Storywell: Designing for Family Fitness App Motivation by Using Social Rewards and Reflection

Herman Saksono[1], Carmen Castaneda-Sceppa[1], Jessica Hoffman[1], Vivien Morris[2], Magy Seif El-Nasr[1], Andrea G. Parker[1]

[1]Northeastern University, Boston, USA [2]Mattapan Food and Fitness Coalition, Boston, USA

saksono.h@husky.neu.edu, vivien.morris@gmail.com,

{c.sceppa, j.hoffman, m.seifel-nasr, a.parker}@northeastern.edu

ABSTRACT

Physical activity (PA) is critical for reducing the risk of obesity, a prevalent health concern that burdens low-socioeconomic status (SES) households. While self-tracking apps can increase PA, encouraging app engagement remains a challenge, thus limiting the app's efficacy. To understand how to better support caregiver's motivation to use family health apps, we designed and evaluated Storywell—a mobile app for promoting family PA. Guided by Self-Determination Theory, Storywell provides social rewards (e.g., storybooks with interactive reflective questions) aimed at supporting relatedness and motivation. Our 3-month qualitative study with 18 families revealed *satisfying moments* that can affect caregiver's motivation. We contribute new knowledge on designing satisfying moments that heighten the motivation to use health apps, especially for low-SES families who face many barriers to using such systems.

Author Keywords

Health, Family, Children, Physical Activity, Motivation, Self-Tracking, Gamification, Self-Determination Theory

CSS Concepts

• Human-centered computing ~ Empirical studies in ubiquitous and mobile computing

INTRODUCTION

Obesity increases the risk of chronic diseases, such as diabetes and cardiovascular diseases, and disproportionately affects adults and children within low-socioeconomic status (SES) households [31]. To reduce the risk of obesity, health organizations recommend regular physical activity (PA) [49]. However, low-SES individuals in the United States (U.S.) face many barriers to being active, such as the cost of sports programs, burdensome jobs, and limited PA facilities [9]. Moreover, while young children are often very active, they tend to be less active between the age of 6-19 years [52]. Therefore, PA interventions designed for children and families of low-SES backgrounds are needed.

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Although Human-Computer Interaction (HCI) research has explored how health apps can support regular PA [8,22,26,30], many also question the efficacy of these apps, especially for families. Despite the fact that PA behavior begins at a young age [52], little work has explored how PA apps can support children and families to be active, with work by Saksono et al. and Stanley et al. being notable exceptions [39,43,46]. Furthermore, while PA apps can be motivating to use initially, prior work has raised concerns about declining engagement once the initial interest wanes [22,24,54]. Therefore, there is a need to further examine how health apps can be designed to nurture family motivation to use such systems.

To investigate this research gap, we turn to the concept of relatedness from Self-Determination Theory (SDT) [37]. *Relatedness* is the feeling of being connected to others or the feeling of caring for others [36]. The satisfaction of the need for relatedness can enhance the motivation to do a task [51]. Given that families are characterized by their emotional connections and shared dwelling [34], social connectedness is a salient feature of families. Therefore, applying relatedness in the design of family health apps could impact the motivation to use such systems. Indeed, prior work shows that relatedness can support the motivation to use health apps and games [38,51]. To this end, we developed Storywell, a mobile app for promoting family PA that uses social rewards as a gameful design element [10]. We define *social rewards* as ones designed to initiate social interactions, satisfy the need for relatedness, and thus heighten the intrinsic motivation to use a system. In Storywell, the social rewards are PA-themed storybook chapters that families can read together if they have completed their step count goals as tracked by wearable PA trackers (e.g., MiBand, Fitbit).

In this paper, we report how social rewards can support caregivers' (e.g., parents) motivation to use family health apps. Understanding caregivers' motivation is important because children's PA behavior is strongly influenced by their caregivers [14]. Our study was guided by the following research questions: 1) *How can social rewards influence caregiver motivation to use a health app?* and 2) *What are the barriers to health app engagement for families of low-SES backgrounds?* By investigating these questions, we seek to address a gap in knowledge regarding how gameful design elements (e.g., social rewards) can support motivation to use health apps, especially in families of low-SES backgrounds.

To answer our research questions, we conducted a three-month qualitative study with 18 families within low-SES neighborhoods. Through our in-depth fieldwork, we found that while using Storywell, caregivers experienced a range of moments that satisfied the need for relatedness and thus heightened their motivation to use the app. At the same time, motivation was also limited by barriers that caregivers may face (e.g., burdening duties, disruptive events). Our contributions are as follows: (1) an understanding of how in-app interaction moments can affect motivation, (2) an understanding of how such moments are often driven by caregiving values that have been internalized; and (3) a discussion of how the concept of *satisfying moments* can be used for designing health apps that are motivating to use.

RELATED WORK

Technology-Based PA Promotion

There is growing HCI research on technology-based tools that utilize novel visualizations, goal-setting, and gamified design elements to promote PA. Systems such as Fish'n'Steps and UbiFit Garden displayed novel visualizations by using familiar metaphors to represent PA data [8,22]. Other work has explored novel goal-setting interfaces for PA behavior change. For example, GoalPost allows users to set a primary goal plus a secondary goal to fall back on [30]. In Bounce, users can choose from a variety of activity goals [26], whereas in UbiFit users preferred to set their own goals rather than choosing from a health guideline or having a system assign a goal for them [7]. Collectively, these studies suggest two design insights. First, PA visualizations need to be designed to help users develop a connection with the system and thus encourage PA. Second, while users need support in setting their goals, they also need some level of autonomy in setting goals that feel personally manageable.

Although these studies help to inform the design of PA promotion systems, comparatively little work has examined how technologies can help families to be active. This gap is important to note because decades of health research has shown that the family is an important source of PA support [14,48]. HCI researchers have begun to investigate this open research area. Saksono et al.'s evaluation of a collaborative family exergame found that caregivers sought in-app competition because they felt that competition can spark social interactions that makes the app more enjoyable to use [43]. Other prior work also shows that family interactions with health apps can initiate support. For example, Katule et al. found that older children played a role in helping families using a PA app [17]. Such findings resonate with work by Lukoff et al. and Schaefbauer et al. evaluating family diet apps, as well as Pina et al.'s work in family informatics. In these studies, the use of tracking apps elicited tangible support from family members [23,34,44].

Prior work has also highlighted the challenge in supporting PA adherence and motivation to use PA apps. First, although PA tracking increases behavioral awareness [21,22], a recent study showed that PA trackers rarely helped users to think about PA support structures [40] — that is, factors that can enable long-term PA adherence [18]. These enabling factors include identifying enjoyable activities, supportive people, and comfortable places in which to be active [14,48]. One approach to developing these support structures is through reflection on PA experiences, because reflection can help families develop PA strategies that are grounded in their experiences [42].

Second, prior work has surfaced the concern that system engagement will diminish over time once the novelty of the app wanes [22,24,54]. Concerns around engagement are also highlighted in Epstein et al.'s stage-based lived informatics model [12]. This model, along with the work by Meyer et al. and Clawson et al., show how self-tracking users can become less engaged or abandon trackers altogether [6,12,29].

To support PA motivation, studies on *gamified systems* have incorporated game design elements [10], such as virtual rewards, challenges, and competition. Some systems used one game design element (e.g., GoalPost), whereas other systems combined several game design elements (e.g., Fish'n'Steps, UbiFit) or used exergame design (e.g., iFitQuest, American Horsepower Challenge or AHPC, Play Mate! [1,24,53]). Evaluations of these tools demonstrated that simple gamification techniques such as badge systems may have limited motivational value [30] and that competition can negatively affect motivation [22,25,53]. As such, more work is needed to study how gamified health apps can be designed to effectively nurture users' motivation.

In summary, prior work has highlighted the need for research investigating how PA apps can be designed to help families 1) engage in reflection that aids in the development of PA support structures, and 2) maintain motivation to use the systems, as a fundamental step towards enabling them to stay engaged with and potentially benefit from these tools.

Motivation and Self-Determination Theory (SDT)

To investigate users' motivation in using health apps, we turn to Self-Determination Theory (SDT) [37]. In this theory, a person's motivation to do a task falls within a continuum of *intrinsic* to *extrinsic* motivation. An intrinsically motivated person does a task because the task is inherently enjoyable or satisfying. Conversely, an extrinsically motivated person does a task because of the rewards. A person is also extrinsically motivated when they do a task because of self-control or because the task is deemed important — if the task at hand is not inherently satisfying. Intrinsic motivation is generally more desirable because an intrinsically motivated behavior is more sustainable [16]. SDT posits that, over time, an externally motivated behavior can be internalized when these basic psychological needs are nurtured: competence, autonomy, and relatedness [37]. *Competence* is the feeling of being able to complete a task; *autonomy* is the feeling of doing a task of one's own volition; and *relatedness* is the feeling of being connected to others or caring for them.

SDT has been used to explain the effect of game design elements on motivation. For example, Peng et al. and Sailer et al. found that game design elements can support competence, autonomy, and relatedness [32,38]. In the context of families, Saksono et al. found that caregivers using a family health app sought opportunities to bond with their children through the app, and gained a sense of relatedness [43]. The importance of relatedness is further highlighted by Vella et al. who shows relatedness predicted game enjoyment [51].

Furthermore, SDT has been used to inform the designs of health and family apps, including a digital weight-loss coach [15], a food literacy game [2], and learning games for children [13]. Collectively, these studies suggest that designing for SDT's relatedness is a promising approach to make health apps intrinsically motivating. In this work, we examined how relatedness experiences emerge when using a *social rewards* design element, especially in a family setting.

METHOD

We developed the Storywell app (an Android mobile app for promoting PA) [41] to examine how SDT's *relatedness* concept can be facilitated to support caregivers' motivation to use health apps. We then conducted a three-month qualitative study to understand how Storywell is being used by families of low-SES backgrounds. Our naturalistic evaluation allowed us to gain insights into how a system aimed at satisfying caregivers' needs for relatedness could support motivation amid interpersonal and community level influences. This study was done in collaboration with a community organization focused on community health [50]. One of the authors is a community leader who was involved during the entire the research process.

Storywell Prototype Design

User Scenario

Families begin using Storywell by reading a PA-themed storybook together (Figure 1.2). At the end of each storybook chapter, Storywell asks the family to answer *reflection questions* that connect their PA experiences with the story's theme (Figure 1.3). Their answers are audio-recorded. To continue on to the next chapter, the caregiver and the child must choose a one-day step-count goal to complete (Figure 1.4). The unlocking of a storybook is a game mechanic in the form of *social rewards*, a term we use to describe rewards that spark social interactions and thus heighten relatedness. We used MiBand 2 wristbands to track the step counts because of their accuracy, long battery life, and low cost [11].

Families track their progress in the Adventure screen (Figure 1.5). Storywell downloads the step count data from the MiBands and visualizes the family's progress using a balloon metaphor (i.e., the hero needs to cross to the next island using balloons). The caregiver and child's progress are represented by the turquoise and red balloons, respectively. If the family members complete their goals, the balloons with their respective colors fill up and the hero crosses the island — thus, the family can unlock the next chapter.

If the family misses their goal, they can still proceed by spinning the *magic needle* to randomly get one of the *exit balloons* (Figure 1.6). There are three kinds of *exit balloons*. *The bypass* exit balloon allows families to unlock the next book chapter immediately. The *fitness tip* exit balloon gives families ideas on how to be active, and then allows them to unlock the next chapter. The *pick another challenge* exit balloon asks the family to pick another fitness challenge for the next day without unlocking the next book chapter.

Design Rationale

Storywell has two key design components: *motivational* and *health intervention*. The motivational component is the *social rewards* in the form of unlocking storybook chapters. When reading the unlocked storybook chapter together, the caregiver and the child can bond as a family. This bonding can satisfy the need for relatedness and help families become more motivated to use Storywell. The *health interventions* are delivered using the (1) storybook chapters, (2) reflection questions, and (3) fitness challenges.

The storybook chapters are *social rewards* designed to help families think about PA. Each storybook consists of four chapters, with each chapter communicating a theme about psychosocial factors that correlate with increased PA (e.g., enjoyment, social support, self-efficacy) [14,48]. To ensure that the storybooks are interesting, we (1) structure every

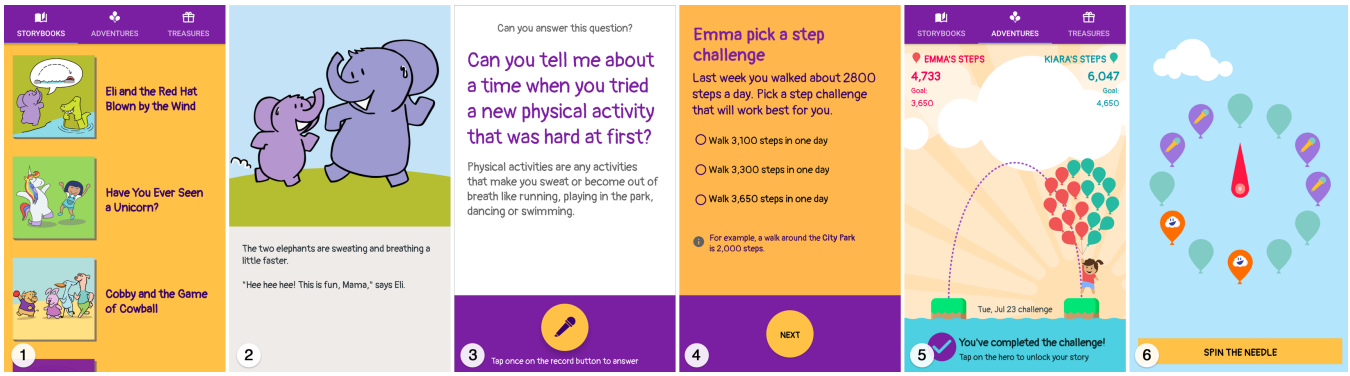

Figure 1 (1) Storywell app begins with the storybook library. (2) A family reads a storybook, then (3) answers a reflection question. To continue to the next chapter, the family must (4) pick a fitness challenge. (5) The adventure screen will show their fitness challenge progress. Completing a goal unlocks the next chapter. Otherwise, (6) the family can spin the magic needle to proceed to the next chapter.

chapter using the Aristotelian three-act structure (i.e., Setup, Confrontation, and Resolution), and (2) end every chapter with a cliffhanger. Our multidisciplinary team (comprised of computing and health sciences researchers) conducted workshops to develop eight stories and reviewed the stories with health and child literacy experts to ensure the appropriateness of the story themes, health themes, and language complexity. To minimize distraction, the storybooks did not include multimedia elements [4].

The end-of-chapter reflection questions were designed to help families use their own experiences to identify factors that can positively influence their PA [42]. The questions consist of a broad experience question, focusing question, and closing statement. For example, families begin with reflecting on their PA experiences broadly, then focus on the specific aspect of their experiences (e.g., self-efficacy, enjoyment, supportive people, comfortable places). The closing statement is aimed at helping caregivers and children conceptualize meanings in their PA experiences [19]. Below is an example of a three-part reflection in Storywell:

1. Can you tell a story about when you learned to do a new physical activity?
2. How did it feel when you decided to try a new activity?
3. Exercising is not about being "the best" all the time. It's also about the journey you take to reaching your goals.

The fitness challenge was designed to help families increase their fitness level gradually. To support agency, Storywell asks the caregiver and the child to choose their own step goal. Storywell also provides support for choosing fitness goals by offering three goal options: a 10%, 20%, and 30% increase of the 7-day steps average. We provide gradual goals to help users adapt to the increased PA and thus minimize the risk of injury, as recommended by Piercy et al. [33,49]. The *magic needle* feature helps ensure that families are adequately exposed to the interventions (i.e., the stories and reflection questions) even if they miss their goals.

Study Design

We conducted a three-month study to evaluate Storywell. We recruited families from four health and family-focused community organizations in a Northeast U.S. city. Families were eligible to participate if (1) they had at least one child aged 3-8 years, (2) owned an Android phone, and (3) lived in a low-income neighborhood or government-subsidized housing. The three-month study duration allowed families to experience Storywell beyond the initial introduction and potentially after the novelty effect [22,24,35] had worn off. This approach helped us study participants' experience with Storywell in a more naturalistic setting.

Our university's ethics board reviewed and approved the study protocol. After caregivers provided consent, we helped them set up Storywell and the fitness bands on their phone. We asked them to wear the bands daily and to check Storywell at least once a week. Then we interviewed the families four times: at the first meeting and then after one, two, and three months. Families could choose to have the interview at their home, community center, or our office. At the end of every session, each caregiver received a $40 gift card. Caregivers who completed the study also received an extra $40 gift card.

Data Collection and Analysis

In the first interviews, we asked the caregivers about their attitudes related to PA and reading. We also asked the caregivers to fill out a survey about their children's PA [27], their 7-day PA [28], and their demographics. In the rest of the interviews, we investigated caregivers' experiences with Storywell, the *social rewards*, the *fitness challenges,* and the *reflection* feature. We also investigated their experiences with the app and the challenges they faced, if any. We conducted over 30 hours of interviews across the four interview sessions, with median durations of 29, 28, 22, and 42 minutes, respectively. At the end of the study we asked the caregivers to fill out a technology acceptance survey [5].

We analyzed the transcribed interviews (n=815 pages) using the general inductive approach [47]. The steps included: 1) open coding by the first author to develop initial concepts, 2) probing and comparing these concepts in the subsequent interviews, 3) grouping concepts to develop higher-level categories, and 4) linking the categories to identify their relationships. Throughout the process, the first author met regularly with the other authors to discuss the findings.

Participants Overview

The study was conducted in April to September 2019. We recruited 36 participants (18 caregivers, 18 children) from 18 families. On average, the caregivers' age was 34 (SD=7) and the children's age was 5.7 (SD=1.7). All of the caregivers were female, and 9 children were female. Almost all of the caregivers self-identified as Black (n=14). Twelve families were single-caregiver households and the median number of children in the family was 3. Most of the caregivers' highest educational level was high school (n=6) or some college/vocational training (n=6). The median income was US$ 21,979 or less (n=9). All family participants' household income was below 150% U.S. Federal Poverty Level.

Caregivers reported a median PA frequency of 1-2 bouts of 30+ minutes PA in the previous week; this is below the recommended PA level [49]. However, most caregivers indicated that their children's median PA frequency was 6-7 bouts of 60+ minutes PA in the previous week. While caregivers' reports show that the children in the study met the recommended PA level [49], children's PA level often decreases as they get older [52]. Therefore, PA interventions targeted for children are especially needed.

FINDINGS

In this section, we begin by briefly discussing the aspirations of caregivers in our study to help contextualize our findings in terms of the caregivers' values. Then, we will describe caregivers' satisfactions with using Storywell and barriers that made it difficult for them to use the app.

Caregivers' Aspirations

Accounts from the caregivers underscore a desire to *regain opportunities* through education because they experienced *missed opportunities* due to immigration status, family structure, and racial discrimination. The majority of caregivers said that they read books to their children almost every day (n=12). For the caregivers, reading is critical for their children's education and future (n=11). In particular, education was important because of their own experiences of missed opportunities growing up with limited resources.

For some caregivers, missed opportunities arose from *immigration status*. For instance, P11 valued education because of growing up in a family who immigrated into the U.S.:

> **P11**: I took it very seriously, education […] What wasn't done to me, I am doing it with them [my children]. My parents didn't talk English, so basically, I was growing up by myself.

P11 felt she missed opportunities because she grew up in a family that did not speak the dominant language and she did not want that to happen to her children. For P04, education is important because her father had to immigrate and felt missed opportunities as a result:

> **P04**: My parents were immigrants. My dad almost finished college, but he had to escape from where he was at. […] This was sad when he come here and none of it transferred over.

For other families, missed opportunities arose from growing up with limiting *family structures*. For instance, P01 strived to support her children's education because she grew up in a single-parent household followed by foster care:

> **P01**: [My father died when I was 11]. I went into [foster care] until I was 18. I didn't really have my mom around me. I didn't have any family to really help me through life. I spend my every waking moment letting my children know that no matter what, right or wrong, I'll always be here for them.

Lastly, for some families, missed opportunities arose from the feeling of *racial discrimination*. For instance, P17 said that education was an important way to work against opportunities missed as a result of racially-based unfair treatment:

> **P17**: I want [my son] to be smart. First of all, my complexion. What I'm saying is we're African American, and we have to push, and we have to strive. […] We're not priority. There's other people that's priority that comes before us.

Although these accounts show the caregivers' discouraging experiences of missed opportunities, their accounts also show their hopefulness for their children to *regain opportunities* in the future. For example, P02 learned first-hand that getting an education allowed her a higher income:

> **P02**: I see how important it was to have an education, because I jumped myself from $9 to a $30 per hour job.

Collectively, this discussion of the caregivers' backgrounds helps provide context for their experiences with Storywell, which will we describe next.

Satisfying Moments While Using Storywell

The technology acceptance survey that we administered in the final sessions suggests that caregivers developed motivation to use Storywell. The caregivers indicated that they would choose (*Med*=4.5, *IQR*=1.0), use (*Med*=4.0, *IQR*=1.25), and recommend (*Med*=4.0, *IQR*=1.0) Storywell (out of 5.0). Supporting this survey, the interview data revealed satisfying moments while using Storywell that appeared to be in play in heightening intrinsic motivation.

Satisfying moments are experiences that satisfy caregivers' need for relatedness in the form of feelings of connectedness and caring for their child [36]. The feeling of caring often emerged when supporting caregivers' aspirations for their children — and these aspirations were often driven by the feeling of missed opportunities, as we have discussed above.

We categorized caregivers' satisfying moments into (1) *bonding moments* that induce a more immediate feeling of connectedness, (2) *discovery moments* that satisfy the need for caring by observing their children's attitude or behavior, and (3) *educating moments* that satisfy the need for caring when caregivers felt their actions supported their child's attitudes or behaviors. Below, we will discuss these three categories of satisfying moments in more detail.

Bonding Moments

Bonding moments were moments when caregivers noticed their child's positive emotions while spending time together, thus satisfying their need for relatedness from the feeling of connectedness (n=10). This feeling of connectedness was stimulated by the social rewards, reflection questions, and fitness challenges. For example, P04 appreciated the bonding opportunity from the *social rewards*:

> **P04**: The story, yeah. It's sweet. So, for me, I say it feels like a treat. […] You get to spend time with your daughter. So, you're able to do something together.

Similarly, P16 echoed the joy of seeing the child's affective reaction when they got the social rewards:

> **P16**: She was happy. She was smiling, and stuff. […] I feel happy with her.

The *reflection questions* also allowed bonding moments by inducing family conversations. For example, P05 said:

> **P05**: [Storywell] kind of forces you to be closer. And then the questions during the story allow the child and the parent to share different ideas or experiences.

Finally, bonding moments were enabled by the *fitness challenges* as well. For example, P08 worked on her fitness goals because completing the goals made her son happy:

> **P08**: I need to work that much harder. I got to work a little bit harder, just to make that goal, because you know, he does get excited when we do make the goal.

Similarly, P05 appreciated the encouragement from her daughter because it shows that her daughter cared for her:

P05: I'm happy that she's thinking about encouraging me. […] That [encouraging] is something she would consider.

Our data suggests that the bonding moments were facilitated by the small mobile phone's screen for viewing Storywell. For example, P05 liked that she could be physically closer to her daughter:

P05: [I use Storywell when] either I'm next to her bed or she comes to get in my bed. […] [It's] the opportunity to get physically close. Because usually when you read a regular bedtime story you're not nuzzled up.

This account suggests a configuration that supports relatedness, namely being proximally close to one's child and being able to see the child's reactions. However, unlike P05 (a mother of one), P11 and P07 (a mother of three) said that the small screen was less suitable:

P11: The girl, she wants to [see the screen] and then they started fighting. That's the big one, when they start fighting. I'm like, "*oh no!*".

Although P11 said she enjoys connecting with her kids while using Storywell, the small screen led her children to compete to see the screen, and this competition led to fights. However, P08 (a mother of three) did not experience such competition:

P08: [My oldest son's] brothers actually sit down and reads with us, so it's a good time for all three of us, me and the two older boys, at least, to really bond.

It appears that it was not the small screen itself that limits caregiver's bonding moments, but rather the children's behaviors that arose from using a small screen.

To conclude, bonding moments arose when caregivers observed their children's positive reactions. Such moments were best facilitated when caregivers were physically close to their children and able to see their children's reactions. However, the enjoyment diminished when the app led to behaviors that distracted the family from using the app.

Discovery Moments

Discovery moments were times when caregivers observed their children's needs and behaviors in pursuit of valued goals (n=8). Such observations helped satisfy their need for relatedness by sparking a feeling of caring for their children. Unlike bonding moments that gave immediate satisfaction, the value of discovering a child's behaviors and needs was more long-term.

In *discovering children's behavior*, caregivers appreciated observing their children's PA and reading behavior. For example, P01 liked seeing her daughter's PA behavior done to unlock storybook chapters.

P01: [Storywell] gives her motivation to want to go outside and so she can make sure she gets her steps up to unlock the next chapter. […] As a parent, it brought a lot of joy to me to watch her eyes, her overall excitement in order to get a book.

Similarly, P17 also appreciated seeing her grandson take exercising seriously:

P17: It was interesting to see that he really wanted to [complete the fitness challenges]. That made me feel good. Especially, he's kind of overweight at his age.

The above accounts show that while unlocking storybook chapters or completing fitness challenges have limited immediate value, in the long term such behaviors can support health and education.

In *discovering children's needs*, caregivers appreciated getting insights about their children's needs because such insights enabled the caregivers to better support their children. For example, P01 liked learning her daughter's feelings about family PA:

P01: [She said] it made her very happy knowing that she could spend time with her family. I liked the questions. They give you a chance to listen to what they think in their little brains.

P01's appreciation for learning the child's feelings was shared by P05, because she did not typically ask such questions:

P05: And as a parent, you get to hear how your child feels, because I wouldn't have thought to ask her, "*How do you feel about physical activity?*"

From her daughter's answers, P05 learned that she can care for her daughter by providing more PA opportunities:

P05: I noticed that she was running out of answers to the questions. And so I was like, maybe we need to just start creating more experiences. And then from there you think about, "*okay, what does the child like, what does she like, what does she not like?*"

Moreover, knowing that P05 has more options made her feel good about herself:

P05: It feels good [knowing that I have more options to help her to be active], but I wish I had more.

If P05 learned that she needs to provide more PA experiences for her child, P15 learned that her son was overly confident:

P15: He always feels like nothing's ever difficult. So [when answering reflection questions] he always answers, "*No, nothing's difficult*." [...] He's a little arrogant. A little cocky. I didn't realize that he was.

Furthermore, P15 valued learning that her son was overconfident because now she can care for her son during moments when he struggles to handle failures in sport:

P15: Now when he didn't get it right off the bat, and he just doesn't wanna do it, and I'm trying to get him to do it… Now I know up front, and it doesn't hit me on the face.

In short, discovery moments were satisfying because such observations nurtured feelings of caring for the child.

Educating Moments

Educating Moments occurred when caregivers felt their actions supported their children's attitudes and behaviors

toward valued goals, thus satisfying their need for relatedness in the form of caring for their children (n=8). Similar to discovery moments, educating moments have more long-term value. However, in educating moments, the caregiver's actions went beyond simple observations.

In *supporting children's behavior*, caregivers appreciated the opportunities Storywell provided them to help build their children's skills. For example, P08 liked seeing her son's excitement with the social rewards because it allowed her to support her son's reading skills:

> **P08**: When he gets excited about unlocking a new story, I really love it, because then we can work on his reading and his recognizing words.

P08 liked supporting her son's reading skills because she believed that being able to read before going to kindergarten is important. Similarly, P05 valued being a parent who could fulfill her daughter's interest in reading:

> **P05**: [My daughter] is into reading a lot right now. And so that's just, you know, as a mother you want to fulfill that. […] She's just into reading stories, that's what she's into, so. Just as a parent, being able to fulfill that, is nice.

P05 was pleased that she could help satisfy her daughter's need for reading—an activity that she valued because she believed it is critical for education and opportunities in life:

> **P05**: If you have education or at least pursue an education, you're more likely to be exposed to opportunities, than somebody that's just working on a job every single day.

P05 and P08's desire to support their children's education was shared by most caregivers (n=13). As we have discussed earlier, caregivers believed that education will positively impact their children's future. For them, education is a way of regaining opportunities that they have missed. For example, P06 wanted her son to avoid *missed opportunities* because he experiences speech-language challenges. Thus, P06 valued the *reflection questions* because they helped her son to express his thoughts verbally:

> **P06**: [The questions are helping him] to explain himself more. And that's helpful, because he's getting speech [therapy], so I feel that it helps that he explains things that he does verbally.

In *supporting children's attitudes*, caregivers appreciated that using Storywell provided them the opportunities to pass on life lessons. For example, P05 valued Storywell because the game mechanics taught her daughter that things do not come for free:

> **P05**: It's a good system for the children to learn about earning things. […] I think it's built into the concept of [Storywell].

That lesson is important for P05 because of the challenges she feels her child will eventually face in life:

> **P05**: It's important to learn how to earn things because in life, life just hits you, especially when you get older. And it may put you in situations where people are not there for you. […] To be able to depend on yourself is a good trait to have.

Here, P05 wanted her daughter to learn the importance of hard work and being able to rely upon herself. She believed that Storywell helps kids learn such a lesson because it requires them to do the work to read the next chapter. For P08, she valued the stories and *reflection questions* about failures because they helped her son to learn how to manage disappointments when struggling with playing soccer:

> **P08**: I love the life lessons that he's learning with that. […] We could relate what was happening in these stories too. "*Remember when you were playing soccer and you guys weren't playing very good? But then the next week you came back and you were playing better?*"

In particular, P08 valued reinterpreting the negative past event because she perceived her son to be sensitive:

> **P08**: [My son is] a very sensitive boy, and he takes everything to heart. And when he wasn't playing good at soccer it really hurt him. It really affected him. And so I think these stories are great for him because he can see that there are other people or characters in this case, that went through the same thing.

Therefore, P05 and P08 valued the passing on of life lessons because they wanted to prepare their children to be resilient adults through hard work and gaining abilities to manage disappointments. This notion of being resilient in the face of obstacles was raised by P15 as well. While using Storywell, P15 discovered that her son was overly confident. She then tried to teach her son to be mindful about his limitations:

> **P15**: I just try to talk to him. Coach him. Like, "*Are you sure nothing is... Are you sure you don't have difficulty with this?*"

Similar to P08, P15's actions were driven by her belief that her son needs to be able to manage disappointments:

> **P15**: I think because of his confidence, that is why it's so difficult for him for some things to be hard for him.

Passing on life lessons can be driven by the experience of missed opportunities. For example, P15 said:

> **P15**: When I played, I thought I was the best. But I feel like if I didn't have that mentality, I would have been more receptive to what my coaches were saying to me, and I would have been even better. Now I know that, at 35. I didn't know that as a kid.

P15's experience of *missed opportunities* (because of her overconfidence as a child) led her to try to teach life lessons about being more receptive to feedback, something that she valued. Similarly, P17 valued Storywell as a tool for teaching her grandson how to achieve his goals:

> **P17**: The app is teaching him what we gotta do — like the activities to get the steps. [...] He's still three so trying to teach him about goals, and all that still kind of young.

Achieving goals was valued by P17 because she believed it is a characteristic of a successful person who had *regained opportunities* in life, given her African American race:

P17: I want him to be strong. What I mean [is I want him to be a] made man, I want him to have his own goals, maybe his own business. […] He's African American. It's hard for us.

P17's account echoed the structural racism experienced by African Americans and other racial and ethnic minority groups that can lead to poverty, stress, and lowered PA [9].

To conclude, educating moments were satisfying because they sparked opportunities for caregivers to educate their children towards behaviors and attitudes that build resilience and *regain opportunities*.

Collectively, our data revealed three categories of moments: *bonding*, *discovery*, and *educating moments*. Caregivers felt these moments satisfy their need for relatedness from the feeling of connectedness and from caring for their children. Their satisfaction of relatedness arose from (1) observing the child's reactions, and also from (2) actively supporting their children, both towards valued attitudes or behaviors. These attitudes or behaviors were valued because they are perceived as a means to regain opportunities.

Barriers to Motivation

So far, we have identified ways in which caregivers experienced relatedness when using Storywell. However, caregivers also faced barriers to using Storywell regularly. These barriers can lessen the feeling of competence in using Storywell effectively [36], thus limiting the development of intrinsic motivation. These barriers include *burdening duties*, *seasonality*, and *disruptive events*.

Burdening Duties

Burdening duties are constant and demanding routines that make it hard to use the app regularly (n=6). P18 (who was a working single mother of two children) explained why using Storywell regularly is hard:

P18: When I got home [from work], I know that I have a certain amount of time to do [household chores]. So, I can't just stop to [use Storywell]. And by the time I'm done [doing chores], I kind of just forget [using the app].

Here, P18 explained that her demanding caregiving duties made her forget to use the app. Being a single mother was also a factor for P18:

P18: Being that it's just me, it's hard [to use the app regularly]. Cause everything has to just fall on me. I guess like if it wasn't just me, probably I will have more time to do the app.

P18 was responsible for all aspects of household duties, thus she was time constrained to use Storywell. Time constraints were also experienced by P11 (a single mother of three):

P11: After you have so much things to do, remembering "*Oh I need to get the phone, get in the app, and reading a book*," it's hard to do every day. […] Either I forget because I have too much going on, or I just don't have time.

Just like P18, P11 said she faced time constraints that inhibited her regular use of Storywell. P11 further explained why her routine was demanding:

P11: I have multiple kids so it's a little harder especially when they're so small. Either one has an appointment or the other one has school, or one has a program. I'm all over the place.

P11's account shows how the responsibilities of a mother of three can be burdening because of her children's differing needs. Similarly, burdening caregiving duties affected P08, a mother in a two-caregiver family who had three boys:

P08: I have all sorts of appointments, I'm in school, and I have three children that have very different schedules, because I have doctor's appointments, different appointments and stuff.

P08's complex schedules made her too fatigued to use Storywell, even if her son asked her:

P08: There's been times where he'll be like, "*Mommy let's do the app*." And I'm like, "*I need five minute*s." […] There have been times where the day has just gotten away from me, and it just, it's a part of being a busy mom.

Similar to P08, P04, who is a mother of five in a dual-parent household, often felt too fatigued to use the app:

P04: [During bedtime] when I was like, "*Oh gotta do the app*." [...] It was kind of like, I just want to go to sleep.

These accounts from P04 and P08 show that the parenting duties of being a mother to three or more children led to fatigue and not wanting to use Storywell. For P01 (a single mother who has one child with attention deficit hyperactivity disorder and one child with autism spectrum disorder), her daily activities depend on how hectic her day is:

P01: [Sometimes] we can't read a book together and like I said it depends on my son's moods. It also depends on the craziness, chaos throughout the day.

These varying duties show the multiplicity of demands that families face. Burdening duties results in time constraints and fatigue that inhibited caregivers use of Storywell with their children. We will discuss these burden sources at the end of this section.

Seasonality of App Use

Another factor that impacted Storywell's use was *seasonality,* that is, times of the year that can interfere with family routines (e.g., summer) and thus limit engagement (n=7). For example, P01's kids are often away from home in the summer. This shift meant that their routine became unpredictable, thus constraining their use of Storywell:

P01: During the summer, our routine is like up in the air. The girls are usually with my mother or their dad's mom. So, the summertime they're not really here all the time.

As their routines became unpredictable, it was difficult for P01 to use Storywell regularly with her child. Similarly, P12 illustrated the disruption of routines during summer break, which include vacations and summer camps:

P12: A lot of parents go on vacation, a lot of kids will start camps. […] Where do you find that time [to use the app]?

P12 highlighted that summer activities can add time constraints for families and limit their ability to use health apps. P04 also said that some parents are not prepared for summer breaks:

> **P04**: Parents forget. They can't drop them off. Parents can't drop their children off. They forget that they're really active. And putting them in front of a TV or being in the house all day is going to solve that, and it doesn't.

P04's quote suggests that children may stay at home more often in the summer and thus increase caregiving burdens.

In summary, seasonality often interferes with app use because children and families are away from home, which creates time constraints; or children spend an increased amount of time at home, which increases caregiving burden.

Disruptive Events

Disruptive events are unpredictable and stressful life events that cause breaks in the family routine and limit caregivers' abilities to use the app regularly (e.g., P03, P10, P13). For example, P03 recently moved from government housing to a shelter (in which she lost her fitness band). In addition, her daughter had been away for several weeks:

> **P03**: I just haven't did [Storywell] with her. But now she's back so I'm looking forward to … Yeah. She's been away for a couple of weeks.

Another mother lost her job during the course of the study and was under stress because of her life situation:

> **P13**: I'm dealing with my own personal situation and it just got in the way. […] I just been stressed, honestly, just stressed.

Here, the effect of stress can lead caregivers to deprioritize some activities, including using a health and educational app like Storywell. Similarly, P10 also experienced stress when her six-month old baby had bone fractures:

> **P10**: [My baby] had a broken bone... a lot has been going on. I forgot how to access my phone. I had to reset my phone. My mind just went blank. I just forgot my pin number.

These accounts emphasize that disruptive events caused major stress for some caregivers and limited how effectively they could use Storywell.

Collectively, our data show the effect of satisfaction barriers, namely time constraints, fatigue, and stress. Our data also reveal the properties of these barriers: frequency and source. The *frequency* of a barrier describes its constancy, which can be consistent (e.g., burdening duties), periodic (e.g., seasonality), or unpredictable (e.g., disruptive events). The *source* of barriers are situations that are intrinsic to each family, such as demanding work hours (P08, P18), number of children (P04, P08, P11), or single-caregiver role (P01, P11, P18). These barrier sources are reflective of the participants' demographics. Furthermore, caregivers often experienced several barriers, which suggests that they may compound to further threaten the development of intrinsic motivation to use apps like Storywell.

DISCUSSION

Our study provides a picture of what motivated caregivers to use a family health app beyond our initial hypothesis — that *social rewards* would satisfy caregivers' need for connectedness and, in turn, heighten their motivation to use the app. In this section, we will discuss caregivers' internally and externally sourced motivations and how to use satisfying moments as a concept to design for motivation.

Internalizing Motivation Through Aspiration Fulfillment

Our data shows a range of *satisfying moments* that caregivers experienced while using a health app such as Storywell. Some of these moments satisfied the need for relatedness simply because they allow caregivers to connect with their children (e.g., *bonding moments*) [36]. Other moments satisfied the need for relatedness because caregivers felt they were able to care for their child in a way that helped them achieve valued goals (e.g., *discovery moments* and *educating moments*) [36]. Such goals were valued often because of caregivers' experiences in marginalized social groups. As we have described, caregivers valued education because of the concerns over *missed opportunities* from growing up in low-SES households or racial discrimination. Caregivers' emphasis on education is consistent with prior work that shows low-SES racial and ethnic minority caregivers have higher educational aspirations for their children [45].

The emergence of moments that satisfy relatedness suggests that intrinsic motivation was in development when caregivers used Storywell with their children. However, relatedness was also satisfied when caregivers felt they cared for their children in the pursuit of valued goals. In SDT, a behavior that is motivated by the value of the task is considered to be extrinsically motivated, albeit from a more internal regulation [37]. This kind of extrinsic motivation can lead to internalization — a process where the value of the task is adopted by or assimilated to the self. From our findings, we suggest that caregivers' actions were motivated by their assimilated goals for their children. In turn, such actions also nurtured caregivers' feeling of relatedness, which will further enable the internalization of motivation.

Furthermore, from the perspective of SDT, the internalization of motivation is a process that happens over time [37]. Therefore, while the satisfying moments can help the intrinsic motivation to use an app, these moments need to be experienced repeatedly in order to internalize the motivation. However, more familiar moments like *bonding moments* during storybook reading may not need to be experienced repeatedly because the satisfactions are more readily available given that caregivers may have had prior relatedness experiences during family storybook reading.

In summary, our data shows that caregivers' aspirations for their children — although appearing on the surface to be external — can be intrinsically motivating. Therefore, a potential design direction is supporting caregivers' motivation to use family health apps by using design elements that are intrinsically enjoyable to use and also yield

interactions that can facilitate caregivers' aspirations for their children.

Satisfying Moments as a Design Concept

Our findings show a range of moments that were satisfying and enjoyable, thus facilitating motivation. Here, we will discuss how to use satisfying moments as a tool to design an interface that supports motivation especially for health apps, as well as how to help users cope with motivation barriers.

Guided by SDT, to make an app more intrinsically motivating to use, we suggest that users should experience satisfying moments repeatedly. We will provide examples of how to implements these moments in app design.

To design for *bonding moments*, a system should support the dyad in experiencing intimacy by being physically close and noticing positive emotional reactions. For example, a mini health game that the dyad can use on the same screen allows the dyad to be physically close and experience game moments together.

To design for *discovery* or *educating moments*, a system should incorporate design elements that cater to the range of aspirations that caregivers may have. We support prior work that advocated health interventions to go beyond supporting behavioral or physiological improvement [3] by incorporating elements that support language and math development, social-emotional skills, and the passing of important family values. For example, an exergame that focuses on learning new words can be seen as a game for supporting PA and literacy. Furthermore, the opportunities to experience these moments might be readily available for the dyads. A system can simply help the user to notice the moments. For example, a caregiver might already feel connected when using an app with the child. By inviting the caregiver to talk about the bonding experience (e.g., "*Can you tell your child how much you feel connected to them*?"), that moment can become heightened in feeling.

Using Epstein et al.'s Stage-Based Model of Lived Informatics [12], these moments can be applied at different stages (e.g., collection, integration, reflection stages). For example, although reflection is a critical stage of personal informatics, current PA trackers have not fully supported users in getting contextual information or reflecting on their data [20,40]. A potential direction is designing reflection that is more intrinsically motivating. For example, a system for the caregiver and child to take turn and draw pictures that give contextual information and emotional meanings of their data, thus supports *discovering moments*.

We also found that satisfying moments can be limited by motivation barriers. Using moments as a framework, when a system detects a drop in engagement (e.g., due to vacation, busy days, disruptive events) the system can offer users to pause using the app for a period of time so they can experience the satisfying moments when their household duties are more manageable. This approach can help users resume tracking after a lapsing stage [12], given that self-tracking users often had breaks from tracking [29]. We also identified the properties of satisfaction barriers, namely frequency and source. While a system cannot change the source of a barrier, a system can offer strategies for families to cope with frequency barriers. For example, if the frequency is consistent, the system can offer the user some strategies to find time based on the source of the barrier. If the frequency is temporary, then the system can offer the user to pause using the app for several days or weeks. Finally, if the frequency is unpredictable and also acute, the system can offer longer pauses and offer local community resources.

With the identifications of these satisfying moments, we suggest future work to further explore the properties of these moments (e.g., intensity, lastingness, repetitiveness). By understanding these properties, designers and researchers can strategically place those moments into the system design. For example, design elements with intense enjoyment that feel repetitive quickly can be sparsely used so the moments can be impactful but do not feel repetitive quickly. Put differently, low-intensity and unrepetitive moments can be placed in the design more often. We recommend future work to further examine the various properties of moments in relation to user's enjoyment and motivation.

CONCLUSION

We designed Storywell, a family PA app that provides *social rewards* and *reflection questions* when a family completes their PA goals. From our three-month evaluation of Storywell with 18 families of low-SES neighborhoods, we identified three *satisfying moments* that can nurture caregivers' need for relatedness and heighten the intrinsic motivation to use family health apps. The three satisfying moments are: bonding, discovery, and educating moments.

These moments satisfy caregivers' relatedness from the feelings of connectedness and also the feelings of caring for their children towards fulfilling the caregivers' aspirations. In turn, caregivers' aspirations were often shaped externally from the feeling of *missed opportunities*, such as from immigration status and racial discrimination. In line with Self-Determination Theory, caregivers' motivations to use health apps are driven by caregivers' lived experiences which produced values (e.g., education is important) that have been integrated into their selves. We suggest that family health apps should be designed to catalyze family social interactions that enable family members to notice each other positive emotional reactions and also facilitate caregivers' aspirations for their children.

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