process. The delivery, timing and context for events are determined by decision rules. Proximal assessments may be carried out to determine the outcome of events, with the outcome of the micro-intervention possibly also being a proxy for an overall clinical goal [8].

Current implementations of micro-interventions have mostly revolved around the interventions themselves rather than micro-intervention care. Micro-interventions have for example been used to promote physical activity [13], positive body image [25] and improve mood [16]. Meanwhile, Meinlschmidt et al. allowed users a daily choice of one of four ecological momentary interventions micro-interventions aiming to improve mood [40]: vicesensory attention (shifting attention from sensations), emotional imagery (imaging emotional situations), facial expression (simulating emotional facial expressions), and contemplative repetition (repeating short sentences) [40]. Micro-interventions events can be triggered in response to context and with resources adapted based on user preference [16] with Everitt et al. using JIT micro-interventions to decrease depressive symptoms [20].

3 System Design

The EFT mobile health application was designed to facilitate the creation and delivery of EFT as micro-interventions on a smartphone platform. As outlined above, the smartphone presents a good platform for understanding the context and behaviour of a person and for delivering an intervention through e.g., the notification system. The "EFT" application was designed for a generic audience in order to investigate the technology and user experience of EFT implemented on a smartphone platform. A selection of the applications screens can be found in Fig. 1.

3.1 Design Process

We considered prior work on EFT, delay discounting, and micro-interventions (Sect. 2) to design our initial prototype, and adopted a human-centred design process to evolve the prototype: The initial design was refined and validated based on feedback from 3 focus groups with in total 11 participants with Type 2 Diabetes Mellitus (T2DM), and further by formative usability sessions where 6 potential users tested core elements of EFT when performing different tasks with the prototype. The aim of the focus groups was to discuss key topics, problems, and opportunities for the design with a target user group that may benefit from EFT (see Sects. 1 and 2.1). The formative usability tests focused on key elements of the design, specifically the self-guided self-generation of cues and initial perceptions of generating and listening to audio cues.

3.2 Design Considerations

In order to deliver a minimal implementation of EFT we aimed for at least three distinct micro-interventions (MIs) and one method for assessment (A): 1. **MI1** – A self-guided generation task for creating cues. 2. **MI2** – Audio-based projection (or review) session where audio cues are experienced. 3. **MI3** – Image-based projection micro-intervention where the image represents one of the episodic futures. 4. **A1** – An adjusting amounts task to assess delay discounting.

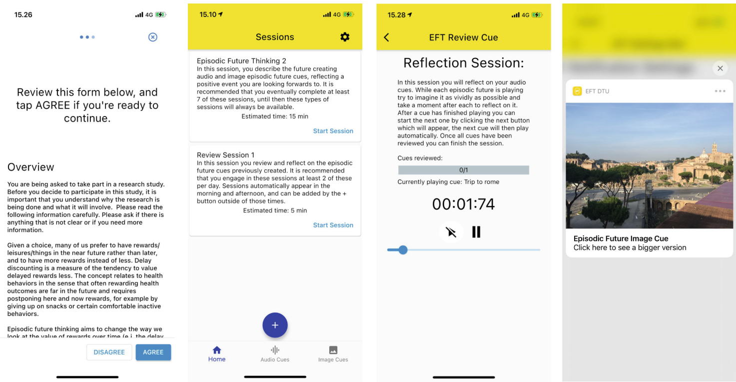

Fig. 1. Design of the EFT mobile application. The leftmost picture shows part of the integrated study consent form. At the centre are the main menu showing different uncompleted sessions and a reflection session playing audio cues. Rightmost is an example of an image based projection delivered through a notification.

Self-guided Generation Task. Generation of episodic futures was facilitated through a series of steps presented to the participants and is based on the self-guided generation task [51]. Positive episodic futures are emphasised as these have been shown more effective at reducing delay discounting [60]. Once a vividly imagined future has been created, the participants record it as an audio cue for future review. Based on the created episodic future, the participants are asked to give the cue a name and to add an image representing the created future event. Each self-guided generation task consists of creating a single episodic future, as it reduces the effort required at any one given time and meets peoples' capacity for smaller investments of time [8], in line with the idea of micro-interventions.

Initially, users complete the first micro-intervention creating a single episodic future, set approximately a month into the future. Following Stein et al.'s suggestion that EFT's effects depend on the number of generated futures and the time frames of those futures [52], we designed additional self-guided generation tasks with different time frames. The initial period of 1 month was chosen based on formative usability testing, as most users could easily imagine events in that time frame. To address any learning curve subsequent self-guided generation tasks were set at increasing time periods i.e., 3 months, 6 months 1 year etc in the future. As suggested in focus groups examples of cues were also added for the different time frames. The most distant future considered for cue generation was 10 years based on formative usability testing with participants expressing doubts they could effectively generate cues in a 25-year time frame and suggesting it might be inappropriate for older persons. As a final step of the self-guided generation task users are asked to add an image representation of their created episodic future, which is used for image-based projection. Users are periodically notified to generate at least 7 cues [17]. The overall design of the cue-creation can be seen in Fig. 2.

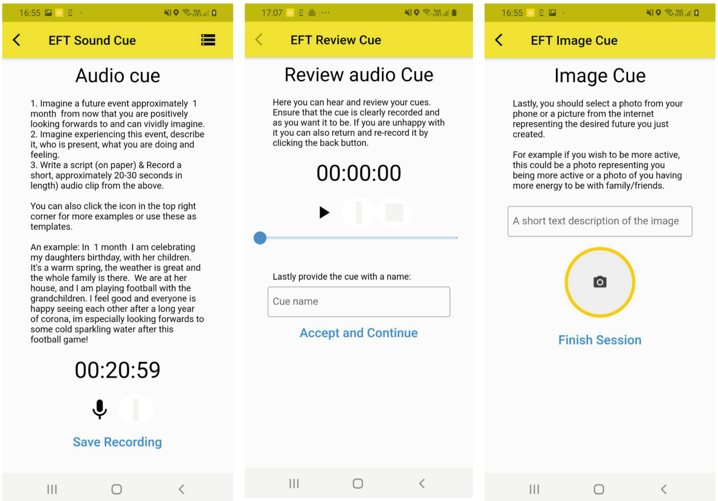

Fig. 2. Design of the app's self-guided generation task. The leftmost picture shows instructions and an initial example as well as the recorder. In the middle users can give their cue a name and review the quality of the recording. The rightmost screenshot shows the tab for creating image cues.

Audio-Based Future Projection. Projection sessions are scheduled twice a day and timed before the first meal and the last meal of the day, respectively [55]. Should participants not complete them, reminders will be sent after a while. Each session consists of pre-experiencing a number of self-generated episodic futures per session by listening to the episodic futures in audio format, thus allowing multiple events to be pre-experienced.

Image-Based Future Projection. Given that it is not always feasible to listen to audio cues an image-only notification representing the episodic future may be useful to remind persons of their episodic future in those contexts. This is reminiscent of the work by Chan & Cameron on mental imaging wherein mental imagery was used to promote active behaviour [12]. In line with micro-interventions these images could be delivered in contexts different to traditional EFT aiming to affect in moment decision making.

Assessing Delay Discounting. The app measures delay discounting through an adjusting-amount task [19]. The task itself is designed as described in Sect. 2.1 and the delay discounting coefficient is calculated based on Mazur's hyperbolic model [39]. The measurement was initially based on the $100 task modified to the local currency (Danish krone) and rounded to the nearest meaningful amount in kroner, resulting in a 1000 kr adjusting amount task. Formative usability tests revealed users generally perceived this amount as inconsequential, requesting higher amounts to be used to make more meaningful decisions, in line with Epstein et al.'s suggestion, that: "Perhaps if a reward is too small, most people discount it [...]" – Epstein [18]. As a consequence, the adjusting amount task was updated to reflect a larger amount, 10.000kr or $1000.

3.3 Implementation

The application was implemented in Flutter and thereby available for both Android and iOS smartphones. The software architecture is shown in Fig. 3 and is based on the CACHET Research Platform (CARP), which is an open source research platform for digital phenotyping[2]. The application makes use of the CARP Mobile Sensing framework [7] for mobile data collection, the CARP Research Package for collection of informed consent from the user and uses the CARP Web Services infrastructure for secure data upload and management. CARP was chosen as the basis for the application as it allows for collection of a wide variety of data automatically and does so securely and in compliance with the General Data Protection Regulation (GDPR). The real-time collection of contextual and behavioural data is especially relevant for this EFT application, as it can be used for just-in-time or ecologically relevant triggers in the application. These automatic triggers are, however, outside the scope of this initial feasibility study. Data collected on the participants smartphone is sent to the CARP Web Service backend, where it is made accessible to the project researchers.

In addition to handling data collection CARP mobile sensing also controls the timing of new sessions, scheduling of notifications and delivery of image reminders through the Study protocol.

4 Feasibility Study

Following the best practices in early mHealth technology research, a single-arm feasibility study was carried out with the aim of gaining a deep understanding

[2] http://carp.cachet.dk/.

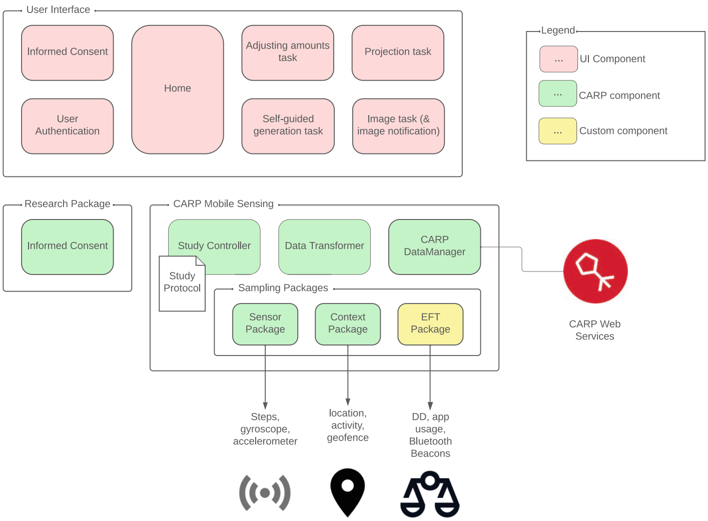

Fig. 3. Architecture of the EFT mobile health application. The application-specific components are shown in red and resemble the UI components such as the ones shown in Figs. 1 and 2. Data collection is handled by the CARP Mobile Sensing framework components (green), which include a custom sampling package for recording usage statistics, beacons and delay discounting (yellow). (Color figure online)

of how and why the system used or is not by its users [33]. Our aim is thus to obtain a comprehensive understanding of use, usability, perceived usefulness and feasibility of EFT as digital micro-interventions in the real world. Given our aim of broadly looking at the usefulness of the micro-interventions, both as self-contained digital micro-interventions and as part of other narratives, we did not impose any restrictions on recruitment. Due to the study's technical and non-clinical objectives, the feasibility study was exempted from ethical approval by the Danish Ethical Committee (journal no. 21066249). The Institutional Review Board at the Department of Applied Mathematics and Computer Science at the Technical University of Denmark (DTU) have approved the study. (DTU-COMP-IRB-2021-02).

4.1 Recruitment

Due to the early nature of this study and the aim of making EFT as micro-interventions generally applicable, participants were recruited more broadly through announcements, board messages, and email lists at (DTU) and through word of mouth externally and not specifically targeting persons with T2DM. Interested subjects were presented with a subject information letter and a link for a sign-up. Upon signing up, participants were invited to the study via email.

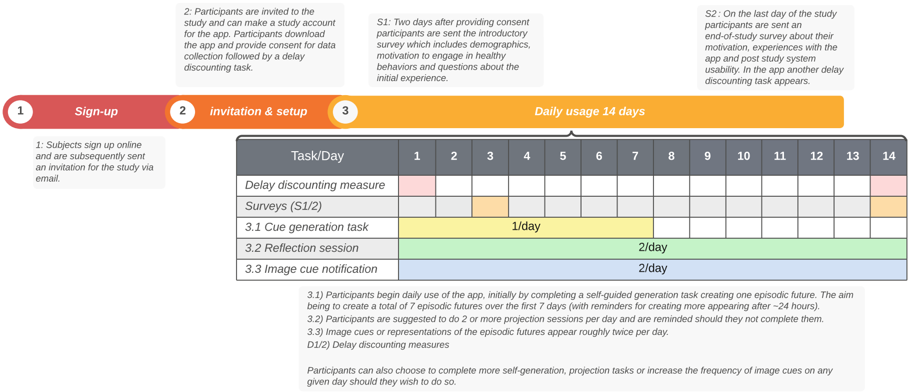

Fig. 4. Overall study structure, showing the major phases of the study from sign-up till completion.

4.2 Procedure

The study timeline can be seen in Fig. 4. Upon signing up for the study, participants were invited to the study through the CARP platform via an email invitation, prompting them to create a study account for the app. When participants had created this account they could download the app and sign-in. Once signed-in participants were presented with the full subject information letter again and asked to provide signed consent for participation via the app.

Once signed consent was obtained, participants were asked to do an initial delay discounting assessment, and once finished the participants can use the app. Initially the main menu presents participants with an introduction to the app and its different features and urge the participant to complete the first self-guided generation task which can be found in a card view of available sessions. A day after setting up the app, participants receive an introductory questionnaire via email exploring the initial experience with cue creation and an assessment of motivation to engage in healthy behaviours through the Treatment Self-Regulation Questionnaire (TSRQ) [36] and some exploratory questions about the initial experience of cue generation/projection. The TSRQ questionnaire specifically assesses the degree of which one's motivation is self-determined or autonomous. In the present case, as the focus revolves around delay discounting in regard to lifestyle changes, we use the versions of TSRQ that focuses on diet and exercise motivation.

Participants were urged to engage with the application two or more times daily in the form of review sessions where they pre-experience their recorded episodic futures. These sessions automatically pop up in the app in the early morning and afternoon, with notification reminders some hours afterwards. Participants may additionally receive notifications containing their image representations of the futures at some points throughout the day. After 2 weeks, the participants were presented with another delay discounting adjusting amount task and an end-of-study questionnaire. This end of study questionnaire consists of the same TSRQ questionnaire on motivation, a Post-Study System Usability Questionnaire (PSSUQ) [37], and additional specific and more general questions about the overall experience.

The specific exploratory questions were inspired by experience sampling and included participants approach, difficulties and experiences with completing the cue generation and reflection sessions. The end of study questionnaire additionally sought to explore perceptions of the interventions focused more broadly on the accumulated experiences with the micro-interventions. The general questions allowed the participants to tell if they liked, disliked or were indifferent towards aspects of the system or micro-intervention events and an opportunity to suggest improvements.

5 Results

In total 24 participants signed up for the study, with 14 accepting the study invitation and downloading the app. Twelve participants answered the introductory questionnaire and 9 the end-of-study questionnaire. 83% of the participants were between 20 and 30 years of age; half were female. 3 participants (25%) were from a minority group.

The CARP Mobile Sensing framework collected a total of 262,223 data points, including location, activity, pedometer, battery, and device information. A total of 1,632 app interactions were recorded. These include opening the app, interacting with the app, and completing sessions, with 2 participants sporadically continuing to use the app after the 14-day study period. Participant engagement over all sessions can be seen in Fig. 5. We were not able to detect any meaningful difference in the measured delay discounting comparing the beginning and end of the study due to the small sample size and low completion rate of the final delay discounting assessment task. Accumulated attrition was 21.4% (day 3), 43% (day 7) and 78.6% (day 14).

We carried out a within-subjects statistical analysis (using python 3.7.0, scipy 1.7.3) of TSRQ score between the study start and end surveys for both diet and physical activity. We did not observe any statistically meaningful differences in TSRQ score for participants between the beginning and end of the study. However, we did observe a noticeable positive mean difference in score of 1.65 (likert scale, $p = 0.31$ relative to baseline) for question 14: "Because I want others to see I can do it" (Physical Activity).

The usability of the application was assessed using PSSUQ and supporting questions, gauging the experience of completing key tasks. The PSSUQ results can be seen in Fig. 6, showing that a majority of the participants were satisfied with the usability of the system, with some adding suggestions for improvements to the UI. However, two exceptions can be found in relation to question 6 and 8 namely "I felt comfortable using this system" and "I believe I could become productive quickly using this system", where participants seem to rate the solution less favourable. The exploratory experience questions added some nuance

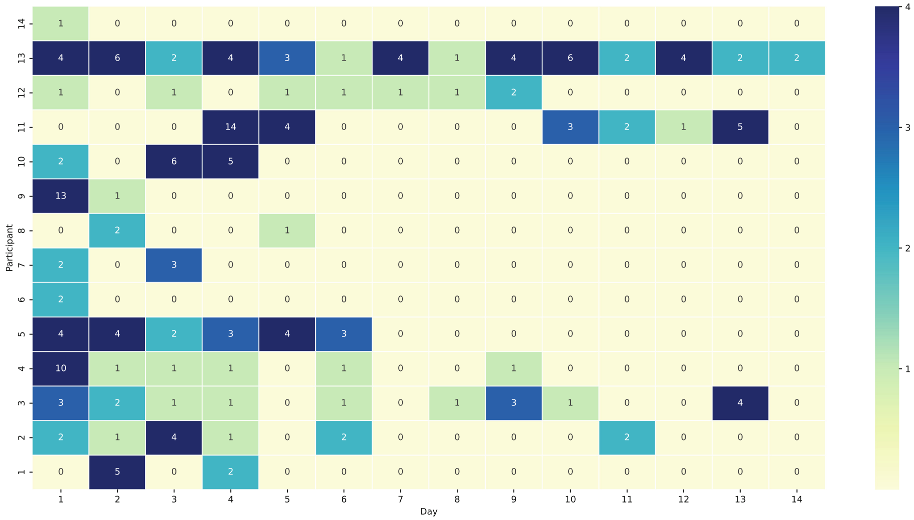

Fig. 5. Number of engagements with self-guided generation tasks, audio or image-based projections, for each user over the 14 day study period.

to these ratings: In terms of feeling comfortable, roughly half the participants commented on the experience of listening to their own voice, to varying degrees describing it as uncomfortable or annoying. Regarding the productivity of using the system, some participants felt that it was unclear how exactly EFT would help them e.g., become healthier, perceiving a disconnect between futures and specific outcomes.

5.1 Qualitative Results

A total of 5 recurring themes were identified through a thematic analysis of participants experiences. These were related to 1) Listening to one's own voice, 2) contextual appropriateness, 3) imagining the future, 4) perceived value, and 5) the facilitating system. In the following paragraphs we have these synthesised insights, highlighting both barriers, facilitators and participants own suggestions for improvement.

Listening to One's Own Voice. Generally, participants reported very different experiences when it came to listening to their voice. Some participants were mostly indifferent or positive towards the experience: "I'm not a fan of my voice so, it was a little odd hearing myself speak", "It was strange hearing my voice" and "I think hearing what I had to say was kinda nice – it was like getting a mail from future me". However, others reported more mild or severe unease/discomfort from listening to their own voice: "I have slight difficulties listening to the recordings of my voice" and "I don't like the sound of my voice so it

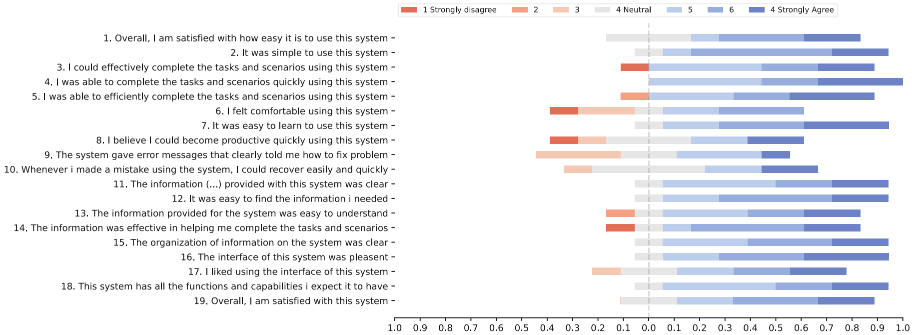

Fig. 6. Results from Post-Study System Usability Questionnaire (PSSUQ).

was very hard for me to be focused on the content of the audio". Approximately half the participants mentioned some degree of initial apprehension towards their own voice suggesting it is a significant barrier to use.

Participants themselves suggested various ways to mitigate this issue; one suggestion was to keep a textual representation of the episodic future used in the self-generation task simply reading it themselves during projection rather than listening to a recording. Another participant suggested that another person could record the audio cue. However, given the personal nature of some futures this may not always be appropriate.

Contextual Appropriateness. Participants commented on the ability to complete projection sessions, stating that it could be difficult to find a quiet place to concentrate in between everyday activities. Some participants also found it was difficult to find time for engaging in the planned projection sessions due to other events or sudden occurrences, suggesting an option to have more sessions on certain days and less at other times.

Comparing audio and image cues, some participants had a preference for image cues, citing the aforementioned issue with one's own voice adding that the image cues suited them better in-moment while others citing a personal preference for image-based intervention formats. One participant commented "I prefer the photo part", with yet another participant adding that the image cue was often enough to remember the episodic future. Participants suggested using different types of media, including text, to deliver the episodic futures: "I would prefer writing something instead of talking to my phone". Participants also touched upon the situational appropriateness of different resources noting: "[It is] a bit annoying that I have to find a place without people to do this. I would prefer text".

Imagining Futures. Some participants noted it could be difficult to imagine events in certain time frames due to uncertainty and that the time period was outside of what they usually think about. Moreover, initial experiences with the projection task indicate that while the examples provided were useful, their limited numbers and variation were not necessarily enough for all participants.

Imagining distant futures was more difficult than those more present, with comments that not everyone considers long-term future events (∼5–10 years). One participant comment from the first survey in particular seems to support the idea of a learning curve effect in cue generation: "Perhaps in the next sessions [cue generation] I would have liked to imagine something bigger like a fitness goal".

Perceived Value. Participants generally found the experience of thinking about the future pleasant in itself, describing it as encouraging to remind one-self about things to look forward to. Some participants found that it provided hope for a bright future: "It gave me a sense of hope, and it felt like something to look forward to" and others commented "It [reflecting on the future] was encouraging", "It is nice to be reminded that there is something to look forward to". However, not all were equally positive and found it difficult to see how EFT or rather future thinking in general would actively help them achieve more tangible health related goals: "It did not particularly motivate me but it did remind of where I want to be" and "I don't think I understand the actual purpose of the task [reflection]".

The System. The system facilitating EFT through micro-interventions was also mentioned as both a facilitator and occasional barrier.

In terms of positive perceptions participants found the system easy to learn and to use, and found information such as task descriptions sufficient to quickly complete micro-interventions. Several participants especially liked the image cues delivered as notifications with their association to the future.

On the contrary, barriers included the design of certain interactions such as manually having to click "next recording" in projection sessions as participants seemingly preferred audio cues automatically playing one after the other. Other negative technical aspects included battery drain (from mobile sensing), some general technical issues, and the stability of certain background processes.

6 Discussion

6.1 Design of the Micro-intervention Events

In this study we designed 3 micro-intervention events and adapted one type of assessment that can also be used as part of a larger therapeutic narrative addressing delay discounting. Results from our feasibility study including suggestions from the participants highlight multiple opportunities for improvements and variations to these micro-interventions. These ranges from the content, i.e., micro-intervention resource, to their timing and intensity based on context. We note, however, that more work is necessary to explore appropriate decision rules for triggering these in relation to context, and whether these *end-user* developed variations are effective. Formative usability tests indicates that *self-guided generation tasks and review sessions can be directly translated to unmoderated micro-interventions*. However, *the tasks must be performed chronologically in sequence*, as a self-guided generation task is needed before a projection of episodic futures can take place.

Based on our qualitative usability data we believe perceived usefulness to be the primary contributor to the observed low usage and thus also the lack of meaningful differences in delay discounting. This is in line with previous research showing that perceived usefulness of a micro-interventions can be linked to usage [24], similar to results from traditional mHealth interventions [57]. This indicates the paramount importance of ensuring perceived value is clear for users in unmoderated micro-interventions if these are to be effective in the real world. Participants' own ideas to solve this perceived gap suggests *goal-oriented EFT* [45] *may be better suited for micro-intervention use* as it bridges the perceived gap between purpose and intervention, which could increase perceived value. Goal-oriented EFT was originally created to explicitly leverage an observed tendency for future thinking to lean towards future goals [45]. In this variation goals are directly and explicitly tied into the future events e.g., "In 2 weeks I am purchasing a new computer" - O'Donnell et al. [45]. Focus group participants even discussed (unprompted) the idea of cues to being tied to specific health goals in diabetes, without prior introduction to goal-oriented EFT by researchers. A recent study similarly expanded on this concept by modifying the financial incentive to health goals i.e., health goal-oriented EFT [5]. While this form of health goal-oriented EFT was not found to be more effective than traditional EFT it was found to have additional behavioural benefits [5]. Prior research therefore indicates that goal-oriented EFT may be more effective compared to traditional EFT [5,45]. Our findings add to this by suggesting goal-oriented EFT has the additional benefit of increasing perceived usefulness.

While it could be argued that the self-guided generation task should not be considered a micro-intervention but rather as required setup for EFT as it is not designed to have a positive effect on target symptoms itself. Our findings indicate that *the task of creating a cue in itself can provide a positive outlook on the future, and therefore has an immediate positive effect* in line with the definition of micro-interventions. Coupled with goal-oriented EFT, this could indeed provide a good starting point for the micro-interventions, highlighting their value and promoting engagement. We therefore argue that the self-generation task is to be seen as a micro-intervention providing a direct impact, in line with Fuller et al's definition of micro-interventions [24]. While the projection task, i.e., listening to audio cues and seeing image representations of future events, attempt an in-the-moment change, our study did not implement a proximal assessment for judging the effect of isolated events. We further note that using a standard adjusting amounts task to judge the effect of individual events may not be feasible for use in the"wild", as this would effectively double task duration. Therefore, further work is required to explore the impact of each events' effect, possibly through micro-randomized trials [34].

Research in EFT has previously shown the ability to reframe temporal decision-making during discrete moments of time [47]. Data collection from the feasibility study indicates that *we may be able to expand the system to include simple just-in-time delivery of EFT, thereby adjusting or entirely avoiding delivery of components when they are not necessary or not preferred* by users [43]. Utilizing the mobile sensing platform, the application successfully collected several kinds of contextual data in near real-time that could allow for delivering EFT micro-interventions in response to the user's context and situation. Examples from our data collection include activity, sedentary behaviour, location based events and beacon proximity, which individually or in combination could be used to identify opportune moments to trigger EFT events. E.g., Alexander et al. has already demonstrated the feasibility of leveraging sensor data from smartphones, smartwatches and Bluetooth beacon proximity to identify contexts where users are having meals [1].

6.2 User Experience

While participants reported some bugs, as well as usability issues specifically related to background processes on iOS, the overall feedback was positive; the participants appreciated the simple design, ease of interaction and the task instructions. We note however, that more work is needed to fully communicate the value of the system, especially if EFT micro-interventions are to be part of a larger narrative. Participants' own suggestion for goal-oriented EFT indicates it may be preferential and a facilitator for value perception. Comments from the formative usability testing implicitly supports this may be accomplished by more directly coupling health goals to episodic futures and the overall condition.

Contextualization: Looking at users' experience we see several potential facilitators and barriers to EFT as micro-interventions. While participants could simply engage with the micro-interventions daily, such as before the first meal and the last, real-world usage may vary depending on the context. *Contextual image based futures may be more appropriate than audio cues situationally.* Participant comments specifically highlight this is the case for both projection tasks and self-guided generation tasks, suggesting engagement is subject to contextual task acceptance. Especially the self-guided generation task was difficult to complete in part due as it was inherently more difficult, requiring relatively quiet and sometimes private spaces for recording of audio cues; it is necessary both to concentrate on cue generation and to ensure recording quality while not inadvertently sharing cues when recording in public, as also noted by some users.

One's Own Voice: Another significant barrier was plainly listening to one's own voice which several participants described as "cringe" inducing, with participants comments indicating this feeling gradually lessened over time. However, even at the 14-day mark, some participants still commented that *listening to one's own voice was distracting*, which could indicate it is a significant barrier to a large group of users and may hinder uptake of the micro-interventions. Given micro-interventions relatively short duration compared to traditional care [24], being unable to overcome barriers related to listening to one's own voice may limit the micro-intervention's effectiveness and perceived usefulness outside traditional psychological uses. Another alternative is to consider an AI voice system to play back cues so they are not in the user's own voice.

Audio vs Visual Cues: The perceived in-moment acceptance of the resource, i.e., the audio, image or text, may impact effectiveness of the intervention in the wild. Users may simply not be able to engage with the resource or may perceive the resource as inappropriate given the surrounding context. Accordingly, comments by participants indicate that this is further complicated by resource preference, where *some users preferred the image based resources whereas others instead suggested textual representations of their episodic futures* that they can read in the moment.

Long vs Short Term: Meeting users capacity for engagement, context and preference may be key to implement EFT in different narratives. In line with observations by Howe et al. we see some indications that suggest *users perceive low effort interventions as more helpful despite results indicating higher effectiveness from high effort ones* [29]. User comments for example suggest the shorter mental imagery delivered was enough to make them think about the future, with some participants preferring this type of projection. Adapting intervention resources to better suit users' preferences may therefore facilitate improved engagement but possibly at the cost of effectiveness requiring further research. Focus group discussions with persons with diabetes further suggests that "*it may be beneficial to provide direct links to the disease or health picture over time*". These discussions also highlight that while people are interested in the longer-term goal of the micro-interventions i.e., increased engagement in diabetes self-management behaviours through a reduction in delay discounting they may not necessarily be that interested in the in-moment effects. However, this could be due to the in-moment effects of EFT not being clearly perceived by users. This observation may be especially important given previous micro-intervention research couples perceived usefulness micro-intervention with user retention [24].

Despite the positive usability feedback received we nevertheless note the resulting engagement was lower than expected. Indications from participants are that the primary contributors were: i) the perceived gap between micro-intervention aims and health outcomes (the perceived value), ii) lack of contextualisation and adaptation to individual preferences, in line with Eyles et al. [21] reporting a potential relation between high attrition and a lack of acceptance and iii) failure to address users' specific needs. As our aim was not to adapt to individual user needs, we note that our participants may not have had a specific *need* or preference for EFT micro-interventions; i.e., we did not specifically recruit from groups with risk of high delay discounting or groups with a particular interest in health goals. Decreased engagement generally occurred within the first few days or after the first week of use. Our attrition rate resembles Baumel et al., looking at app uptake in the wild with the majority of retention loss occurring in the first week [9]. Perceived usefulness and acceptance is apparently judged either immediately or within a relatively short period of time and may determine continued use before any longer term benefits may have reached the user [31]. This time frame may thus be indicative of the window of opportunity where suggesting other micro-interventions could retain longer term engagement.

6.3 Potential Use Cases

Interviews with participants with T2DM indicates they themselves perceive EFT as an interesting intervention shortly after diagnosis representing one concrete narrative use. This is further supported by a recent project [48], where in an open co-creation process participants identified discounting of the future in diabetes as an issue. While the participants themselves did not refer to this as delay discounting, they found the inactivity problematic in avoiding future comorbidities.

Looking at other possible narrative use cases for smartphone delivered EFT as micro-interventions we may get inspiration from previous suggested targets for EFT which has shown effects in a multitude of contexts [10,14,15,47,51,54]. EFT as micro-interventions may thus be relevant to systems working with changing behaviours related to: prediabetes, overeating, cigarette smoking, or more generally where discount of the future may have an adverse effect on future outcomes.

Based on the usage-data made available by the CARP platform, we stipulate that it would be possible to leverage mobile sensing to identify poor adherence, such as not listening to cues, and in turn as an opportunity to suggest other interventions to enrich the narrative [8].

We found the implemented EFT micro-interventions to be subject to user preference, with certain individual barriers to the use of EFT, negatively affecting adherence. This suggests the need for conceptual models of use for determining which users are susceptible to EFT, alternative EFT micro-interventions or if users should be provided other micro-interventions.

6.4 Overall Feasibility

The design of our application and the resulting feasibility study hint that it may be feasible to implement EFT as digital micro-interventions, potentially opening the doors for EFT to become part of a larger micro-intervention care narrative that could provide value in different clinical and therapeutic processes involving behaviour change. Furthermore, the implementation of simple just-in-time and ecological momentary interventions using CARP mobile sensing seems feasible and potentially enable targeting specific in-moment behaviours with EFT, which has previously been shown as effective in both laboratory and simulated real world settings [47]. However, future work is needed to determine the acceptability of receiving EFT in different contextual real world settings and what format of resource can best engage users in these different contexts.

7 Limitations

Although our study shows promising initial results, supporting the application of EFT as part of micro-intervention care narratives and the potential feasibility of delivering simple just-in-time events aiming to affect in-moment decision making, our study did not explore the effectiveness of these. Furthermore, while our study included testing in-the-wild, our relatively small sample size and limited time frame for use limit the generalizability of our results. In the presented exploratory study, our focus has been on discussing findings in-depth with perspectives from existing literature. Future research is required to explore the effectiveness of micro-intervention based EFT delivered with simple just-in-time events, both in order to explore the effect of the different types of events and the overall effect as part of a larger micro-intervention care narrative. Given the technical and usability focus of the study, diversity in recruitment was also limited and does not necessarily include a high delay discounting group, nor were persons with T2DM or other chronic diseases targeted.

8 Conclusion

In this paper we presented the design of an mHealth application for delivering EFT as a series of three micro-interventions and we explore the users' experience of these interventions, their facilitators and barriers. The technological design of the mHealth application was based on a general-purpose mobile sensing framework, which in future applications will allow for flexible collection of contextual data and enable the use hereof to trigger just-in-time events. The system was subject to a single-arm feasibility study involving 14 participants to explore the experience of EFT as micro-interventions, their design, and the implications for use as part of larger micro-intervention narratives.

User's themselves rated usability positively, however engagement was relatively low with identified causes including intervention context, user traits, and perceived value. Based on their experiences, participants themselves suggested various new micro-interventions for different contexts, situations, and preferences. Participant feedback indicates goal-oriented EFT may be preferably compared to traditional EFT due to the direct relation between health and episodic futures. Initial analysis of collected data further suggests the feasibility of leveraging mobile sensing to target simple contexts where EFT may positively affect in-moment decision making.

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References

1. Alexander, B., et al.: A behavioral sensing system that promotes positive lifestyle changes and improves metabolic control among adults with type 2 diabetes. In: 2017 Systems and Information Engineering Design Symposium (SIEDS), pp. 283–288. IEEE (2017). https://doi.org/10.1109/SIEDS.2017.7937732
2. Amlung, M., Vedelago, L., Acker, J., Balodis, I., MacKillop, J.: Steep delay discounting and addictive behavior: a meta-analysis of continuous associations. Addiction **112**(1), 51–62 (2017). https://doi.org/10.1111/add.13535
3. Aonso-Diego, G., González-Roz, A., Martínez-Loredo, V., Krotter, A., Secades-Villa, R.: Episodic future thinking for smoking cessation in individuals with substance use disorder: treatment feasibility and acceptability. J. Subst. Abuse Treat. **123**, 108259 (2021). https://doi.org/10.1016/j.jsat.2020.108259
4. Atance, C.M., O'Neill, D.K.: Episodic future thinking. Trends Cogn. Sci. **5**(12), 533–539 (2001). https://doi.org/10.1016/S1364-6613(00)01804-0
5. Athamneh, L.N., et al.: Setting a goal could help you control: comparing the effect of health goal versus general episodic future thinking on health behaviors among cigarette smokers and obese individuals. Exp. Clin. Psychopharmacol. **29**(1), 59 (2021). https://doi.org/10.1037/pha0000351
6. Balaskas, A., Schueller, S.M., Cox, A.L., Doherty, G.: Ecological momentary interventions for mental health: a scoping review. PLoS ONE **16**(3), e0248152 (2021). https://doi.org/10.1371/journal.pone.0248152
7. Bardram, J.E.: The carp mobile sensing framework-a cross-platform, reactive, programming framework and runtime environment for digital phenotyping. arXiv preprint arXiv:2006.11904 (2020). https://doi.org/10.48550/arXiv.2006.11904
8. Baumel, A., Fleming, T., Schueller, S.M., et al.: Digital micro interventions for behavioral and mental health gains: core components and conceptualization of digital micro intervention care. J. Med. Internet Res. **22**(10), e20631 (2020). https://doi.org/10.2196/20631
9. Baumel, A., Muench, F., Edan, S., Kane, J.M., et al.: Objective user engagement with mental health apps: systematic search and panel-based usage analysis. J. Med. Internet Res. **21**(9), e14567 (2019). https://doi.org/10.2196/14567
10. Bromberg, U., Lobatcheva, M., Peters, J.: Episodic future thinking reduces temporal discounting in healthy adolescents. PLoS ONE **12**(11), e0188079 (2017). https://doi.org/10.1371/journal.pone.0188079
11. Campbell, J.A., Williams, J.S., Egede, L.E.: Examining the relationship between delay discounting, delay aversion, diabetes self-care behaviors, and diabetes outcomes in us adults with type 2 diabetes. Diabetes Care **44**(4), 893–900 (2021). https://doi.org/10.2337/dc20-2620
12. Chan, C.K., Cameron, L.D.: Promoting physical activity with goal-oriented mental imagery: a randomized controlled trial. J. Behav. Med. **35**(3), 347–363 (2012). https://doi.org/10.1007/s10865-011-9360-6
13. Conroy, D.E., Hojjatinia, S., Lagoa, C.M., Yang, C.H., Lanza, S.T., Smyth, J.M.: Personalized models of physical activity responses to text message micro-interventions: a proof-of-concept application of control systems engineering

methods. Psychol. Sport Exerc. **41**, 172–180 (2019). https://doi.org/10.1016/j.psychsport.2018.06.011
14. Daniel, T.O., Stanton, C.M., Epstein, L.H.: The future is now: comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. Appetite **71**, 120–125 (2013). https://doi.org/10.1016/j.appet.2013.07.010
15. Dassen, F.C., Jansen, A., Nederkoorn, C., Houben, K.: Focus on the future: episodic future thinking reduces discount rate and snacking. Appetite **96**, 327–332 (2016). https://doi.org/10.1016/j.appet.2015.09.032
16. Elefant, A.B., Contreras, O., Muñoz, R.F., Bunge, E.L., Leykin, Y.: Microinterventions produce immediate but not lasting benefits in mood and distress. Internet Interv. **10**, 17–22 (2017). https://doi.org/10.1016/j.invent.2017.08.004
17. Epstein, L.H., et al.: Effects of 6-month episodic future thinking training on delay discounting, weight loss and HbA1c changes in individuals with prediabetes. J. Behav. Med. **45**(2), 227–239 (2022). https://doi.org/10.1007/s10865-021-00278-y
18. Epstein, L.H., et al.: Role of delay discounting in predicting change in HBA1c for individuals with prediabetes. J. Behav. Med. **42**(5), 851–859 (2019). https://doi.org/10.1007/s10865-019-00026-3
19. Epstein, L.H., et al.: Delay discounting, glycemic regulation and health behaviors in adults with prediabetes. Behav. Med. **47**(3), 194–204 (2021). https://doi.org/10.1080/08964289.2020.1712581
20. Everitt, N., et al.: Exploring the features of an app-based just-in-time intervention for depression. J. Affect. Disord. **291**, 279–287 (2021). https://doi.org/10.1016/j.jad.2021.05.021
21. Eyles, H., et al.: Co-design of mHealth delivered interventions: a systematic review to assess key methods and processes. Curr. Nutr. Rep. **5**(3), 160–167 (2016). https://doi.org/10.1007/s13668-016-0165-7
22. Fleming, G.A., Petrie, J.R., Bergenstal, R.M., Holl, R.W., Peters, A.L., Heinemann, L.: Diabetes digital app technology: benefits, challenges, and recommendations. a consensus report by the European association for the study of diabetes (EASD) and the American diabetes association (ADA) diabetes technology working group. Diabetes Care **43**(1), 250–260 (2020). https://doi.org/10.2337/dci19-0062
23. Fleming, T., Bavin, L., Lucassen, M., Stasiak, K., Hopkins, S., Merry, S., et al.: Beyond the trial: systematic review of real-world uptake and engagement with digital self-help interventions for depression, low mood, or anxiety. J. Med. Internet Res. **20**(6), e9275 (2018). https://doi.org/10.2196/jmir.9275
24. Fuller-Tyszkiewicz, M., et al.: A randomized trial exploring mindfulness and gratitude exercises as ehealth-based micro-interventions for improving body satisfaction. Comput. Hum. Behav. **95**, 58–65 (2019). https://doi.org/10.1016/j.chb.2019.01.028
25. Gobin, K.C., McComb, S.E., Mills, J.S.: Testing a self-compassion micro-intervention before appearance-based social media use: implications for body image. Body Image **40**, 200–206 (2022). https://doi.org/10.1016/j.bodyim.2021.12.011
26. Golay, A., et al.: Taking small steps towards targets-perspectives for clinical practice in diabetes, cardiometabolic disorders and beyond. Int. J. Clin. Pract. **67**(4), 322–332 (2013). https://doi.org/10.1111/ijcp.12114
27. Griauzde, D., et al.: A mobile phone-based program to promote healthy behaviors among adults with prediabetes who declined participation in free diabetes prevention programs: mixed-methods pilot randomized controlled trial. JMIR Mhealth Uhealth **7**(1), e11267 (2019). https://doi.org/10.2196/11267

28. Hollis-Hansen, K., Seidman, J., O'Donnell, S., Epstein, L.H.: Episodic future thinking and grocery shopping online. Appetite **133**, 1–9 (2019). https://doi.org/10.1016/j.appet.2018.10.019
29. Howe, E., et al.: Design of digital workplace stress-reduction intervention systems: effects of intervention type and timing. In: CHI Conference on Human Factors in Computing Systems, pp. 1–16 (2022). https://doi.org/10.1145/3491102.3502027
30. Jones, A., et al.: Integrated personalized diabetes management goes Europe: a multi-disciplinary approach to innovating type 2 diabetes care in Europe. Prim. Care Diabetes **15**(2), 360–364 (2021). https://doi.org/10.1016/j.pcd.2020.10.008
31. Karapanos, E., Zimmerman, J., Forlizzi, J., Martens, J.B.: User experience over time: an initial framework. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 729–738 (2009). https://doi.org/10.1145/1518701.1518814
32. Kirby, K.N., Petry, N.M., Bickel, W.K.: Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. J. Exp. Psychol. Gen. **128**(1), 78 (1999). https://doi.org/10.1037/0096-3445.128.1.78
33. Klasnja, P., Consolvo, S., Pratt, W.: How to evaluate technologies for health behavior change in HCI research. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 3063–3072 (2011). https://doi.org/10.1145/1978942.1979396
34. Klasnja, P., et al.: Microrandomized trials: an experimental design for developing just-in-time adaptive interventions. Health Psychol. **34**(S), 1220 (2015). https://doi.org/10.1037/hea0000305
35. Lebeau, G., et al.: Delay discounting of gains and losses, glycemic control and therapeutic adherence in type 2 diabetes. Behav. Proc. **132**, 42–48 (2016). https://doi.org/10.1016/j.beproc.2016.09.006
36. Levesque, C.S., Williams, G.C., Elliot, D., Pickering, M.A., Bodenhamer, B., Finley, P.J.: Validating the theoretical structure of the treatment self-regulation questionnaire (TSRQ) across three different health behaviors. Health Educ. Res. **22**(5), 691–702 (2007). https://doi.org/10.1093/her/cyl148
37. Lewis, J.R.: Psychometric evaluation of the PSSUQ using data from five years of usability studies. Int. J. Hum.-Comput. Interact. **14**(3–4), 463–488 (2002). https://doi.org/10.1080/10447318.2002.9669130
38. Matta, A.D., Gonçalves, F.L., Bizarro, L.: Delay discounting: concepts and measures. Psychol. Neurosci. **5**(2), 135–146 (2012). https://doi.org/10.3922/j.psns.2012.2.03
39. Mazur, J.E.: An adjusting procedure for studying delayed reinforcement. Quant. Anal. Behav. **5**, 55–73 (1987)
40. Meinlschmidt, G., et al.: Smartphone-based psychotherapeutic micro-interventions to improve mood in a real-world setting. Front. Psychol. **7**, 1112 (2016). https://doi.org/10.3389/fpsyg.2016.01112
41. Meinlschmidt, G., et al.: Personalized prediction of smartphone-based psychotherapeutic micro-intervention success using machine learning. J. Affect. Disord. **264**, 430–437 (2020). https://doi.org/10.1016/j.jad.2019.11.071
42. Meyerowitz-Katz, G., Ravi, S., Arnolda, L., Feng, X., Maberly, G., Astell-Burt, T., et al.: Rates of attrition and dropout in app-based interventions for chronic disease: systematic review and meta-analysis. J. Med. Internet Res. **22**(9), e20283 (2020). https://doi.org/10.2196/20283
43. Miller, C.K.: Adaptive intervention designs to promote behavioral change in adults: what is the evidence? Curr. Diab.Rep. **19**(2), 1–9 (2019). https://doi.org/10.1007/s11892-019-1127-4

44. Mönninghoff, A., et al.: Long-term effectiveness of mhealth physical activity interventions: systematic review and meta-analysis of randomized controlled trials. J. Med. Internet Res. **23**(4), e26699 (2021). https://doi.org/10.2196/26699
45. O'Donnell, S., Daniel, T.O., Epstein, L.H.: Does goal relevant episodic future thinking amplify the effect on delay discounting? Conscious. Cogn. **51**, 10–16 (2017). https://doi.org/10.1016/j.concog.2017.02.014
46. Odum, A.L.: Delay discounting: i'm ak, you're ak. J. Exp. Anal. Behav. **96**(3), 427–439 (2011). https://doi.org/10.1901/jeab.2011.96-423
47. O'Neill, J., Daniel, T.O., Epstein, L.H.: Episodic future thinking reduces eating in a food court. Eat. Behav. **20**, 9–13 (2016). https://doi.org/10.1016/j.eatbeh.2015.10.002
48. Persson, D.R., Zhukouskaya, K., Wegener, A.M.K., Jørgensen, L.K., Bardram, J.E., Bækgaard, P.: Exploring patient needs and solutions in type 2 diabetes: a co-creation study. Publication in preparation (2023)
49. Schacter, D.L., Benoit, R.G., Szpunar, K.K.: Episodic future thinking: mechanisms and functions. Curr. Opin. Behav. Sci. **17**, 41–50 (2017). https://doi.org/10.1016/j.cobeha.2017.06.002
50. Skinner, T., Joensen, L., Parkin, T.: Twenty-five years of diabetes distress research. Diabet. Med. **37**(3), 393–400 (2020). https://doi.org/10.1111/dme.14157
51. Stein, J.S., et al.: Bleak present, bright future: II. Combined effects of episodic future thinking and scarcity on delay discounting in adults at risk for type 2 diabetes. J. Behav. Med. **44**(2), 222–230 (2020). https://doi.org/10.1007/s10865-020-00178-7
52. Stein, J.S., Sze, Y.Y., Athamneh, L., Koffarnus, M.N., Epstein, L.H., Bickel, W.K.: Think fast: rapid assessment of the effects of episodic future thinking on delay discounting in overweight/obese participants. J. Behav. Med. **40**(5), 832–838 (2017). https://doi.org/10.1007/s10865-017-9857-8
53. Stein, J.S., Tegge, A.N., Turner, J.K., Bickel, W.K.: Episodic future thinking reduces delay discounting and cigarette demand: an investigation of the good-subject effect. J. Behav. Med. **41**(2), 269–276 (2017). https://doi.org/10.1007/s10865-017-9908-1
54. Stein, J.S., Wilson, A.G., Koffarnus, M.N., Daniel, T.O., Epstein, L.H., Bickel, W.K.: Unstuck in time: episodic future thinking reduces delay discounting and cigarette smoking. Psychopharmacology **233**(21), 3771–3778 (2016). https://doi.org/10.1007/s00213-016-4410-y
55. Sze, Y.Y., Daniel, T.O., Kilanowski, C.K., Collins, R.L., Epstein, L.H.: Web-based and mobile delivery of an episodic future thinking intervention for overweight and obese families: a feasibility study. JMIR Mhealth Uhealth **3**(4), e4603 (2015). https://doi.org/10.2196/mhealth.4603
56. Sze, Y.Y., Stein, J.S., Bickel, W.K., Paluch, R.A., Epstein, L.H.: Bleak present, bright future: online episodic future thinking, scarcity, delay discounting, and food demand. Clin. Psychol. Sci. **5**(4), 683–697 (2017). https://doi.org/10.1177/2167702617696511
57. Tatara, N., Årsand, E., Bratteteig, T., Hartvigsen, G.: Usage and perceptions of a mobile self-management application for people with type 2 diabetes: qualitative study of a five-month trial (2013). https://doi.org/10.3233/978-1-61499-289-9-127
58. Weller, R.E., Cook, E.W., III., Avsar, K.B., Cox, J.E.: Obese women show greater delay discounting than healthy-weight women. Appetite **51**(3), 563–569 (2008). https://doi.org/10.1016/j.appet.2008.04.010

59. Xu, X., et al.: Creating a smartphone app for caregivers of children with atopic dermatitis with caregivers, health care professionals, and digital health experts: participatory co-design. JMIR Mhealth Uhealth **8**(10), e16898 (2020). https://doi.org/10.2196/16898
60. Ye, J.Y., et al.: A meta-analysis of the effects of episodic future thinking on delay discounting. Q. J. Exp. Psychol. 1876–1891 (2021). https://doi.org/10.1177/17470218211066282