Finding the Sweet Spot(s): Understanding Context to Support Physical Activity Plans

GAURAV PARUTHI, University of Michigan
SHRITI RAJ, University of Michigan
NATALIE COLABIANCHI, University of Michigan
PREDRAG KLASNJA, University of Michigan
MARK W. NEWMAN, University of Michigan

Creating actionable plans has been shown to be helpful in promoting physical activity. However, little re`search has been done on how best to support the creation and execution of plans. In this paper, we interviewed 16 participants to study the role that context plays in the formulation and execution of plans for physical activity. Our findings highlight nuanced ways that contextual factors interact with each other and with individual differences to impact planning. We propose the notion of *sweet spots* to encapsulate how particular contextual factors converge to create optimal states for performing physical activities. The concept of sweet spots helped us to better understand the creation and execution of plans made by our participants. We present design guidelines to show how sweet spots can help support physical activity planning and guide the design of context-based tools for planning support.

CCS Concepts: • **Human-centered computing → Ubiquitous and mobile COMPUTING systems and tools;**

Additional Key Words and Phrases: Context-aware systems, Behavior change, physical activity, planning, routine modeling, implementation intentions

ACM Reference Format:

Gaurav Paruthi, Shriti Raj, Natalie Colabianchi, Predrag Klasnja, and Mark W. Newman. 2018. Finding the Sweet Spot(s): Understanding Context to Support Physical Activity Plans. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 2, 1, Article 29 (March 2018), 17 pages. https://doi.org/10.1145/3191761

1 INTRODUCTION

Lack of physical activity is one of the most important behavioral risk factors for chronic diseases such as diabetes and coronary heart diseases. Yet, less than 20% of North Americans attain the recommended amount of physical activity [54]. The prevalence of chronic diseases continues to rise and is now responsible for over 70% of U.S. healthcare expenditures [27]. To address this problem, researchers have sought to leverage technologies such as mobile phones, web applications, and social networking tools to encourage physical activity [11] due to their low cost, high penetration, and integration in people's everyday lives.

Social cognition models, such as the Theory of Planned Behavior [3], have characterized motivational factors, such as people's intention to perform a particular health behavior, as the most proximal determinants of

Authors' addresses: Gaurav Paruthi (gparuthi@umich.edu), Shriti Raj, Natalie Colabianchi, Predrag Klasnja, Mark W. Newman, School of Information, 105 S. State St. Ann Arbor, MI 48109, USA

2474-9567/2018/3-ART29 $15.00

https://doi.org/10.1145/3191761

that behavior. However, it is a challenge for many people, even when motivated, to adopt and regularly perform a desired health behavior. To overcome this "intention-behavior gap," specifying plans about how to enact one's intentions and how to deal with difficulties in one's goal pursuit is a promising strategy [51]. Specifically, for physical activity, planning is a key predictor of physical activity maintenance over time [28,39].

While tools have been extensively used to encourage physical activity using a variety of techniques (e.g., motivation, information, reflection, reminders, and social influence)[15], there is limited support for specifying plans in such tools. That is, the design space for planning support as part of tools to promote physical activity remains largely unexplored and hence, creates an opportunity for researchers to contribute. Understanding how plans are made and when they fail or succeed could lead to the incorporation of improved planning support in tools to promote physical activity.

To better understand how people make plans for physical activity and how tools can be designed to support planning, this study aims to answer the following research questions:

1. What factors do people consider while specifying plans for physical activity?
2. What are the challenges of creating and executing plans for physical activity?

We interviewed 16 participants who demonstrated considerable motivation to perform physical activity but struggled to fit exercise into their lives. We found that multiple contextual factors such as weather, location, time, social interaction, and affect were considered by our participants in making physical activity plans. Moreover, these factors interact with each other and with the individual preferences of our participants to influence their plans for physical activity. Acknowledging the complexity that the consideration of multiple contextual factors and individual differences brings to planning, we present the notion of the *sweet spot*, a phenomenologically grounded construct to understand the role of context on plans.

While connections between context and activity have been noted in previous work [37], the notion of sweet spots helped to shed light on the nuanced interplay between these factors and the challenges they create for plan creation and execution. Specifically, we found that plan creation was challenging because of the need to consider multiple contextual factors, the constraints imposed by one's preferences and priorities that affected how participants weighed these factors, and the need to coordinate with others. Plan execution was challenging because of the difficulty in anticipating favorable and unfavorable contextual conditions, and in sustaining engagement in the face of fluctuating motivation. Additionally, we report that in dealing with these challenges, a few participants tried to strategize for improved plan execution.

We demonstrate how *sweet spot*, as a unified representation of converging factors, provides a novel and useful perspective to (a) bridge the gap between phenomenological and positivist perspectives of context to allow for computational support, and (b) inform the design of systems intended to support physical activity planning.

2 RELATED WORK

In this section, we describe prior work relevant to this study. We first provide a background on existing planning strategies and interventions to support planning. We then provide an overview of research on understanding factors affecting health behaviors, which is pertinent to our research question about understanding factors that affect physical activity plans.

2.1 Types of Planning Strategies

Creating plans is found to be one of the most effective ways of reaching behavior goals [34]. A plan for a behavior consists of different elements, such as specifying a behavior ('what'), a time ('when'), a place ('where'), and elaborations on execution ('how'). Gollwitzer [22] defined *implementation intentions* as explicit *if-then* plans that link anticipated critical situations (i.e., when, where) to goal-directed responses (i.e. what, how). This form of an explicit plans has been identified as an effective strategy for bridging the intention-behavior gap [44]. Two distinct types of implementation intention strategies have been studied: action planning and coping planning [9]. *Action planning* involves specifying the action (when, where, and how) to act in the service of one's intentions. *Coping planning* involves specifying the anticipated response to potential barriers or obstacles that could get in the way of the intended action. Preliminary evidence has shown that high-quantity planning (creating more action plans) and high-quality plans (plans with higher specificity [60]) may lead to higher levels of physical activity [56].

2.1.1 Interventions to Support Planning

Although, many interventions have been designed to incorporate implementation intentions as one of the intervention components to support physical activity [30,44], little is known about lived experiences around how implementation intentions are formed and how technology could support people in setting implementation intentions by specifying high quality plans. Interventions using technology to support planning have mostly focused on motivating users to make more and higher-quality action plans by sending text messages [41,53]. Although, systematic reviews generally support such planning strategies [23,32], their effectiveness to behavioral interventions was not evident in all settings [43,57].

Given the difficulty in creating high quality plans, many people resort to the Internet for help [35], where the quality of plans may be contentious [50]. Moreover, plans found online may fail to account for the individual preferences and opportunities [43], and are less likely to be tried than personalized feedback [2,45]. In order to seek personalized plans, people sometimes seek help from experts in the form of coaching. Coaching, in general, shows increased likelihood of achieving ones goals [38,46], however the expense (>$18 per hour) [61] and time commitment required for personalized coaching are not feasible for everyone.

Therefore, we sought to understand situated planning for physical activity and how the design of tools to promote physical activity can incorporate support for making high quality plans.

2.3 Understanding the Context of Health Behavior

Most theories of health behavior change (such as the Theory of Planned Behavior [3] and Social-Cognitive Theory [4]) aim to understand the role of psychosocial and environmental factors between people (i.e. inter-individual variation). The need for a more idiographic approach to behavioral science seeking the description of within-person processes [33,42] and the recent availability of methods such as ESM can allow researchers to study time-varying factors such as cognitions, mood, physiological states, and contexts [17]. Recent studies have uncovered cognitive factors [18], affective factors [18,19], mood [21], social [48,49], and environment [25,29] that influence physical activity. Yet the role of such factors over the course of the day is quite less [37] leading to a disconnect between health management practices and the context of health related activities, such as time of day, location, and daily activities [31].

Context in literature has been viewed from a number of lenses. The phenomenological view of context defines context as interactional. Context shapes one’s actions, is dynamically defined by actions, and is scoped by its relevance to the action concerned [16]. The positivist perspective on context defines context in terms of concrete attributes to computationally represent and utilize context in applications [6]. In order to design context-aware systems for behavior change, it is not only important to understand how significant the role of context is, but also represent the context such that it is amenable to computational reasoning. Inherent complexity in real world behavior change makes those theories unusable, that have “poor specification, both in construct definitions and in the relationships between them” [26]. Hekler et al. posit the need for knowledge about "ongoing, dynamic feedback loops of behavior in response to ever-changing biological, social, personal, and environmental states" to articulate an abstract model structure. An example of a dynamical model utilizes a “fluid-analogy” to articulate an abstract model structure. In this analogy, the inputs to a model are represented as values that fill a reservoir representing an aggregated factor [40]. The analogy is able to depict how the physical activity behavior is influenced by “inflows, outflows and feedback loops” between the various concepts [52].

The model proposed is far from actually being applied to many constructs but is one way in which researchers can map out the dynamics of this "complex and nested" problem [52].

An opportunity, one that this paper also tries to explore, lies in bridging the gap between computational models and the lived experience of people's lives by using qualitative methods. This approach can help ground the abstract notions of construct dynamics to recorded instances of how people experience challenges in their real life, thus providing the designer with a strong understanding of how the model might work in real world. Prior work on computationally extracting causal relationships between people's context and actions that describe their routines [5] could provide a basis to model the effect of context on specific behaviors, such as making plans for physical activity. Such models could potentially help people improve their routines [13,14], including those that support physical activity.

On the more applied side, applications that have exploited the dynamic nature of context are few. Making associations between contextual factors and physical activity visible allow users to increase their awareness of the factors that influence their physical activity [36]. The inferred insights about participant's correlations between pairs of contexts showed positive outcomes in physical activity of its users as well improved long-term engagement [7]. Moreover, reflecting on physical activity and context leads to finding more opportunities for physical activity [20]. In exploring physical activity and eating behavior, MyBehavior system leveraged users' context to provide them with actionable suggestions, which was found to be more effective than generic suggestions [45].

This body of prior work suggests that making people aware of the context in which health practices take place could improve those practices. Leveraging context information for planning tools is an area that is relatively unexplored. While automated planning and scheduling approaches have been proposed [59], there is an opportunity for a user-centered approach towards designing such a system.

In this work, we delve into 1) what context information is considered relevant while making plans for physical activity, 2) how contextual factors challenge or support planning, and 3) how contextual factors can undermine existing plans. Given the importance of planning in predicting adherence to physical activity, understanding the role of context can inform how context information could be incorporated in system design to aid planning.

3 METHODS

Our goal was to understand the factors that people consider while planning physical activity and the challenges they face in creating and executing their plans, that is, how people plan for performing physical activity and how those plans materialize or fail to materialize. We do not seek to make generalizations about how particular factors impact activity, but to qualitatively understand how people take context into account, alongside other factors, when making and executing plans.

We specifically studied people who were motivated to exercise more than they currently do and who had a (self-described) busy work schedule. In doing so, we were guided by prior work that has found lack of time to be a barrier for physical activity [10,55]. We expected that a person with a somewhat full schedule would have more constraints around planning physical activity as compared to a person with a flexible routine with little time pressure. Because we wanted to maintain consistency around the nature of planning issues faced by our participants, we chose to study people who had similar work schedules. Our participants' work hours were approximately 9-5p, Monday to Friday.

3.1 Participants and Recruitment

We interviewed 16 adults who self-reported that their satisfaction with their physical activity is low (they are motivated to exercise more) and who worked at least 40 hours per week. The interviews were conducted between December 2015 and April 2016. We recruited participants through mailing lists at the authors' university. Respondents were asked to fill out a screener with 13 short-answer questions asking about their daily routine, typical physical activities and demographic information. Potential participants indicated their score of overall satisfaction with their current level of physical activity on a Likert scale from 1-5. The participants with satisfaction score less than 3, were chosen after the screening for in-person or online audio interviews. Interviews lasted 50 minutes on an average. The participants were located in Michigan, California, Maryland and Illinois. Out of the 16 participants, 3 were male, and 13 were female. Eleven participants were aged 25-35 while 5 were 35-45.

We analyzed data as we collected, to improve our understanding and also improve the probes we use in future interviews. We noticed data saturation occurring with our last few participants, realize that interview responses became repetitive, so we stopped enrolling more participants (although we had people wanting to participate).

3.2 Data Collection

The first author conducted all the interviews using a semi-structured interview protocol. At the beginning of the interview, each participant reported their activity levels on a standard Activity Scale (NASA JSC Physical Activity Status Scale). The average physical activity level for the participants was found to be 3.8 on the scale of 7. During each interview, participants were asked about their daily routines, how they made plans for exercise, the challenges they faced, and how they dealt with those challenges. We further probed participants on some critical incident to explore participants' experience of successful and unsuccessful plan execution in depth. Many of our participants identified such incidents of plan creation and execution. Participants also described the context around which their physical activity happened. Although, our interest in this study was to understand what contextual factors play a role in making and executing plans for exercising, it is important to note that contextual factors are difficult to be asked about individually. Hence, we sought to understand the role of context by asking about participant's daily routines, incidents around physical activity, and the relation of these incidents with the plans that participants made. Contextual factors were often discussed organically by participants, and were further elicited through probes.

3.3 Data Analysis

All interviews were audio-recorded and transcribed. The interviews were coded and analyzed using a mix of structural coding and in vivo coding [47] consisting of an iterative process of generating, refining, and probing the themes that emerged. Codes were initially drawn from research questions and then supplemented with those that emerged from the interviews. The first and the second author performed data analysis, starting with a few interviews to reach an agreement on codes, and understanding of concepts. The coding process was further supplemented with group discussion with the other authors as a form of peer debriefing [12] to develop the understanding of emerging themes.

In the another round of analysis, coded data were grouped under themes using affinity diagrams [58]. Coded data was analyzed to compare and understand the differences between participants and how they make and follow through on their plans with regards to the types of challenges faced and the types of coping strategies.

4 FINDINGS

Our findings shed light on the challenges of plan creation and execution arising out of multiple contextual factors that affect physical activity plans. Contextual factors including the time, location, type of activity, duration of activity and presence of others during activity influenced choices relating to physical activity such as when, where and how. Additionally, we found that participants weighed these contextual factors differently depending on individual differences, such as priorities and preferences, as well as affect and motivation. While the role of context in physical activity promotion has been reported in prior work [7,36,37], our work adds to the literature by showing how multiple aspects of context interact with each other to influence physical activity

Table 1. P14's sweet spot was found to be a convergence of multiple contextual factors. P14 considered these factors in creating her physical activity plans.

Contextual Factor	Values
Activity	Exercise at gym
Location	Nearby gym
Time	Morning
Social preference	Likes the social environment of gym
Social preference X Time	Wants evenings free for socializing
Affect after exercise	Feels very satisfied
Affect on missing exercise	Feels regret

planning and execution. Moreover, we show how individual differences affect the role of specific contextual factors in planning physical activities.

Operationalizing contextual factors and personalizing content and services to the user are two main aspects of a context-aware system. A deeper understanding of context is especially important to understand when seeking to inform the design of context-based systems that can support planning, which is our ultimate goal.

4.1 Successful Planning Requires Finding "Sweet Spots"

Our findings show that all our participants engaged in planning for physical activity by considering certain contextual factors. Although the relevance of contextual conditions varied across participants, they had to co-occur for participants to find an opportune circumstance that supported a given physical activity. That is, a right combination of time, location, activity, affect and social preferences was needed to perform a physical activity successfully. A state when these conditions were satisfied simultaneously was described by P3 as a "sweet spot":

"But the problem is, again with my schedule, really that 5:30 to 6:30. If it ends before 7:00, that is my sweet spot. But so many of the classes started at 7:00, and I just can't do a weekly commitment. I can't take two days a week, two evenings a week from the other work I have to do."

P3's work schedule and the schedule of martial arts classes determined her sweet spot for exercise. Such reports from our participants demonstrate that different factors are considered in planning for exercise. They also show that these factors converge to create conditions that support or deter the execution of those plans. Inspired by this understanding, we propose a notion of *sweet spots* for physical activity, that is *a state that supports a desired activity, formed by a favorable convergence of perceived contextual factors, and sustained for a sufficient period of time to successfully perform the activity.* The construct of sweet spots helped us better understand how contextual factors interacted to influence plans. While every participant had their own way of formulating plans, the concept of sweet spots unifies the diverse approaches adopted by our participants: planning can be seen as a matter of making choices around factors that form one's sweet spots.

In what follows, we describe our findings with the help of the notion of sweet spots. Our participants considered multiple factors to create plans based on their own preferences and priorities. It should be noted that much of the consideration and weighing of factors was not explicit—that is, these were not the terms or framing that participants used, but rather the analytical categories imposed by us to understand the role of context in planning. Additionally, we describe our findings under the two main themes – challenges of plan creation and challenges of plan execution. Plan creation and execution are complex and often intertwined in the lives of people [20]. We make a distinction here with the goal of unpacking the complexity and thereby extract the distinct challenges associated with them. Once articulated, the challenges of planning can be well scoped for the designers of context-aware system to tackle. Our primary goal is to unfold the complex role of context (e.g., time, location, social factors, affective state, and activity) and individual differences in planning physical activity.

4.2 Challenges of Plan Creation

As noted above, planning is a critical component for health behavior change. All our participants described some degree of conscious, explicit planning to try to incorporate physical activity into their routines. Although many health interventions tend to treat creation of plans as straightforward, we observed three ways that participants faced challenges in plan creation: considering multiple contextual factors, being influenced by the interaction between their individual preferences and relevant contextual factors, and coordinating with others.

4.2.1 Plan creation requires considering multiple contextual factors

Planning generally included choosing an activity, deciding on a time, and identifying a suitable location and environment. Other factors were sometimes included, such as coordinating with others or securing resources (e.g., registering for a class). Our participants considered many such contextual factors simultaneously. Participants had to make decisions about the type of activity they would perform, the place and its facilities, the duration of activity, their commute to the location, and constraints associated with certain aspects of their routine, such as work engagements and family obligations. For example, the kind of plan participants could create was restricted by the facilities accessible at a location (e.g., gym, shower) as mentioned by P3, *"when you work out at work on our lunch hour, or ride your bike in, we don't have a shower there. The smell is not terrible, [chuckle] but I would rather be clean when I go to work."* She did not have a shower at her workplace so she could not bike to work or exercise during office hours. Thus, any plans that she made to exercise were usually after work hours.

Some of these factors challenged plan creation more than the others. For example, work and family responsibilities limited the scope for plan creation. Lack of time, family obligations, and social engagements are known barriers for physical activity [62]. While the participants could better control a few factors, other factors, such as competing priorities at work and home, were more difficult to navigate.

4.2.2 Individual differences impose constraints on plan creation

Although, the set of contextual factors that were considered for plan creation were mostly consistent across participants, individual differences governed how each participant preferred to weigh these factors, which in turn affected their plans. One individual difference was around time preference. For example, different participants felt a sense of accomplishment by exercising at different times in their daily schedules. Some participants liked to exercise before work, while others preferred exercising after work. Some participants preferred to exercise at the same time across all days of the week, whereas some chose variable times for different days of the week. Depending on the time of the day, the reason for feeling accomplished varied across participants. For example, P14, a single female, professional, who was socially outgoing, thought that morning was better because it gave her free time during the rest of the day to do other things, such as socializing: *"If I've gone in the morning, I'm really satisfied because I did my workout, and now I'm going to have the rest of the evenings to do whatever I want. My first preference is always going in the morning because something can come up. I could have a team dinner or a team outing."* On the other hand, P1, a single female graduate student who spent most of her time alone, preferred evenings because her sense of accomplishment was driven by the feeling of being done for the day. She went for a walk after finishing the day's work and before sunset. At this time, there was still natural light in the park and more importantly she felt satisfied knowing that she can go home, take a shower, eat dinner and relax after completing her walk. As seen in the above two examples, *time of the day*, one's *work schedule* and *individual differences* over what led to satisfaction, determined the plans for physical activity. The favorable conditions of contextual factors such as time of day, work, daylight, and social factors resulted in sweet spots for P14 and P1. P14's sweet spot was bound by multiple contextual factors as shown in Table 1. While creating physical activity plans, P14 considered these factors and how they interacted, which was particular to social preferences of P14. Anticipating contextual conditions for successful plan execution may thus be seen as anticipating these sweet spots (that is, making plans that lead to sweet spots) and then choosing one (or more) of them for executing physical activity.

Another individual difference observed was around the desire to be with other people. Consistent with the above example, we found that this factor affected participants differently. As noted by prior work [8], for some participants in our study having people to exercise with was a necessary motivation. That is, without others they were less likely to create plans for physical activity and, if they did plan, their plans for exercise were less likely to materialize. For example, P4, who had been motivated to lose weight for many years, only decided to exercise when her friend at her workplace invited her to join a weight loss program*: "It was not until my colleague asked me to lose weight with her together, at that point I really started to do the exercises… After she left the office. I do not know a reason I stopped going to the gym. I think she played a very important role in my exercise program."* P4 was aware of her preference and acknowledged that it inhibited plan creation, as it was difficult to find people with whom she could plan.

In contrast to P4, the presence of too many people in the gym was a deterrent for P10 and she preferred to plan exercise around times when the gym would be relatively less crowded. Time in the gym was her "me time," which she wanted to spend with as few people around her as possible. Consequently, she made observations about the crowd patterns in the gym to conclude that her gym got very crowded after Christmas holidays. Using this information, P10 avoided the times when the gym was crowded and planned exercise sessions so that she could exercise at home on those days when the gym was crowded. P4's anticipation further required awareness about the various contextual factors that make up her sweet spot and how variations in each factor affected her plans.

Competing priorities in the context of work and home obligations was another factor that interacted with individual differences. Although competing priorities inhibited plan creation for all participants, we found that the relevance of barriers associated with competing priorities was different for different participants. For example, participants living with spouses and children had priorities dominated by family obligations, whereas participants living independently reported the desire for socialization (e.g., going out with friends) as a competing priority. This eventually determined the plans they would make. For instance, P14, whose priority was socialization, preferred not to create evening plans for exercise as that was a time when she socialized with friends and colleagues. The same contextual factors thus affected each participant differently depending on the individual differences in their preference for people, priorities, and sense of achievement and satisfaction.

4.2.3 Plan creation requires coordination with others

Participants living with their family needed to coordinate with others and plan around others' activities while making their own plans for exercise. This was because their schedules were directly influenced by other people's schedules. For example, P9 looked at her husband's schedule to plan her exercise. The couple could not go to the gym together because they shared childcare duties. In this case, presence of family members creates a need for coordination. In response to how she planned her exercise, she reported: *"I pretty much have it planned. The days that I work, I have it planned that I get home, rest for half hour or something, change, and go to the gym. I do it that way because my husband also likes to go to the gym, so I try to go so when I come back and he can go before dinner time."*

The effects of social aspects on plan creation varied from participant to participant. Most participants with families described schedules that were interdependent with those of other family members, thus having continuous social impact, as evident from P9's case. But for P14, who lived alone, vulnerability arising out of interdependent schedules was rare. Only when her friend visited her did she have to give up on her exercise plan as she wanted to be with her friend.

4.3 Challenges of Plan Execution

Even when the challenges of plan creation could be overcome, most of our participants reported having difficulty in executing physical activity plans once they were made. Unexpected and unplanned events can disrupt the execution of planned physical activity during the sweet spots, resulting in plan failures. That is, the sweet spots that could have been utilized for the desired behavior proved to be infeasible because of unfavorable conditions. Whether their plans were executed as expected was dependent on: a) the near-term anticipation of favorable and unfavorable contextual conditions that would support and deter their plan execution respectively (e.g., unexpected events), and b) fluctuating motivation levels. In the rest of this paper, we refer to the failure to execute plans as plan failures.

4.3.1 Anticipating unfavorable contextual conditions

When anticipating the conditions for physical activity, it was difficult for participants to foresee contextual conditions that would ruin their plans, e.g., unexpected and unplanned events. Most of the participants reported instances when a planned physical activity failed to happen because of an unforeseen event. For example, one of the participants described these events as out-of-the-ordinary things that came up and threw her off routine, affecting her physical activity plans: "*sometimes there are things, you know, like maybe somebody is sick or something like that too. I mean that would be something that would throw off my routine and something out of the ordinary.*" Feeling sick was one the most common reasons participants mentioned by participants, as also mentioned by P12: "*Then the last few days I was sick, so I didn't get to do my weights. I did running except for yesterday because I wasn't feeling good. Obviously I was not happy with those.*" Other than being sick, such unexpected events also involved impromptu activities needing attention. Most commonly these impromptu activities included errands, as reported by P15: "*I planned to run on Monday evening, after work, but then I ended up having to meet my husband somewhere to do some errands. And then we didn't get home until it was too late. Because I had planned to do that [run] from 6:00 to 7:00 but then we didn't get home until 7:30 or maybe 8:00.*"

Another participant (P4) blamed impromptu socialization for disrupting her plans for exercise. Her friends would ask her for a meal together in the evening and her plan to exercise got deprioritized because of her time with friends. She mentioned: "*a friend would say 'hey do you want to have dinner together? And then if I need to hangout first, then I will socialize first and then think about exercise… I think it is something I need to balance my daily life on.*" It is also important to note that some of these unfavorable conditions have less probability of occurrence, such as a sick kid, and some are more predictable for some people, such as an outing with friends or a long workday.

4.3.2 Sustaining engagement despite fluctuating motivation levels

Some participants reported that lack of novelty can lead to boredom, which demotivated them to follow through on their plans. For example, P10 found that routine can engender boredom, which eventually would lead her to fall off the routine, "*The thing that I have a problem with is I get bored easily so I know some people that like go to the gym and run on the treadmill like I hate and I don't think I can do that. So, I have to like mix it up and mix up where I'm at... I try not to get bored because if I get bored then I don't stick with it or if it becomes too routine, I get bored with it.*"

Lack of novelty discouraged sustained engagement in physical activity to the extent that it also led a few participants to completely discontinue planning physical activities. They stopped planning for and performing any physical activity. For example, P7 said she was bored of doing the same set of things as physical activity: "*I mean I would love to get back into a routine. I've tried workout videos at home as I do it for about a week and that's about it… So I go on spurts. I do it then I stop. I have a Wii. Done that. Then, get bored of that. I have a treadmill at home. Just never find time to use that either.*" As mentioned in the interview quote, for each new mode of exercise the motivation depleted over time, and required planning new activities for continued engagement.

4.4 Dealing with Challenges

In dealing with the challenges of plan execution, a few of our participants strategized for improved plan execution by creating backup plans or by mixing up activities.

4.4.1 Strategizing the execution of plans

While most of the participants acknowledged the presence of vulnerabilities because of poor anticipation of contextual factors, we found that only some of the participants had developed strategies to plan for physical activity and work around plan vulnerabilities. Such strategies resulted in more robust plans that led to improved physical activity execution. For example, one of the participants (P15) had created multiple exercise plans and she chose to execute one of them depending on the contextual conditions for any given day. This decision was governed by when she got back from work and what available time she had for exercise: "*I've got couple different routes [to run]. If I don't have a lot of time, I'll go on my shortest route, which is maybe 20, 30 minutes. Then if I have a longer time, I've got a route that takes about an hour. And then if I don't have an hour but I have more than just the shortest route, I've got sort of a 45 minutes one that I can do. And so I usually just rotate between those options.*"

The above-mentioned strategy followed by P15 made her plans less vulnerable to being disrupted. That is, she could deal with a situation in the week when she would end up getting home late from work, giving her less time for exercise. Because she could adjust to a plan that required less or more time to exercise, she did some exercise instead of missing it altogether. For P15, forming stable exercise routines was a result of being able to anticipate potential plan disruptions. Another planning strategy was to mix up different types of activities. For example, P8 was doing Yoga classes, but also did strength training with arm-weights because of the ease with which she could plan this activity. Having multiple desired activities increased the scope for execution as the participants could execute one of the activities depending on the contextual conditions.

6 DISCUSSION

This study explored how people seek to make and carry out plans for physical activity. Findings from this study bring to light two aspects of physical activity plan creation and execution—plans encompass multiple contextual factors (weather, social factors, affect, time, other activities) that interact with individual differences (preferences, priorities), and planning requires acknowledging and understanding the transient nature of contextual conditions. These two characteristics are indicative of the complex ways in which context affects the creation and execution of physical activity plans of our participants. Considering this complexity, we identified the concept of sweet spots, a favorable convergence of multiple contextual factors, to better understand the influence of context on physical activity plans. Given the central role of context in affecting plans, in this section, we briefly discuss the implications of our findings and the concept of sweet spots when viewed through the lens of the dichotomous view of context that exists in current literature on context-awareness, that is the phenomenological and the positivist views of context. We argue that the model of sweet spots is an initial step towards bridging the gap between these two views to aid the development of applications that use context to support a situated behavior. We further demonstrate how the results of this study inform the design of context-based tools to support planning for physical activity.

The phenomenological view of context treats human activity as an ongoing process of interpretation where the interaction between context and action shape each other [16]. The positivist perspective defines context in terms of objective representations that form attributes of a computational system [6]. While the phenomenological view is less clear in terms of operationalization, the positivist view oversimplifies the complexity and nuances of context. Both these conceptualizations have their own merits and limitations and we do not aim to argue for the importance of one over the other. While the socio-technical gap cannot be completely bridged [1], designing context-aware applications requires one to apply phenomenological understanding to system design. That is, understanding how context can be best incorporated in system design to support a situated behavior requires understanding the nuanced role context plays in relation to the behavior being studied and requires a construct to computationally utilize context in designing tools to support the behavior. In this study, we provide a deeper understanding of the role context plays in creation and execution of physical activity plans, and offer a phenomenologically grounded construct (sweet spots) to understand and computationally model the effect of context on plans. Sweet spots as a computational framework is rooted in phenomenological understanding, and hence, bridges the two approaches to understand context and its role in affecting a behavior.

Although, intuitively the concept of sweet spots may seem straightforward, the merit of this construct becomes clearer once we consider the complexity that the phenomenological view of context brings to the design space of context-aware systems. For planning physical activities, findings from our empirical investigation unpack this complexity by a) highlighting that it is not just isolated contextual factors that matter but that their combination must be considered as well, b) anticipating changes across multiple contextual factors and their effect on actions is challenging, and c) individual differences affect what specific factors or combination of factors matter for whom and how, indicating that there is no "one size fits all" solution. This points to the diversity in the design space of context-based applications to support a behavior such as exercising. Although context is unique for each user, to design applications using context we need a framework that offers some degree of generalization while being flexible to the unique needs of users. Sweet spots, as described above, is one way to achieve this goal.

Our findings show the diverse interactions between context and individual differences, implying that a universal mapping between context and planning is not entirely possible. What might work for one user would not work for another. This is where a phenomenologically grounded notion of sweet spots becomes more useful: as an abstraction that captures the importance of context in planning without pre-defining rigid and specific relationships between context, and plan creation and execution.

6.1 Predicting Sweet Spots

Sweet spots provide one way to understand the effect of context on plans. We hypothesize that the notion of sweet spots can potentially have greater explanatory and predictive power for the creation of actionable plans. Computational models of contextual factors and desired behaviors, that leverage the notion of sweet spots could then be used to predict likely sweet spots and suggest opportunities for being active. When plans fail, a predictive model could help repair the plan by suggesting alternative sweet spots. Automated prediction and reasoning about human behavior is a challenging research problem given the inherent uncertainty in human behavior [5]. However, recent work on extracting routines from behavior logs holds promise. The work by Banovic et al. [5] on routine modeling can be leveraged to define sweet spots in terms of a computational model. Given the scope of this paper, our intention is to convey the intuition of a plausible approach rather than providing the details of the actual implementation. In the following paragraphs, we first briefly outline the approach used by Banovic et al. We then describe how their approach may be extended to include the notion of sweet spots. Finally, we provide an example to help understand this computational model as a basis for predicting sweet spots and for predicting the plans that would result with those sweet spots.

Banovic et al. present an approach to model the causal relationship between contexts and the actions that people perform in those contexts. Their model consists of contextually-defined states mapped to actions that a person can take in that state. They calculate the probability distribution of actions, given the states and the state transition probability distribution from behavior logs. This allows their system to extract routines, as well as variations in those routines.

Translating their model to our intended use, a state represents combination of contextual factors such as recent activity, location, time and weather. Actions represent the activity (behavior) that can be performed in the given context. Based on the knowledge of states and the state transition probabilities, it is possible to extrapolate future states from any given state. Considering the diversity in context and behavior data, it is possible for a model like this to end up with large number of states. However, highly predictable events from a user's day (sleeping, office meetings) could effectively prune the state space, reducing the number of likely subsequent

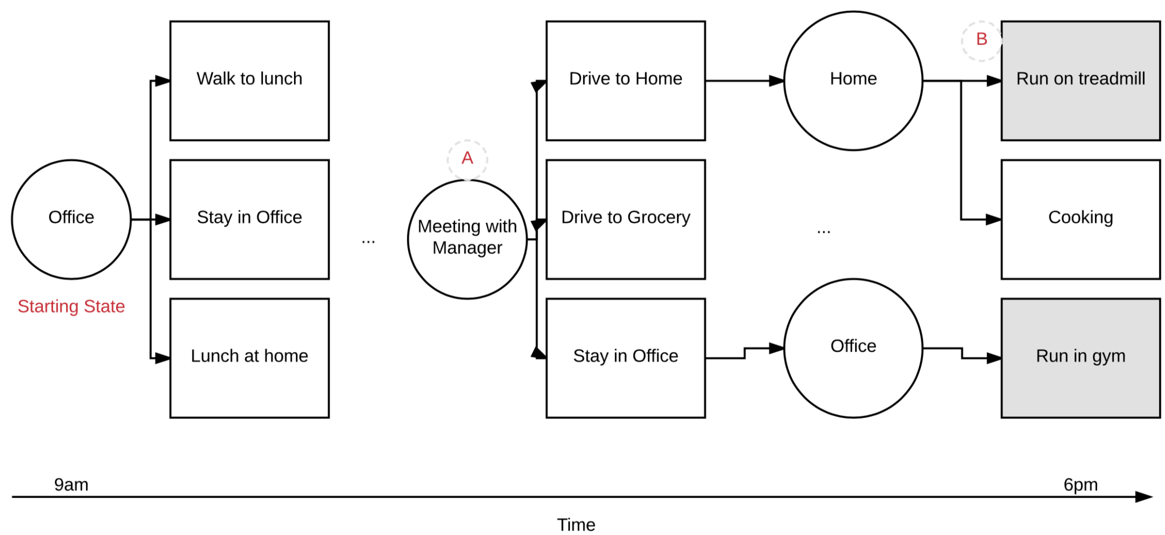

Fig. 1. An example of the state-action space for a person, simplified to convey two points: A) A high probability state restricts the state space of future states. B) Exercise being the desired behavior is identified as the sweet spot. Although a state captures multiple contexts, state in this scenario is only represented by the activity of the state for simplicity.

states. In this model, each state includes an activity feature that tells us the predicted behavior (physical activity in this case). The likelihood of a desired behavior can then be calculated by aggregating the likelihood of all states, at a given time, where the desired behavior/activity exists. Situated in such a model, a sweet spot for a person can be defined as *a state when the probability of a desired behavior happening is high, considering constraints of multiple factors including location, activity, and user's preferences* (e.g. desired behavior is in the top 10 most probable behaviors for a given set of factors.)

We now present an example of a routine day for a hypothetical user. Assuming the user's current state is (Activity=Work, Location=Office, Weather=Nice), the future state space (a collection of possible states) maybe predicted as shown in Figure 1. The state space is only a simplified version of the state space that might exist in reality. This state space is constricted by highly likely states, such as a recurring meeting with one's manager. We consider two predicted states with the desirable behavior "Run outside" and "Run in gym" to exist at around 6pm. The likely time for desired behavior for the user would then be predicted by the model as consisting of these two desirable states (run outside, and run in gym), inclusive of three factors (Time=6pm, Location=Home, Activity=Run Outside and Time=6pm, Location=Office Gym, Activity=Run in Gym), and the paths that lead to those states. The predicted states are sweet spots, and the paths are plan simulations, which when followed could result in successfully executed sweet spots.

7 DESIGN IMPLICATIONS

Our elaboration of sweet spots as a construct to model context data makes it amenable to computational support. While prior computational work on context data to support health-related needs has suggested ways to discover correlations between pairs of contextual factors [7] or suggest activities [45], sweet spots offer a way to improve the explanatory and predictive power of existing models by holistically accounting for multiple contextual factors affecting a behavior/activity to a) present context as information to the user to support awareness around a behavior, and b) use context to trigger services/suggestions in support of a behavior. Considering these broad use cases for incorporating context in designing tools, we now provide design directions for tools to support planning as implied by the findings from our study, using the construct of sweet spots as a basis.

7.1 Support Creation of Plans by Learning User's Behavior

Anticipating favorable and unfavorable contextual conditions is a challenging aspect of planning. For our participants, considering multiple factors in their plans introduced challenges for plan creation and execution. A system supporting plan creation and execution could suggest potential opportunities for exercise and reduce the need for explicit planning. Although, existing systems do this by considering the user's calendar and prior behavior [24], we propose that systems need to consider multiple contextual factors simultaneously while suggesting potential opportunities to the users.

In terms of sweet spots, based on the factors and preferences relevant to the user, the system could predict and suggest sweet spots– the states when the user is likely to execute physical activity plans successfully. A system could, for instance, provide a look ahead into the user's day or week suggesting all the slots on the user's calendar when a specific physical activity is feasible. Alternatively, the system could recommend multiple sweet spots having considerable probability to occur and let the user choose a primary sweet spot and one or more backup sweet spots in case the primary sweet spot becomes infeasible.

7.2 Suggest Paths of Successful Plan Completion

The dynamic nature of contextual conditions made our participants' plans fragile. At the same time, sweet spots become *missed opportunities* for exercise when the conditions are favorable but the user did not realize the opportunity to do the desired behavior. Therefore, there is a need and an opportunity to support the creation and modification of plans to fit the changing contextual conditions to – a) deal with potential failures arising out of unfavorable conditions and b) take advantage of emergent sweet spots that represent unplanned opportunities for exercise.

Owing to the fragile nature of plans, it is important to have strategies that accommodate the changing nature of contextual conditions. We observed that only three participants employed such planning strategies to ameliorate plan failures by creating flexible or backup plans. We believe that such strategies would benefit other users as well.

Sweet spots, as a phenomenological account can support the use of existing computational models for suggesting multiple paths (series of state transitions) in the predicted state space that lead to a sweet spot/desirable behavior. The presence of multiple paths can help the user choose paths to achieve the desired behavior. These paths are useful in themselves as they represent the changes in context and the potential actions that could be taken by the user in order to reach a certain behavior. They can thus be used to guide plans for that behavior as they are essentially detailed simulation of plans for a behavior/activity. Paths that reach the desired behavior are "successful" transitions while the paths that do not reach the desired behavior are "unsuccessful" paths. Visualizing and recommending successful and unsuccessful paths can make the user aware of unforeseen and disruptive contexts that may occur.

7.3 Help the User Reflect when Failures Happen

Not understanding how different factors affect one's plans challenged plan creation and execution for our participants. Planning tools could represent the relationship between contextual factors and outcomes to facilitate self-awareness about how contextual factors come together to affect plan creation and execution. The framework of sweet spots, encapsulating the knowledge of desirable and undesirable states and paths that lead to those states, can aid designers in highlighting patterns of plan failures - i.e. highlighting the paths that have less probability of reaching desired behavior. Consequently, causal contextual factors, i.e. the states/events along the path that lead to deflection from the desired behavior, can also be highlighted to promote reflection over one's plan failures. For example, a system could nudge users by highlighting the differences between conditions when they fail and succeed. Such comparisons over instances of physical activity provide a more concrete way of self-reflection that builds on previous works that show association between contextual factors and physical activity [36]. Such information can be presented as natural language statements that associate context data with a particular behavior/activity [7]. This may help the user draw actionable insights to avoid failures. In doing so designers should be aware of the discouragement and any undesirable emotional response that assessing one's own failures could engender.

7.4 Help the User Explore New Ways of Achieving One's Goal

As found in this study, lack of novelty in some cases discouraged sustained engagement in making plans for physical activity. To deal with this issue, tools to support planning should suggest new options from time to time, such as a new physical activity or a new location. Such suggestions can be triggered using context-based cues, that is, changes in context that lead to the emergence of a sweet spot. For example, repeated plan failure for a given activity that the user has been trying to perform can trigger suggestions for new activities that result in new sweet spots for the user. Alternatively, changes in seasons can be used as cues to trigger suggestions for activities more appropriate for the season. The new options may also be learned from trajectories of other users who are similar to the user. Since incorporating new activities into a daily routine requires planning afresh for those activities, using a sweet spot representation could be used to help the user become aware of the relevant contextual factors that the system considered while suggesting new options or new sweet spots, which would also need to be considered while making plans for the suggested activity.

8 LIMITATIONS

Our study has limitations that may be addressed in future work. We used interviews to understand how participants made plans and executed them. Although, this allowed us to gain deep insights into participants' daily routines and the nuances of how they plan, future work could incorporate methods like Ecological Momentary Assessments [18] to gain deeper insight into creation and execution of plans in their actual context.

Furthermore, our methodology and recruitment strategy imposed restrictions on the type of participants we interviewed. All our participants belonged to relatively high socio-economic status. As noted earlier, most of our participants were women and fairly young and healthy. Additionally, we scoped our data collection to explicitly planned activities and thus, our findings may not generalize to spontaneous physical activities. Although, these factors might have restricted our understanding about the role of context and the challenges with planning to a sub-set of all possible roles, we believe that the notion of sweet spots provides a useful intuition, backed by empirical evidence, for designing tools for planning support for a wider audience. Future studies aimed at understanding planning behavior can utilize the concept of sweet spots to design and evaluate planning support tools.

9 CONCLUSION

In this paper, we reported results of an interview study with 16 participants to understand the impact of contextual factors on physical activity plans. We found that our participants faced certain challenges in creating and executing physical activity plans. This was because their plans encompassed multiple contextual factors, and planning required acknowledging and understanding the transient nature of contextual conditions. The primary findings of our study lead us to conclude that context and individual differences play a complex role in affecting people's physical activity plans. To ameliorate such complexity, we use the phenomenologically grounded notion of sweet spots- states that represent a favorable convergence of contextual factors to support a desired behavior. Sweet spots can be utilized to improve the predictability of context-based tools or models that support creation and execution of plans for physical activities. This work suggests new opportunities for research in context-aware systems for physical activity promotion and for exploring the role of contextual information in creating and executing physical activity plans.

REFERENCES

[1] Mark Ackerman. 2000. The Intellectual Challenge of CSCW: The Gap Between Social Requirements and Technical Feasibility. *Human-Computer Interaction* 15, 2 (September 2000), 179–203.

[2] Elena Agapie, Lucas Colusso, Sean A. Munson, and Gary Hsieh. 2016. PlanSourcing: Generating Behavior Change Plans with Friends and Crowds. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* (CSCW '16), 119–133. DOI:https://doi.org/10.1145/2818048.2819943

[3] Icek Ajzen. 1991. The theory of planned behavior. *Organizational behavior and human decision processes* 50, 2 (1991), 179–211.

[4] Albert Bandura. 2002. Social foundations of thought and action. *The health psychology reader* (2002), 94–106.

[5] Nikola Banovic, Tofi Buzali, Fanny Chevalier, Jennifer Mankoff, and Anind K. Dey. 2016. Modeling and Understanding Human Routine Behavior. 248–260. DOI:https://doi.org/10.1145/2858036.2858557

[6] Jared S. Bauer, Mark W. Newman, and Julie A. Kientz. 2014. What designers talk about when they talk about context. *Human–Computer Interaction* 29, 5–6 (2014), 420–450.

[7] Frank Bentley, Konrad Tollmar, Peter Stephenson, Laura Levy, Brian Jones, Scott Robertson, Ed Price, Richard Catrambone, and Jeff Wilson. 2013. Health Mashups: Presenting Statistical Patterns Between Wellbeing Data and Context in Natural Language to Promote Behavior Change. *ACM Trans. Comput.-Hum. Interact.* 20, 5 (November 2013), 30:1–30:27. DOI:https://doi.org/10.1145/2503823

[8] Lisa F. Berkman. 1995. The role of social relations in health promotion. *Psychosomatic medicine* 57, 3 (1995), 245–254.

[9] Natasha Carraro and Patrick Gaudreau. 2013. Spontaneous and experimentally induced action planning and coping planning for physical activity: A meta-analysis. *Psychology of Sport and Exercise* 14, 2 (2013), 228–248.

[10] Jaesung Choi, Miyoung Lee, Jong-koo Lee, Daehee Kang, and Ji-Yeob Choi. 2017. Correlates associated with participation in physical activity among adults: a systematic review of reviews and update. *BMC Public Health* 17, (April 2017). DOI:https://doi.org/10.1186/s12889-017-4255-2

[11] Sunny Consolvo, Katherine Everitt, Ian Smith, and James A. Landay. 2006. Design requirements for technologies that encourage physical activity. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '06), 457–466. DOI:https://doi.org/10.1145/1124772.1124840

[12] John W. Creswell. 2013. *Qualitative inquiry and research design: Choosing among five approaches*. Sage.

[13] Scott Davidoff, Brian D. Ziebart, John Zimmerman, and Anind K. Dey. 2011. Learning Patterns of Pick-ups and Drop-offs to Support Busy Family Coordination. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11), 1175–1184. DOI:https://doi.org/10.1145/1978942.1979119

[14] Scott Davidoff, John Zimmerman, and Anind K. Dey. 2010. How routine learners can support family coordination. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2461–2470. Retrieved September 15, 2016 from http://dl.acm.org/citation.cfm?id=1753699

[15] Stephan U. Dombrowski, Falko F. Sniehotta, Alison Avenell, Marie Johnston, Graeme MacLennan, and Vera Araújo-Soares. 2012. Identifying active ingredients in complex behavioural interventions for obese adults with obesity-related co-morbidities or additional risk factors for co-morbidities: a systematic review. *Health Psychology Review* 6, 1 (March 2012), 7–32. DOI:https://doi.org/10.1080/17437199.2010.513298

[16] Paul Dourish. 2004. What we talk about when we talk about context. *Personal Technologies* 8, 1 (February 2004), 19–30.

[17] Genevieve Fridlund Dunton and Audie A. Atienza. 2009. The Need for Time-Intensive Information in Healthful Eating and Physical Activity Research: A Timely Topic. *Journal of the American Dietetic Association* 109, 1 (January 2009), 30–35. DOI:https://doi.org/10.1016/j.jada.2008.10.019

[18] Genevieve Fridlund Dunton, Audie A. Atienza, Cynthia M. Castro, and Abby C. King. 2009. Using Ecological Momentary Assessment to Examine Antecedents and Correlates of Physical Activity Bouts in Adults Age 50+ Years: A Pilot Study. *Annals of Behavioral Medicine* 38, 3 (December 2009), 249–255. DOI:https://doi.org/10.1007/s12160-009-9141-4

[19] Genevieve Fridlund Dunton, Yue Liao, Stephen Intille, Jimi Huh, and Adam Leventhal. 2015. Momentary assessment of contextual influences on affective response during physical activity. *Health Psychology* 34, 12 (2015), 1145–1153. DOI:https://doi.org/10.1037/hea0000223

[20] Daniel A. Epstein, An Ping, James Fogarty, and Sean A. Munson. 2015. A Lived Informatics Model of Personal Informatics. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (UbiComp '15), 731–742. DOI:https://doi.org/10.1145/2750858.2804250

[21] Lise Gauvin, W. Jack Rejeski, and Beth A. Reboussin. 2000. Contributions of acute bouts of vigorous physical activity to explaining diurnal variations in feeling states in active, middle-aged women. *Health Psychology* 19, 4 (2000), 365.

[22] Peter M. Gollwitzer. 1999. Implementation intentions: strong effects of simple plans. *American psychologist* 54, 7 (1999), 493.

[23] Peter M. Gollwitzer and Paschal Sheeran. 2006. Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in experimental social psychology* 38, (2006), 69–119.

[24] Google. 2016. Find time for your goals with Google Calendar. Retrieved May 15, 2017 from http://blog.google:443/products/calendar/find-time-goals-google-calendar/

[25] Eric B. Hekler, Matthew P. Buman, David Ahn, Genevieve Dunton, Audie A. Atienza, and Abby C. King. 2012. Are daily fluctuations in perceived environment associated with walking? *Psychology & Health* 27, 9 (September 2012), 1009–1020. DOI:https://doi.org/10.1080/08870446.2011.645213

[26] Eric B. Hekler, Susan Michie, Misha Pavel, Daniel E. Rivera, Linda M. Collins, Holly B. Jimison, Claire Garnett, Skye Parral, and Donna Spruijt-Metz. 2016. Advancing Models and Theories for Digital Behavior Change Interventions. *American Journal of Preventive Medicine* 51, 5 (November 2016), 825–832. DOI:https://doi.org/10.1016/j.amepre.2016.06.013

[27] C. Hoffman, D. Rice, and H. Y. Sung. 1996. Persons with chronic conditions. Their prevalence and costs. *JAMA* 276, 18 (November 1996), 1473–1479.

[28] Jennifer L. Huberty, Diane Ehlers, Jason Coleman, Yong Gao, and Steriani Elavsky. 2013. Women bound to be active: differences in long-term physical activity between completers and noncompleters of a book club intervention. *Journal of Physical Activity and Health* (2013). Retrieved September 14, 2016 from http://scholarworks.boisestate.edu/kinesiology_facpubs/111/

[29] Nancy Humpel, Neville Owen, and Eva Leslie. 2002. Environmental factors associated with adults' participation in physical activity: a review. *American journal of preventive medicine* 22, 3 (2002), 188–199.

[30] Robert Hurling, Michael Catt, Marco De Boni, Bruce William Fairley, Tina Hurst, Peter Murray, Alannah Richardson, and Jaspreet Singh Sodhi. 2007. Using Internet and Mobile Phone Technology to Deliver an Automated Physical Activity Program: Randomized Controlled Trial. *Journal of Medical Internet Research* 9, 2 (April 2007), e7. DOI:https://doi.org/10.2196/jmir.9.2.e7

[31] Predrag Klasnja and Wanda Pratt. 2012. Healthcare in the pocket: Mapping the space of mobile-phone health interventions. *Journal of Biomedical Informatics* 45, 1 (February 2012), 184–198. DOI:https://doi.org/10.1016/j.jbi.2011.08.017

[32] Dominika Kwasnicka, Justin Presseau, Martin White, and Falko F. Sniehotta. 2013. Does planning how to cope with anticipated barriers facilitate health-related behaviour change? A systematic review. *Health psychology review* 7, 2 (2013), 129–145.

[33] James T. Lamiell. 2003. *Beyond individual and group differences: Human individuality, scientific psychology, and William Stern's critical personalism*. Sage.

[34] Gary P Latham and Edwin A Locke. 1991. Self-regulation through goal setting. *Organizational Behavior and Human Decision Processes* 50, 2 (December 1991), 212–247. DOI:https://doi.org/10.1016/0749-5978(91)90021-K

[35] Sophie Lewis, Samantha L. Thomas, R. Warwick Blood, David Castle, Jim Hyde, and Paul A. Komesaroff. 2011. "I'm searching for solutions": why are obese individuals turning to the Internet for help and support with "being fat"? *Health Expect* 14, 4 (December 2011), 339–350. DOI:https://doi.org/10.1111/j.1369-7625.2010.00644.x

[36] Ian Li, Anind K. Dey, and Jodi Forlizzi. 2012. Using Context to Reveal Factors That Affect Physical Activity. *ACM Trans. Comput.-Hum. Interact.* 19, 1 (May 2012), 7:1–7:21. DOI:https://doi.org/10.1145/2147783.2147790

[37] Yue Liao, Eleanor T. Shonkoff, and Genevieve F. Dunton. 2015. The Acute Relationships Between Affect, Physical Feeling States, and Physical Activity in Daily Life: A Review of Current Evidence. *Front Psychol* 6, (December 2015). DOI:https://doi.org/10.3389/fpsyg.2015.01975

[38] Aleksandra Luszczynska. 2006. An implementation intentions intervention, the use of a planning strategy, and physical activity after myocardial infarction. *Social Science & Medicine* 62, 4 (February 2006), 900–908. DOI:https://doi.org/10.1016/j.socscimed.2005.06.043

[39] Emily L. Mailey and Edward McAuley. 2014. Impact of a brief intervention on physical activity and social cognitive determinants among working mothers: a randomized trial. *Journal of behavioral medicine* 37, 2 (2014), 343–355.

[40] C.A. Martin, D.E. Rivera, W.T. Riley, E.B. Hekler, M.P. Buman, M.A. Adams, and A.C. King. 2014. A dynamical systems model of Social Cognitive Theory. In *American Control Conference (ACC), 2014*, 2407–2412. DOI:https://doi.org/10.1109/ACC.2014.6859463

[41] Chetan D. Mistry, Shane N. Sweet, Ryan E. Rhodes, and Amy E. Latimer-Cheung. 2015. Text2Plan: Exploring changes in the quantity and quality of action plans and physical activity in a text messaging intervention. *Psychol Health* 30, 7 (2015), 839–856. DOI:https://doi.org/10.1080/08870446.2014.997731

[42] Peter CM Molenaar. 2004. A manifesto on psychology as idiographic science: Bringing the person back into scientific psychology, this time forever. *Measurement* 2, 4 (2004), 201–218.

[43] Jeni Paay, Jesper Kjeldskov, Mikael B. Skov, Lars Lichon, and Stephan Rasmussen. 2015. Understanding Individual Differences for Tailored Smoking Cessation Apps. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15), 1699–1708. DOI:https://doi.org/10.1145/2702123.2702321

[44] Andrew Prestwich, Marco Perugini, and Robert Hurling. 2010. Can implementation intentions and text messages promote brisk walking? A randomized trial. *Health Psychology* 29, 1 (2010), 40–49. DOI:https://doi.org/10.1037/a0016993

[45] Mashfiqui Rabbi, Angela Pfammatter, Mi Zhang, Bonnie Spring, and Tanzeem Choudhury. 2015. Automated Personalized Feedback for Physical Activity and Dietary Behavior Change With Mobile Phones: A Randomized Controlled Trial on Adults. *JMIR mHealth and uHealth* 3, 2 (May 2015), e42. DOI:https://doi.org/10.2196/mhealth.4160

[46] Milagros C Rosal, Cara B Ebbeling, Ingrid Lofgren, Judith K Ockene, Ira S Ockene, and James R Hebert. 2001. Facilitating Dietary Change: The Patient-Centered Counseling Model. *Journal of the American Dietetic Association* 101, 3 (March 2001), 332–341. DOI:https://doi.org/10.1016/S0002-8223(01)00086-4

[47] Johnny Saldaña. 2015. *The coding manual for qualitative researchers*. Sage.

[48] Sarah-Jeanne Salvy, Julie Wojslawowicz Bowker, James N. Roemmich, Natalie Romero, Elizabeth Kieffer, Rocco Paluch, and Leonard H. Epstein. 2007. Peer influence on children's physical activity: an experience sampling study. *Journal of pediatric psychology* 33, 1 (2007), 39–49.

[49] Sarah-Jeanne Salvy, James N. Roemmich, Julie C. Bowker, Natalie D. Romero, Phillip J. Stadler, and Leonard H. Epstein. 2008. Effect of peers and friends on youth physical activity and motivation to be physically active. *Journal of pediatric psychology* 34, 2 (2008), 217–225.

[50] S. L. Saperstein, N. L. Atkinson, and R. S. Gold. 2007. The impact of Internet use for weight loss. *Obes Rev* 8, 5 (September 2007), 459–465. DOI:https://doi.org/10.1111/j.1467-789X.2007.00374.x

[51] Paschal Sheeran. 2002. Intention—behavior relations: A conceptual and empirical review. *European review of social psychology* 12, 1 (2002), 1–36.

[52] Donna Spruijt-Metz, Eric Hekler, Niilo Saranummi, Stephen Intille, Ilkka Korhonen, Wendy Nilsen, Daniel E. Rivera, Bonnie Spring, Susan Michie, David A. Asch, Alberto Sanna, Vicente Traver Salcedo, Rita Kukakfa, and Misha Pavel. 2015. Building new computational models to support health behavior change and maintenance: new opportunities in behavioral research. *Behav. Med. Pract. Policy Res.* 5, 3 (September 2015), 335–346. DOI:https://doi.org/10.1007/s13142-015-0324-1

[53] Shane N. Sweet, Lawrence R. Brawley, Alexandra Hatchell, Heather L. Gainforth, and Amy E. Latimer-Cheung. 2014. Can persuasive messages encourage individuals to create action plans for physical activity? *Journal of sport & exercise psychology* 36, 4 (2014).

[54] Richard P. Troiano, David Berrigan, Kevin W. Dodd, Louise C. Masse, Timothy Tilert, Margaret McDowell, and others. 2008. Physical activity in the United States measured by accelerometer. *Medicine and science in sports and exercise* 40, 1 (2008), 181.

[55] Stewart G. Trost, Neville Owen, Adrian E. Bauman, James F. Sallis, and Wendy Brown. 2002. Correlates of adults' participation in physical activity: review and update. *Medicine & Science in Sports & Exercise* 34, 12 (2002), 1996–2001.

[56] Emely de Vet, Anke Oenema, and Johannes Brug. 2011. More or better: Do the number and specificity of implementation intentions matter in increasing physical activity? *Psychology of Sport and Exercise* 12, 4 (2011), 471–477.

[57] Emely De Vet, Anke Oenema, Paschal Sheeran, and Johannes Brug. 2009. Should implementation intentions interventions be implemented in obesity prevention: the impact of if-then plans on daily physical activity in Dutch adults. *International Journal of Behavioral Nutrition and Physical Activity* 6, 1 (March 2009), 11. DOI:https://doi.org/10.1186/1479-5868-6-11

[58] Wikipedia. 2017. Affinity diagram. Retrieved November 12, 2017 from https://en.wikipedia.org/w/index.php?title=Affinity_diagram&oldid=772829913

[59] Wikipedia. 2017. Automated planning and scheduling. Retrieved May 13, 2017 from https://en.wikipedia.org/w/index.php?title=Automated_planning_and_scheduling&oldid=779693832

[60] Jochen P. Ziegelmann, Sonia Lippke, and Ralf Schwarzer. 2006. Adoption and maintenance of physical activity: Planning interventions in young, middle-aged, and older adults. *Psychology & Health* 21, 2 (2006), 145–163.

[61] May 2016 National Occupational Employment and Wage Estimates. Retrieved May 10, 2017 from https://www.bls.gov/oes/current/oes_nat.htm#00-0000

[62] Overcoming Barriers to Physical Activity | Basics | Physical Activity | DNPAO | CDC. Retrieved November 20, 2015 from http://www.cdc.gov/physicalactivity/basics/adding-pa/barriers.html

Received May 2017; revised November 2017; accepted January 2018