

Examining the Effect of Historical Planning Records on People's Planning and Execution of Subsequent Daily Physical Exercise

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ABSTRACT

Making and executing physical exercise plans have been shown to help people improve their physical activity levels. Still, it's hard for people to anticipate potential barriers to plan execution, which puts their plan at risk of being disrupted. Little research has been done on leveraging people's previous planning records to inform their planning for future physical exercises. In this paper, we conducted a 28-day study with 17 participants to understand their experience of planning for regular physical activity without and with historical planning records. Findings show that people could reflect on their historical planning records and develop strategies accordingly to address the challenges in their plan creation and execution. Reflecting on findings, we discuss the implications for supporting people to reflect on historical planning records and use them to inform future planning.

Author Keywords

physical activity, planning, routine modeling, self-reflection

1 INTRODUCTION

Participating in regular physical exercise helps people reduce the risk of chronic disease including cardiovascular diseases and type 2 diabetes [36]. To maintain substantial health status, adults are recommended to do at least 150 minutes of moderate-intensity aerobic physical activity per week [46]. However, less than 25% of American adults meet this guideline [22]. 25.7% of American adults reported sitting for more than 8 hours per day, and 44.6% were physically inactive [40]. Several barriers prevent people from being physically active including lack of time, lack of motivation [10,15]. Researchers utilized digital devices, including mobile phones and fitness

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rings, to support people with their practice of being more physically active as they provide feasible ways to track and help people reflect on their physical activities [11,17,19,32].

Planning has been found to be an effective way to transfer people's intentions into actions [18] and has been used as a strategy to help people be more physically active [29]. Prior work explored how digital technology could support people to form effective action plans by specifying when, where and how in their action planning [16,31,43], thus improve their physical activity level [13].

Though supporting people to specify their plans helps overcome the "intention-behavior gap" [12], people face many challenges in executing their plans. Since people's physical exercise can be influenced by different contextual factors (e.g., activity types, environment, social factors) [34], their physical exercise plans can be disrupted by personal (e.g., emotion, perceived lack of time) and environmental barriers (e.g., weather, temperature) [15]. Prior literature suggested utilizing contextual factors as a way to support people to identify the "sweet spots" on their schedule that they are more likely to perform physical activity [30]. But still, it was difficult for people to foresee unexpected events (e.g., impromptu social events, emergency, sudden tiredness) when making their plans. Even though the activity was planned within the "sweet spots," their plans could be disrupted by unexpected and unplanned events [30].

When monitoring their physical activities, people found value in their historical information and considered historical records as a source to find trends [28] and patterns of success and failures [11]. Prior work suggests that historical records might potentially help people anticipate future situations. Sniehotta et al. argued that planning was grounded on personal experience and suggested that coping planning might be more effective after participants have had experience with the intended activity. [35]. People would reflect on past experiences and use that reflection to plan for future activities by imagining future events [37]. While prior work suggests that historical information may help with people's planning, it's unclear how people would leverage their historic planning records into their later planning, and whether they can utilize historical information to deal with challenges in the plan execution. To better understand how historical planning records might affect people's planning and execution for subsequent physical activity, this study aims to answer the following questions:

1. How would people use historical planning records to inform their planning for future physical exercise?
2. Could historical planning records help people deal with challenges in plan execution?

To answer these questions, we developed two versions of a physical exercise planning app, Physicify, as probes to understand people's experience of planning without and with historical records. Physicify 1 provided users with the basic experience of planning and reporting regular physical exercise without historical reference. Built upon Physicify 1, Physicify 2 allowed users to refer to their historical planning data, including successful and unsuccessful plans, when planning for physical exercise. We recruited 17 participants to participate in a 28-day user study, during which they used the app to plan without and with historical records each for 14 days. For each participant, we conducted multiple interviews to understand their experiences of planning and performing regular physical exercises without and with historical records.

Findings from this study showed that people could refer to their historical records and plan for future exercises accordingly. First, with historical planning records presented, participants were able to identify common characteristics shared by failure records. Second, participants could utilize historical records to identify the likelihood of being disrupted by looking at their planning results across different conditions (e.g., different days of the week, different time-of-day). Third, historical records could help participants form and tailor their routines for physical exercise by identifying risk factors. Additionally, we found that historical records benefited participants' self-experimentation in finding preferable conditions to perform physical exercise.

Overall, this study makes contributions in the following ways:

1. We contribute to the understanding of how people would reflect on their historical planning records, and suggest ways to support people's sensemaking with their historical records.
2. We provide empirical evidence that historical planning records could help people avoid unexpected events in their planning process. We make suggestions on designing tools to better support people to identify the uncertainties in their future schedules and plan physical exercise accordingly.
3. We demonstrate that historical planning records can be used as a way for people to carry out self-experimentation around performing physical exercise under different conditions. We provide suggestions on how to use historical records to facilitate people's self-experimentation.

2 RELATED WORK

In this section, we review prior work relevant to this study. We start with providing a background of existing works that aimed to help people plan for physical exercise. Then we provide an overview of understanding how people reflect on their activity records.

2.1 Planning for physical exercise

Planning has been found to be an effective strategy to help people maintain regular moderate physical activity [29]. When making plans, forming implementation intentions by making if-then plans help people deal with the intention-behavior gap [20]. Making plans for physical activities helped people increase the likelihood of working out [6]. The if-then planning connects an anticipated situation (i.e., when, where) with the action (i.e., how) [18]. Action planning and coping planning are two strategies of forming implementation intention [9]. Action planning refers to the planning method of specifying when, where and how to perform a behavior. Coping planning refers to identifying potential barriers that might impede plan execution. Successfully carrying out the implementation intention strategy needs the plan to be as precise as possible [41] and viable [13].

Prior work suggests several ways to support people's planning. PlanSourcing explored creating behavior-change plans for individuals by strangers and friends [3]. And CrowdFit evaluated the idea of using crowdsourcing to create exercise plans for individuals [2]. Lee et al. showed that self-experimentation could be used as a way to help users create their own personalized behavior-change plans [25]. HeartStep leveraged users' contextual information to send them contextual tailored information to help users form action plans to be physically active [23]. Wang et al. presented a mobile-based personal mobility pattern visualization app to assist people to make better walking plans for reducing sedentary behavior [42].

Though those strategies helped people form better plans, people face challenges in executing their plans. Contextual factors, such as weather, social factors, time and other activities, impact how people create and execute their plans [30]. Thus, successful plan execution requires users to anticipate contextual conditions that support the intended physical activity [30]. Though people could identify such sweet spots in their planning process, their plans were still vulnerable when facing unexpected or unplanned events, such as impromptu social events and emergency situations. Therefore, we aim to understand how people deal with those challenges in this study.

2.2 Reflect on historical records

The Theory of Planned Behavior suggests that people's past behavior could be treated as a source to reflect on the factors that determine the intended behavior [4]. User-generated data could be used as a source of self-reflection on behavior [1] and help with decision-making. Li et al. defined the reflection process as people reflecting on their personal information by looking at collected personal information or interacting with information visualizations [27]. This reflection helps them decide what action to take [27]. Nowadays, with the help of digital devices such as mobile phones and fitness trackers, people can easily collect data to facilitate self-reflection. Prior work addresses how to support people with their self-reflection. Thudt et al. explored using visualization of users' data to facilitate self-reflection [38]. LifelogExplorer aimed to present users with their past experiences to allow them to discover patterns in their reactions to different life events [24]. Lee et

al. found that reflecting on their past experience helped people set up personalized walking plans [26].

Defined as a process of recalling past experience and using reflection to inform future practice [44], "self-reflection" connects people's experience with their intended actions. When people are looking at their personal data, they will try to find patterns and trends in their historical data [28]. The history of people's past behavior, which helps them find patterns of failures and success, further contribute to their awareness of physical activity level [11]. Reflecting on past experiences facilitates how people imagine and plan for future activities [37]. Prior studies have shown that reflecting on past experiences improved people's well-being in general [8,21]. Few studies have addressed how people could utilize reflection on previous experiences to inform future planning. In this study, we are interested to see how technology could be better designed to support people's reflection on their past experiences and how people could leverage their historical planning records to inform future planning.

3 METHOD

This study aimed to understand people's experience of planning for regular physical exercise with historical planning data. Prior literature suggests that reflecting on contextual factors and physical activities help people find opportunities for physical activities [14]. To understand how participants could utilize historical records to identify future opportunities for physical exercise, we wanted to present participants with contextual information, such as weather, time-of-day and day of the week, that associated with historical planning records. We wanted to organize and summarize the historical data in a way that participants can quickly perceive. And we wanted participants to be able to report and plan for regular physical exercise in a relatively low burden way. To implement those design aspects, we chose to develop a mobile activity planning app, Physicify, to deliver the experience of planning with historical records to participants.

We divided this 28-day study into two phases to compare participants' planning experiences without and with historical records (Fig 1). In the first phase, which lasted for 14 days, we provided participants with a basic planning experience without any historical data using Physicify 1. This study phase aimed to better understand participants' characteristics in planning for physical exercises and the challenges in their planning and execution process. The first phase also let participants accumulate planning data they can refer to in the second phase. In the second phase of this study, we incorporated historical references into their planning process. Participants were provided with their historical planning data when using Physicify 2 to plan physical exercise. In doing so, we want to see if the historical reference helped to solve the challenges encountered in the previous stage. To collect data regarding participants' planning experiences without and with historical reference, we held three interviews remotely with each participant at the start of the study, at the end of the first phase and the end of the second phase.

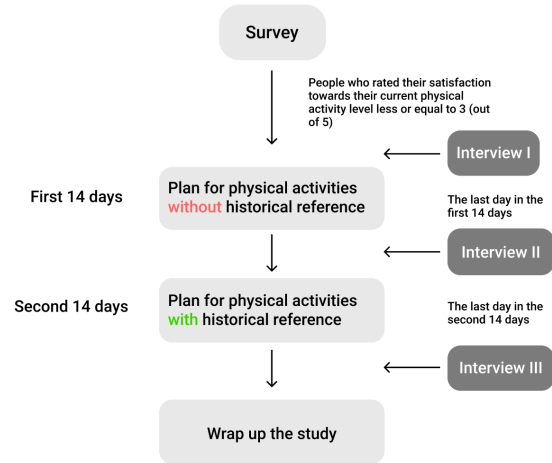


Figure 1. The study has been divided into two phases. Each participant participated three interviews and shared their experience of performing physical exercises

3.1 Participants and Recruitment

Participants were recruited through mailing lists at the first author's university. Recruiting emails contained a screening in which we asked respondents to indicate their satisfaction towards their current physical activity level on a Likert scale from 1-5. Respondents who reported their satisfaction were equal to or lower than 3 were invited to participate in this study.

We recruited 20 participants at the start of this study. All participants were either current students (Undergraduate students, Master's students and Ph.D. students) or alumni at the first author's school. 3 participants quit in the middle of this study because of a busy schedule or technical issues (couldn't install the Physicify app). Their data were excluded from the final data analysis. Out of the 17 participants who completed the whole study, 1 was male and 16 were female. To let participants generate sufficient historical data that they could refer to, we required participants to plan and report physical exercises at least 4 times a week to get full compensation of \$77. They could choose to do 1 extra plan per week and earn \$2 for each extra plan. In total, they were able to earn \$8 for extra planning.

3.2 System Design

To probe participants' experience of planning for regular physical exercise without and with historical reference, we developed two versions of a physical activity planning tool, Physicify. Both Physicify 1 and Physicify 2 were iOS applications developed by the team and distributed to participants using Apple's Testflight service. Both app versions allowed participants to plan and report their physical exercise with participants' plans and reports uploaded to Google Firebase. The major difference between Physicify 1 and Physicify 2 was that Physicify 2 provided participants with their planning records and contextual data (weather, temperature, schedule) while Physicify 1 only allowed participants to plan and report their physical exercises.

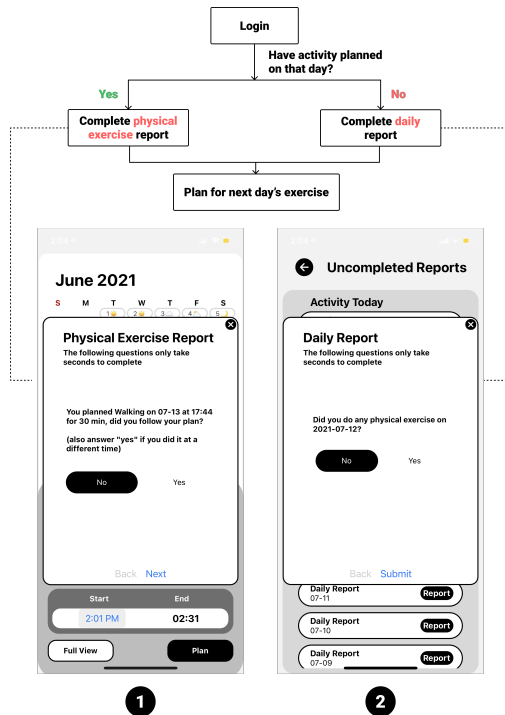


Figure 2. At the end of each day, participants were required to report their plans and plan for a new exercise for a future date. Inside the app, participants could either: (1) report their plan completion if an exercise was planned on that day, (2) report if they did any physical exercise if no exercise was planned on that day

We asked participants to complete a report daily at the end of each day (Fig 2). The daily reports have two forms: If participants had physical exercise planned on that day, they needed to report if they had completed their plans (Fig 2 (1)). If participants didn't have any physical exercise planned, participants needed to report whether they did any physical exercises (Fig 2 (2)). If participants did exercise in either situation, they were asked to report their satisfaction towards that exercise experience (participants also chose from "Unsatisfied", "Neutral" and "Satisfied") [5,7]. If they didn't complete their plan, they needed to report the reason and if they engaged in any other physical exercise. In the interviews, We used the reported satisfaction of each experience to understand if they performed the planned exercises in the way they preferred. This self-report interaction is the same on Physicify 1 and Physicify 2.

To plan physical exercise for the next day, participants needed to specify the date they want to conduct the exercise, the type of the exercise and the start time of the exercise (Fig 3 (2)). They could add self-defined exercises if they didn't find the intended exercise type in the predefined list. To better understand how participants anticipate future opportunities for performing physical exercise, participants were only allowed to plan for one physical exercise on one future date each time. Participants were asked to plan for a physical exercise at least 4 times a week to get full compensation. Both Physicify 1 and Physicify 2 sent notifications to participants to remind them of their plans 1 hour before the starting time.

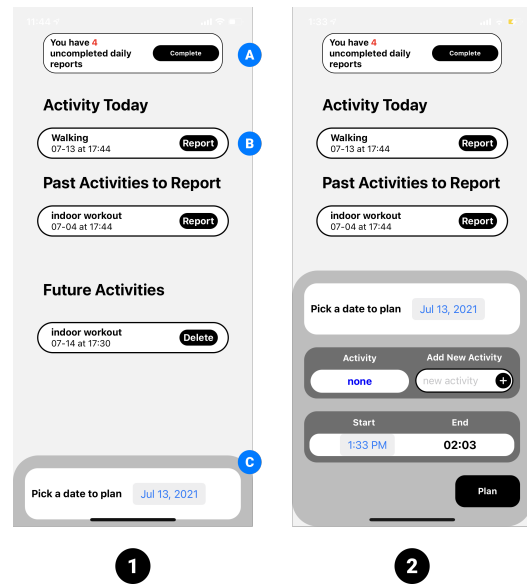


Figure 3. (1) Both the Physicify 1 and Physicify 2 share the same planning panel which asks users to specify the exercise type and the start time. (2) Physicify 1 provided participants with a basic planning experience without historical reference on their previous plan completion. On Physicify 1, users could: (A) complete daily reports (report the days without a physical exercise plan), (B) report physical exercise report (report planned physical exercise), (C) specify the planning condition by dragging up the planning panel

At the beginning of the study, we recommended participants always open the Physicify 1 / Physicify 2 at the end of each day, complete the report for that day, and then plan for an exercise tomorrow. Still, participants had the option to plan for any future date. Both app versions reminded them to report and plan for a future exercise at 8 pm each day.

3.2.1 Physicify 1

Physicify 1 aimed to provide participants with a basic experience of planning for regular physical exercises (Fig 3 (1)). It would list participants' previous unreported plans in case they didn't report their exercise in time. It would also show them the exercise they planned for the future. Once the participants completed the report regarding specific exercise plans, that record of that exercise plan would disappear from the screen.

3.2.2 Physicify 2

Physicify 2 was developed on top of Physicify 1, and it focused on providing participants with the experience of planning with historical data and contextual information. Physicify 2 aimed to help participants explore their historical planning records from multiple perspectives and reduce their burden of interpreting their records.

Based on what they reported about how they conducted previous physical exercise plans, participants' historical planning records were visualized and presented in two views: a summary view and a calendar view (Fig 4 (1)(2)). We color-coded participants' planning records on both views (red represented uncompleted plans and green represented completed plans). The summary view and calendar views were organized as

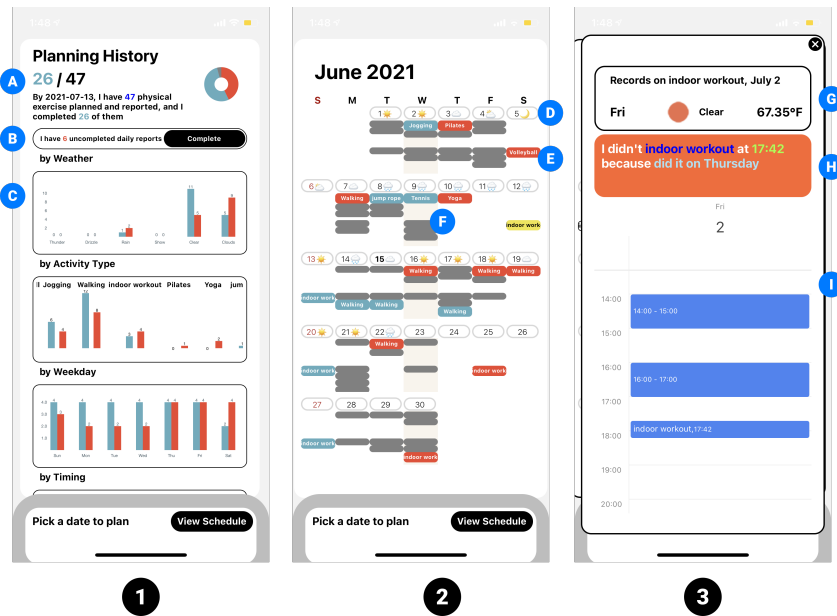


Figure 4. Physicify 2 allowed participants to explore their historical planning data from multiple perspective. (1) On the historical summary view, participants could: (A) view their total completion by numbers and on the pie chart, (B) complete previous unreported plans, (C) view their completion records under different conditions in bar charts. (2) On the calendar view, participants were presented with detailed information regarding their planning records, including (D) the weather condition, (E) the physical exercise type and completion status (color coded), (F) other events scheduled on their Google Calendar, events planned on the same day of the week were highlighted by the light yellow bar. (3) By clicking on the planning records on the calendar, participants could see (G) the contextual information regarding a specific records (i.e., day of the week, weather and temperature) (H) their plan completion status (i.e., whether the plan was completed, completed exercise and start time, reason for fail to complete the plan) (I) how the physical exercise was planned within their schedule

cards on the same screen so participants could easily swipe between.

To give participants a clear overview of their plan completion under different conditions, we used the summary view to group participants' planning records by different conditions (weather, type, days of the week, time-of-day). We used bar charts to represent users' planning records as the bar chart was easier for users to perceive regarding its readability and comprehension [39] (Fig 4 (C)). On each bar chart, the height of the bar indicated the number of the records (e.g., 5 uncompleted planning records on Wednesday, 10 completed planning records before 12 pm). The summary view also offered an overview of participants' overall completion rate (plans that they completed versus the total number of plans they made) at the top (Fig 4 (A)).

To allow participants to further explore and interact with their planning records, we also designed calendar views which listed participants' Google calendar events (Fig 4 (2)): the grey boxes and physical exercise plans (Fig 4 (E)) (both future plans and previous plans) in a calendar format. The personal information (title, description, location, etc.) associated with their Google calendar events had been removed for privacy concerns. The boxes which represented their plans had the name of the planned exercise and were color-coded to indicate the status of the plan (green represented participants successfully executed the plan, red meant they failed to execute the plan and didn't do any physical exercise on the planned day,

yellow represented they didn't follow the plan but did other exercises instead).

Prior work found that contextual information, including time-of-day and activity, could help people identify future opportunities when planning [30]. In this study, we wanted to further understand how historical records change the way of reflecting on contextual information and identifying future opportunities. On Physicify 2, we presented different types of contextual information including weather (Fig 4 (D)(G)), schedule (Fig 4 (I)), temperature (Fig 4 (G)), time-of-day (Fig 4 (H)(I)) and days of the week (Fig 4 (E)(G)). On the calendar view, their events have been divided into two rows based on if the events started before 12 pm or after 12 pm. Events in each row were organized in chronological order. Depending on the date they chose, all the events on the same day of the week would be highlighted (Fig 4 (F)). The weather on each date was indicated by an icon beside the date (Fig 4 (D)). By clicking on a date, participants could see the details regarding that day (Fig 4 (3)), including the weather and temperature information (Fig 4 (G)), their planning details (Fig 4 (H)) and their schedule on that day (Fig 4 (I)).

To plan a new physical exercise using Physicify 2, participants could first view their schedule on the intended date. When they were specifying the activity type and the start time, a filter would be applied to the calendar view to show them only similar records. Participants could remove the filter at any point without affecting how they specify their plans. The

filter provided participants with a way to look back at similar records when planning for future exercise.

3.3 Interviews

We conducted interviews to understand participants' experience of planning for regular physical exercise without and with historical reference. Interviews were conducted by the first author using a semi-structured interview protocol. All interviews were audio and video recorded. The interviews were later transcribed and coded.

3.3.1 Interview I

The first interview was held at the start of the study. The first interview aimed to understand participants' experiences with performing physical exercises before the study and their barriers. We used this first interview to understand participants' characteristics in performing physical exercise and their preferences. Participants were first asked to walk through their recent experience of conducting physical exercises. Based on their response, we further asked them why they chose to do certain activities at certain times. To understand their barriers to performing regular physical exercise, we asked participants the reason for being unsatisfied with their physical exercise level. We also used this interview to understand participants' planning experience prior to this study. If the participants mentioned they would plan for physical exercise, we would ask them to provide more details regarding what they would consider when making plans and the challenges for them to follow their plans. If the participants mentioned they would use mobile apps to assist their planning process, we asked them to show us the app and tell us the features they thought useful.

After the first interview, participants were instructed to install Physicify 1.

3.3.2 Interview II

14 days after the first interview, we hold a second interview to understand participants' experience of planning for physical exercise (without any historical reference). We first asked participants to walk us through their general experience of conducting physical exercises in the past two weeks. To understand participants' thinking process of making physical exercise plans, we asked participants to plan a physical exercise for the next day in front of the investigator by sharing their screen. We then asked participants to provide the reasons for planning for certain activities at a certain time.

We then asked participants' plan execution experience. To help them recall their experiences, we prompted participants with information regarding their plans. (e.g., the plan completion, planned exercise type, time-of-day and satisfaction). We first asked participants to walk us through one of their recent experiences of following the plan. Then we asked them to walk through some critical incidents (e.g., completed the plan but unsatisfied, outliers regarding planning style, failed to follow the plan, changed the planning condition, etc.). At the end of the interview, we asked participants to talk about how they think physical exercise experience is different from their experience before the study.

After the second interview, participants were instructed to install Physicify 2.

3.3.3 Interview III

After using Physicify 2 for 14 days, participants were invited to the last interview. The last interview aimed to understand participants' experience of planning with historical records. In this interview, we wanted to see how historical records helped to inform participants' planning for future exercises. In the last interview, we started by asking participants to go through their planning records on Physicify 2 by sharing their screen. To better understand how participants perceived and interpreted their historical records on the calendar view and summary view, we asked participants to speak out aloud about anything that came into their mind when walking through the historical records. To evaluate if the historical records helped to generate insights regarding planning experience, we asked participants if they found anything interesting in their records after the walking through. Based on their response, we asked participants how they would refer to the historical records and different factors in their planning process. To explore how participants applied their understanding of historical records to their planning process, we asked participants to plan a new exercise for tomorrow in front of the investigator and verbally walk us through their thinking process. We also asked participants if they would refer to any specific events in their previous planning experience and how they prioritize different factors in their planning process.

We wanted to know how historical records affect the way participants specify their plans. We looked back into their response regarding their planning style and challenges in the second interview and asked them if anything changed. With their records shared on the screen, we asked them to walk us through some records we found interesting (change of planning style, patterns, etc.). We also asked them the challenges for them to stick to their plans during this stage.

3.4 Data Analysis

We audio-recorded and video recorded all the interviews. Interviews were later transcribed and coded using in vivo coding [33]. Codes were first organized based on the interview sequence (i.e., first interview, second interview, third interview) to allow comparison between different stages (i.e., pre-study planning experience, first phase planning experience and second phase planning experience). Codes were then grouped to address the research questions (e.g., challenges of plan execution, challenges of plan creation, factors affected plan execution, factors affect plan creation). Codes were later re-grouped with the themes that emerged from interviews (e.g., reflection on failure records, deal with future uncertainties, practice of tailoring routines, practice of self-experimentation). The first author conducted the data analysis by further grouping codes to reveal potential findings regarding participants' experience of planning for regular physical exercise without and with historical reference. The coded data under each potential finding was then analyzed to evaluate if the finding was valid.

4 FINDINGS

The findings from the interviews shed light on how participants used historical planning records to inform their plans for future exercise. While prior studies reported challenges for people to anticipate potential plan disruption in plan creation [30], our work further addressed those challenges by showing how people could refer to their historical planning records and deal with those challenges.

4.1 Participants were able to identify common characteristics shared by their failure records

The findings from the interviews showed that participants could interpret their failure records as a whole by identifying their common characteristics. Participants tended to pay attention to their failure records when they were looking at their historical records. The historical records provided participants with a way to evaluate multiple failure experiences as a whole. When interpreting their failure records, participants would try to draw connections between them based on their common characteristics (e.g., same time-of-day, same day of the week). In this way, participants were able to make assumptions about the common reason that caused the failure. Additionally, we found that failure records motivated participants in general but might have some negative effects on their physical activity level.

4.1.1 Participants tended to pay attention to their failure records when going through their historical planning records. When P12 was looking at her events on the calendar view, she would first consider the failure records even though she could see all the records: *"whenever I am looking at it [the calendar view], I look at it as a whole, so I [usually] looked at the previous two weeks activities [...] but whenever I was planning, it was like okay I wasn't able to do this last Saturday, and it was because of this reason, so I should take into consideration and then plan."* The color coding further helped participants quickly perceive the portion of the data that indicated the failure, as reported by P6: *"I think the red [records] I [could] quickly perceive that as things I didn't do, the blue would probably take me like two or three seconds [to perceive]."*

4.1.2 With the historical data presented, participants were able to make sense of their failure records by identifying common characteristics between them. The common characteristics (e.g., on the same day of the week, at the same time-of-day) associated with the failure records allowed participants to interpret previous failures as a whole and explain the reason behind. When P12 was looking at her records on the calendar view, she saw all her failure records were on weekends: *"I could also see that mostly Saturdays [and] Sundays, I was not able to do activities [...] I somehow got an idea that planning on weekends or relying on weekends [may not be reliable], since you have a very ambiguous plan on weekends"*. By looking at the calendar view, P10 also found that she had 5 yellow records (that she didn't follow the plan but substituted with other physical exercises). Since all those yellow records were about doing workouts, she reached the assumption that sticking to one type of exercise might not be a good idea: *"actually for the activity type. I have quite five yellows here*

[...] it would tell me that keeping up on one activity is not interesting enough. And I need to make it more diverse".

4.1.3 Failure records further motivated participants to better follow their plans as they tried to avoid the negative feedback from failure records. When looking at the failure records, participants had a negative perception in general. When P9 was walking through her planning records on the historical summary view, she mentioned that: *"I don't like seeing the red records [...] It made me want to complete stuff more, but it didn't affect how I planned [...] I think like having a visual [representation] of how many times you didn't complete something and red is like a very negative connotation, and that made me want to keep that [failure records] low"*. Though most of the participants were motivated by the failure records, we observed one participant mentioned she tended to plan for easier activities in case of having failure records, as reported by P8: *"I really don't feel like I need to be really sure about what I'm gonna do tomorrow. So (when I plan exercise that) it's either going to be an easy one, or I just don't plan anything [because] I don't want to see the red part in my report."*

To conclude, participants tended to pay attention to their failure records when looking at their historical records. Participants were able to interpret their failure records as a whole by connecting them with their common characteristics. Moreover, we found that failure records could motivate participants to better stick to their plans but potentially had some negative effects.

4.2 Historical planning records helped participants identify different levels of uncertainties in their future schedule

We also found that historical planning records could help participants identify different levels of uncertainties in their future schedules. The different levels of uncertainties refer to the likelihood of being disrupted by unexpected events when executing the plan. We used this term, "levels of uncertainty", because most of the participants failed to identify any specific future events that might disrupt their plans. Instead, when participants were presented with the historical planning records, they were able to identify the conditions (e.g., certain days of the week, certain time-of-day) which involve higher risks of being disrupted. We further found that those anticipated uncertainties in people's daily lives can be grouped around those conditions. Instead of identifying the specific events that might disrupt their plans, participants could tell that planning under certain conditions would bring more uncertainties to their plan execution. Based on this understanding of the anticipated uncertainties, Participants could develop planning strategies to handle those uncertainties, thus avoiding unexpected events indirectly.

4.2.1 Participants' schedules involve different levels of uncertainties under different conditions. There were certain conditions that involved higher risks of being disrupted by unexpected events. Among those conditions, the days of the week and time-of-day were commonly mentioned. For some participants, the levels of uncertainties depended on different days of the week. In the second interview, P12 mentioned

there were certain days of the week that she was more likely to have unexpected events: *“usually on Fridays or on weekends, sometimes we just have unexpected plans.”* Some participants mentioned that the uncertainties of their schedule varied with different time-of-days in a day, as mentioned by P16: *“actually morning is good because usually compared to other times like in the afternoon [...] Things rarely happen suddenly in the morning.”* Participants seemed to have a sense of which days of the week or times might be more suitable for doing the exercise based on the likelihood of being disturbed. However, without any historical information presented, when participants were planning for future exercise by referring to their previous experience, they tended to only focus on the most recent ones (experience within a few days).

4.2.2 Participants could identify the conditions with higher levels of uncertainty by referring to the historical planning records. P7 found out that she was less likely to do workouts on certain days of the week when she saw that she failed to carry out all her plans on Tuesdays and Wednesdays by referring to the by-weekday bar chart on the historical summary view, and she would like to avoid those days of the week in her future planning: *“I can see for Tuesday and Wednesday, it’s easier for me to not complete the plan, and for other days is easier for me to complete the plan [...] so by this view, I will think about like for Tuesday and Wednesday, maybe I should change.”* After seeing the distribution of uncertainties in their planning history, P7 also try to explain the reason behind: *“maybe for those two days, I always have other plans, or I always feel lazy that I don’t want to do the exercise.”* By referring to the records on the calendar view, P3 saw that she usually skipped the weekends when making physical exercise plans, she further explained that her weekends’ schedule involved more uncertainties which made it hard for her to plan: *“for me like my weekends are kind of all over the place. So I don’t typically plan for them. (But) like Friday is the most predictable [...] More often than not. I can plan easier on weekdays rather than weekends”.*

4.2.3 Participants could develop planning strategies to reduce the uncertainties involved in their plan execution. Even without an understanding of different levels of uncertainties, participants would tend to plan physical exercise under the conditions with a higher completion rate. Participant P2 found out she was more likely to stick to her plan on certain days of the week by referring to the records on the historical summary view. Though she was not sure about the reason, this made she tended to plan more on that weekday: *“I planned for something, and I will do that on Thursday, maybe plan for dancing on Thursday, because it seems I do stick to my plan for some reason on Thursday.”* P5 also tended to plan more under the condition with higher completion rates: *“I have a way higher percentage of like successfully completed activities in the afternoon like oh that’s true I’m gonna keep planning for the afternoon.”* Some participants could find out the reason behind and change their planning strategy accordingly. After looking at the completion status of her plans and how her plans were distributed on the calendar view, P10 tended to plan more on the days that she was more likely to do exercise and avoid the days with more failures: *“I definitely schedule with the work-*

out on Sunday because that’s pretty promising and Monday could do too, maybe avoid [Wednesday] [...] if I look at my schedule, on Wednesday, I have more meetings and [might be] tired or something because of that. If I plan, there’s a chance that I don’t do that.” During the second phase, participants still found it was hard for them to anticipate unexpected events. In this case, planning under the condition which involved less uncertainties helped them avoid unexpected events in general, as mentioned by P11: *“I feel in terms of unexpected things happening, I still cannot make a good control for it. But one thing changed, I started to do exercise during the time that I’m more likely to be free [...] I did have some of the physical activities at 3 pm to 4 pm, [because] I usually I have nothing to do at that time, and nobody will chat with me during that time.”* In the second phase, P12 identified weekends as the conditions with high-level uncertainties and avoided planning on weekends, she reported that this strategy helped her avoid unexpected events: *“I did not face that [unexpected events] this weekend, because when I planned I kept in mind that I could not do a few things last weekend, and I could see that. I could not do activities on Saturday and Sunday [...] so I would just leave it on, you know, the day to see if I’m really available and then decide on what to do”.*

To summarize, we found that participants’ schedules involved different levels of uncertainties. With the historical records presented, participants were able to identify different levels of uncertainties and associated it with different conditions (days of the week and time-of-day were mostly mentioned). By avoiding planning under conditions with higher levels of uncertainties or plan more under conditions with lower levels of uncertainties. Participants were able to avoid being disrupted by unexpected events in their plan execution.

4.3 Historical planning records helped participants tailor their routines for performing regular physical exercises

We found that having routines helped reduce uncertainties in participants’ planning, and historical records could further help participants tailor their existing routines for performing regular physical exercises. During the study, some participants noticed that they could better follow their plans on the days of the week, which involved a routine (mostly workdays), compared to days without a life routine (mostly weekends). But still, some of their routines were not tailored for physical exercise. In those cases, though the physical exercise was planned within their routines, it still faced the risk of being disrupted by events before or after the exercise. The historical records provide participants with a way to reflect on their routines which involved physical exercise. With a better understanding of the impact of their routines on physical exercise, participants could better tailor their routines for physical exercise by rearranging the order of activities.

4.3.1 Having a routine helped reduce uncertainties in participants’ daily schedules and therefore helped them better plan for physical exercises. Participants mentioned that they were less likely to be disturbed on the days they had routines, like workdays, compared to other weekdays, mostly weekends. P1 was a recent graduate student and was actively looking for jobs during the study. Given the fact that his schedule was

flexible at that time, he found it was hard to plan for exercise since his schedule involved lots of uncertainties: *"scheduling for my next exercise, for me, especially when I was working from home right now, is kind of difficult because there are so many unpredictable things that will be happening tomorrow"*. P1 thought a routine would reduce the uncertainties in his schedule and benefit his physical exercises: *"I mean in the future, [when] I got the job, and I [will] have a very fixed routine. I'll start my walk at night and get back at 6, and I will plan some of the exercises, maybe in the evening. [After that my schedule] will be predictable and I would like to definitely plan for that [more physical exercise]"*. Compared to the workdays with a routine, the weekends usually involve more uncertainties for many participants. Participants found it was hard for them to plan physical exercise on the weekends because of this uncertainty, as mentioned by P8: *"[for workdays] my time is more scheduled. At 2 or 3 [pm], I just like, that's my exercise time or else I don't have other stuff to do, it's kind of helped me to form that routine. For the weekend I'm completely free [...] I don't think I can keep my exercise plans on weekends, just impossible"*.

4.3.2 Physical exercise planned within a routine would be affected by events before and after. Though planning physical exercise within routines helped reduce uncertainties, participants' plan execution situation still depended on the events before and after. During the second interview, P13 would consider leaving enough time after the exercise to get ready for later activities. So in some cases she won't do the exercise even though there was a free time: *"[if I have] to get a lot of things done in one day [...] even if it [the physical exercise] was like very basic like 10 minutes, I think I was just like oh I don't have the time to do this right now and then to get ready for the other things I had to do that day afterward."* For participants who had a routine that involved physical exercise, the physical exercise plan could also be affected by the prior events, as mentioned by P8: *"so usually 30 minutes to one hour after the lunch I'll do the exercise. So if I eat my lunch at 12 tomorrow I would exercise at one, but if I had a late lunch, then it will be postponed."* During the first phase of the study, P10 used to plan for physical exercises around 9 pm since she was mostly available at that time after a series of activities. However, when the existing life routine was not tailored for physical exercise, the activities prior to the exercise brought more uncertainties, which added the risk of being disrupted when executing the physical exercise plans. P10 mentioned a typical failure of following her plans was caused by the delay of prior events and leaving time to sleep: *"I went to a grocery and we got home quite late and had dinner very late [...] so when we got home around 8 or 9, then we made dinner and then walk dog, and after everything, I guess, I was like a little tired [...] I really want to go sleep as early as possible, maybe it's 12am or 1am in that situation that I won't do the exercise."*

4.3.3 Historical records provide a way for participants to refer to their previous experience and find out the flaws in their routines so they can make changes accordingly. During the second phase of the study, P10 realized that her previous routines involved too many distractions after referring to her failures records on the calendar view: *"I realized that if I*

keep doing it at nine, there will be a lot of distractions so I decided to reconstruct my own whole schedule". By referring to failure records on the calendar view, P7 also realized that her routines of always planning for physical exercise at 10 pm might not work for Fridays since she might go home late after hanging out with friends: *"I think for Friday I may go out with my friends and I may choose other exercise types, maybe walking. Or, other activities, instead of workouts, because I know like when I get home late, I may not want to start doing the workouts, but if it's an exercise I could do it with my friend together in the daytime it may be easier for me to follow the plans."* To avoid being disrupted, P10 rearranged her routine by associating the workout with activities which involve fewer uncertainties: *"I decided to move the time [of doing workout] from nine to five, which is before the dinner, and at that time, I have fewer distractions [...] It gives me a mind that I need to work out at five like before I eat or before I go out or something, so it gives me a message that I should work hard before this stuff [...] It just give me a better idea that what activities should be before workouts and what activities should be after the workout."*

Participants' experience showed that having routines helped reduce uncertainties on their schedule and they were less likely to be disrupted on the days that involved routines. However, exercises planned within a routine may still be impacted by the events before and after. In those cases, historical records provided participants with a way to figure out how their plans were impacted by other routine events and make changes accordingly. By rearranging the exercise to the place that was less likely to be disrupted in the routine, participants were able to better stick to their plans.

4.4 Historical planning records help participants find preferable conditions of performing physical exercise

We found that the historical records could help participants find out preferable conditions for performing physical exercise. Participants with little prior experience performing regular physical exercise found it hard to specify conditions in their plans because they were unsure about their capability under different situations. In those cases, participants would try planning physical exercises under different conditions (e.g., different activity types, different time-of-day) until they found a preferable activity or a preferable time. During this practice, participants considered their historical records as a source to reflect on their trials. By referring to the trial records in their historical data, participants better understood their capability, thus improving planning strategies to fit their own conditions.

4.4.1 Participants with little prior experience of performing regular physical exercise found it difficult to specify their plans. For participants who didn't exercise regularly before this study, it was hard for them to find a preferable condition of performing physical exercise (e.g., find a preferable exercise or find a preferable time-of-day, etc.). When P13 was talking about her experience in the first phase of the study, she mentioned that: *"Probably picking what to do is the hardest part [...] it's just a question of what I want to do, what do I think I feel like doing"*. P12 mentioned that it took time for her to understand her capability of doing different exercises: *"it takes time to realize how*

much you can work out and how much you can do [...] maybe I shouldn't work out for 30 minutes when I'm doing Zumba, but jogging for 30 minutes is okay [...] [if] I just do this (do too much Zumba), you know, and next thing I realized that maybe I worked out too much yesterday." When planning for physical exercises on a regular basis, this unsureness towards one's capability of doing certain activities impacted the future exercise experience. In P12's case, Sometimes she would overdo the exercise, and being tired for the following days, which disrupted other physical exercise plans: "[planning on a regular basis] was really challenging because doing it every single day kind of takes lots of efforts [...] sometimes you're just too tired, like I did a lot of Zumba one time and I had a pain in my hands or on my legs for like two days, so it was really difficult to keep up with that".

4.4.2 Participants would try to plan physical exercise under different conditions to find a preferable one. When participants were involved in a new exercise, they would try performing the activity under different conditions to figure out a preferable one. Prior to this study, P16 would go running with her friends regularly, and she mentioned it took time for them to figure out a good time to run: "Maybe it was the beginning, and we were kind of trying different times, but now we learned that a time is good for us, so it was a time when we were kind of adjusting the time, and I think later we found that eight is a good time for us". Prior to this study, P8 also tried to do the exercise at different times. She later changed her planning strategy based on those experiences: "I tried it once in the morning, it was a disaster. I didn't eat anything, and I feel dizzy immediately after the abs. I can't even continue the following, so I realized eating is really important. And then another time I ate lunch, and right after lunch I started to do exercise and I started to puke. So it's like you can't do exercise immediately after eating and that's how I learned. [So I] always made my plan after lunch, but some time after lunch." For participants who didn't have prior experience of performing regular physical exercise, they had several trials on the way of performing physical exercise through the planning process, as mentioned by P13: "I see here there's a lot of trials and errors that I did over these past two weeks or these past four weeks [...] the first week was kind of rushing into doing things without really considering [...] I kind of jumped around the first week, and that was a trial week and I was trying more things that are going to be better for me or make me feel better".

4.4.3 Historical records helped participants reflect on their trials to figure out a preferable condition for performing physical exercise. By planning physical exercise under different conditions (e.g., different time-of-day, different exercises) and refer to those records in the historical planning data, participants gained a better understanding of their capabilities and were able to adjust their planning strategies accordingly. P5 would evaluate her completion in the historical records to have a general understanding of which exercises might be suitable for her and change planning strategy accordingly: "I'm noticing that I was missing a lot of exercises before and just seeing that like Okay, so I thought this [exercise] would work, but I keep missing them so it's not working, so I need to do something different." When P13 was planning for future exercise during

the second phase, she used the records on the calendar view to figure out her capability of performing different exercises: "while I was on the second version of the app, I definitely looked back at what I'd done for those first two weeks [...] [the calendar view] kind of gave me an overview for like how those two weeks went and being able to see that as like a whole entity. And then I could remember how did I feel at the end of the first week, like I felt a little bit tired and a little bit sore." Even though the calendar view provides a limited amount of information regarding each record (e.g., completion, weekday, weather, temperature, etc.), P13 was able to recall and evaluate the experience by referring to the records on the calendar view. P13 then applied this understanding to her planning strategy by planning the preferable exercise more: "I can look back at this [the calendar view] and remember that Oh, I did this [exercise] one week and that [exercise] didn't really work for me, but I performed this activity much better so I can take that and move forward". P12 also mentioned that the historical records on the calendar view helped her better understand her capabilities and helped with her planning: "Looking at my previous record helps me to gauge my own strengths or capabilities and then helps me in planning that activity accordingly." When planning for future activities, P12 tended to narrow down the activity type to be the most effective one that she figured out from her historical records: "in the previous week, I was kind of planning different activities [...] but when I worked out, I felt that [the workout] was the most effective activity.. that's why I switched to one activity [only perform workout] that I like".

The study showed that it took time for participants who lack prior experience of performing regular physical activities to find out the preferable conditions to plan. For those participants, they tended to first try different ways of performing physical exercises until they found a preferable condition. We found that historical records could help participants with this practice. Historical records provided a way for participants to reflect on their trials and better understand their capabilities. With a clear understanding of their capability of performing regular physical exercise under different conditions, participants were able to adjust their planning strategies to better fit with their own conditions.

5 DISCUSSION

This study explored how people would leverage their historical planning records to inform their planning for future physical exercise. We found that historical planning records could potentially help people better plan for regular physical exercises and execute their plans. Findings from this study shed light on how people would reflect on their historical planning records and develop their planning strategies accordingly. In this section, we summarize our findings and discuss opportunities for future research.

5.1 Support users' sensemaking with their failure records

Our findings suggest that people tend to look at their failure records when presented with historical planning records. Historical records which involve contextual information (e.g., time-of-day, days of the week, activity type) could help people draw connections between failure records and evaluate them as

a whole based on the common characteristics. More work may be needed to understand how to support people's sensemaking process with their failure records.

5.2 Support people's practice of identifying different levels of uncertainties

This study demonstrated that historical records could potentially help people identify different levels of uncertainties by grouping their planning records around different conditions. People may apply this understanding in their planning process to avoid planning under conditions that involve higher uncertainties, thus avoiding being disrupted by unexpected events. Based on this finding, we propose that a physical exercise planning tool that leverages people's historical planning records may consider supporting people to identify different levels of uncertainties in their planning process.

5.3 Support people tailor their routines for physical exercise

We found that historical planning records could help people tailor their routines for physical exercise. Incorporating physical exercise into routines may help people better make and execute their plans. And historical records could allow people to reflect on the existing routine and tailor it for physical exercise by rearranging the activities in the routine. Therefore, there is a need to support people's practice of incorporating the intended physical exercise into their routine and better tailor their routines for physical exercise.

5.4 Support people's self-experimentation with historical data

This study revealed that historical planning records could help people find preferable conditions for performing physical exercise. For people who are unsure about their capability of performing physical activities under certain conditions, historical planning records allow them to try performing physical exercise under different conditions and reflect on their records to find a preferable way of doing physical exercise. When designing a physical activity planning tool with historical planning records, researchers may need to consider users' needs of carrying out self-experimentation in their planning process. And we suggest that such a tool could better support users' self-experimentation with their historical planning data.

6 LIMITATIONS

The study result might not fully represent real-life situations due to the exploratory nature of the study. Participants in this study were asked to plan physical activities at a relatively high frequency (at least 4 times a week) over a short (28 days) period, which might not reflect the real-life planning experience. During the study, participants were aware of being participating in a study and being observed, making them tend to stick to their plans. However, this study was designed to be an exploratory study aiming to understand how people leverage their historical planning records to inform their future planning. The empirical evidence from this study provided insights into the potential effect of historical records on people's planning behavior. Future work may want to evaluate the possibility of incorporating historical planning records into a long-term

planning intervention and quantitatively evaluate the result by looking at their plans' completion rate.

Also, the types of participants were limited in this study. Findings from the study may not apply to a broader population. For all the 17 participants who completed the study, there was only one male. All participants were either current university students or new graduates, the way they organized their daily schedule might be different from people with years of working experience. Participants in this study also had prior experience with digital planning tools, such as Google Calendar. Future works might want to evaluate the effect of planning with historical records with a diverse population (e.g., middle-aged, older adults [45]).

7 CONCLUSION

This paper examined people's experiences of planning for regular physical activity without and with historical planning records. Our findings indicate that users can use the historical planning records to inform their planning for future physical activities. With historical planning records presented, users are able to draw connections between their failure records and interpret failure records under different conditions. By reflecting on the failure records, people further develop their understanding of their capabilities and are able to identify different levels of uncertainties in their daily schedule. Based on this understanding, people are able to avoid unexpected events when executing their plans and tailor their routines for physical exercises. Overall, this paper extends the previous discussion on supporting physical activity plans and contributes to an understanding of the effect of the historical planning records. This work suggests future research opportunities of leveraging historical planning data to support people's planning for regular physical activity.

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