Designing Ambient Narrative-Based Interfaces to Reflect and Motivate Physical Activity

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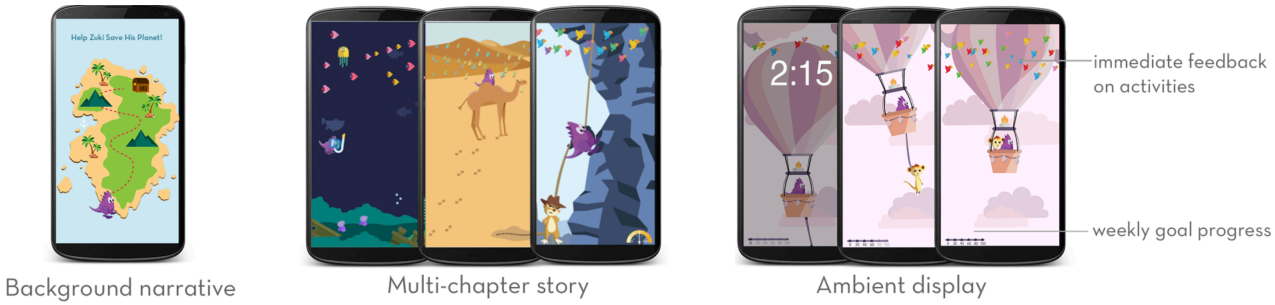

Figure 1. The WhoIsZuki system reflects tracked physical activity through narrative-based feedback ambiently displayed on a smartphone's lock and home screens. As a user logs activities and meets goals, the plot progresses and achievements are similarly reached by the story's main character, Zuki.

ABSTRACT

Numerous technologies now exist for promoting more active lifestyles. However, while quantitative data representations (e.g., charts, graphs, and statistical reports) typify most health tools, growing evidence suggests such feedback can not only fail to motivate behavior but may also harm self-integrity and fuel negative mindsets about exercise. Our research seeks to devise alternative, more qualitative schemes for encoding personal information. In particular, this paper explores the design of data-driven narratives, given the intuitive and persuasive power of stories. We present WhoIsZuki, a smartphone application that visualizes physical activities and goals as components of a multi-chapter quest, where the main character's progress is tied to the user's. We report on our design process involving online surveys, in-lab studies, and in-the-wild deployments, aimed at refining the interface and the narrative and gaining a deep understanding of people's experiences with this type of feedback. From these insights, we contribute recommendations to guide future development of narrative-based applications for motivating healthy behavior.

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Narrative Feedback, Ambient Display, Mobile Health

CCS Concepts

•Human-centered computing → Human computer interaction (HCI); User centered design; *Smartphones;*

INTRODUCTION

The world currently faces serious public health challenges that are often preventable and manageable through behavioral changes. In this paper, we focus on physical activity, which is not only crucial to wellbeing but also one of the top risk factors for premature death [62]. Lack of physical activity is a primary contributor to chronic diseases like diabetes, heart disease, obesity, and stroke, which have become a global epidemic affecting billions around the world [74, 87]. In the United States, more than three quarters of adults fall short of mobility targets [12, 72], and it is estimated that over five million annual deaths worldwide could be prevented just by increasing physical activity [6, 52, 73].

Technology has the potential to help address this challenge and promote activity in an effective, low cost, and scalable manner. Indeed, a great deal of effort has been put towards the design of systems to track and encourage physical activity. In particular, sensor-laden, broadly-adopted smartphones and increasingly wearables provide vast amounts of data about physical activity and health and enable near-continuous interactions with users to try to motivate healthy behaviors.

However, the majority of existing apps use a monitoring strategy based on charts, graphs, and statistical reports — a heavily *quantitative* approach that can be hard to interpret and overwhelming [27, 59] and a less effective style of feedback [41, 46]. In fact, research finds that such formats can not only fail to improve health but can actually have the opposite effect, potentially harming motivation and self-integrity [14] and fueling negative mindsets that make physical activity seem distressing rather than desirable [24].

In this paper, we explore a more *qualitative* form of feedback. Specifically, we encode personal activity data and progress towards fitness goals into comic-like stories that we deliver through ambient smartphone wallpapers. Central to our design is the use of narrative, which is commonly defined as a cohesive story with an identifiable beginning, middle, and end, that provides information about scenes and characters, and raises and resolves conflict. "Narratology" is the humanities discipline concerned with the study of narrative, its structure, and how it impacts human perception and sensemaking.

Research shows that storytelling is persuasive in promoting healthy behavior in large part because individuals perceive narrative as more believable, memorable, and personal [41, 46]. Stories help people make sense of their experiences [8] and create opportunities for self-affirmation [14], which suggests the power in using visual narratives to promote curiosity, engagement, and self-reflection during personal data sensemaking. Further, ambiently displaying such stories on smartphone screens provides at-a-glance feedback that may further enhance immersion, given people check their phones ∼80-200 times per day [32, 93]. Prior work utilizing ambient nudging has shown it effectively motivates behavior, by reducing barriers to information while increasing self-awareness [21].

Building on all these ideas led us to develop the system WhoIsZuki, an Android mobile application that provides a glanceable wallpaper display of a visual narrative that translates the user's physical activity into story development. In this paper, we overview the iterative user-centered design process we undertook to craft the narrative-based interface and explore people's receptivity towards such a system. In doing so, we investigate research questions surrounding how individuals react to their behaviors and goals being represented as components of multi-chapter stories and how our narrative feedback affects activity, attitude, and engagement.

Our specific contributions include:

- A novel approach for promoting physical activity through narrative-based feedback, including to introduce salient theories from narratology, together with strategies for translating those principles into concrete design goals.
- A functional, interactive system that implements these ideas by encoding manually and passively tracked activity data into visual narratives delivered on a mobile ambient display.
- Findings from online, in-lab, and in-situ studies that characterize how people make sense of and engage with narrative feedback formats, including to increase understanding of the impact such interfaces can have on promoting physical activity attitudes and behaviors in everyday life.

RELATED WORK

Here we review theories from narratology and psychology that informed our approach, along with relevant HCI research.

The Power of Narrative as a Motivational Technique

A rich body of literature indicates that narratives can strongly influence beliefs and behavior. Early work examining the motivating nature of narrative focused on identifying the precise psychological underpinnings that allow humans to create meaning from stories, determining that readers use information about temporality, spatiality, the protagonist, causality, and intentionality to make sense of events [95].

The perception of being immersed or transported [39] by a piece of text has been described as a state not unlike that of flow, as proposed by Csikszentmihalyi [25]. Narrative transportation theory suggests that such immersion is persuasive because beliefs, emotions, and intentions can change to reflect those presented in the story [38, 67, 90]. "Narrative engagement" builds on the idea of transportation, identifying that people combine information from the text with personal experience to construct a mental model of story events [8, 9], which can have strong impacts on attitude and behavior [26].

The Extended Elaboration Likelihood Model (E-ELM) further explains that becoming absorbed in a narrative suppresses counterarguments to persuasive content, as the cognitive processing of the story precludes cognitive resistance [83]. This idea that narrative absorption is fundamentally incompatible with counterarguing [82] suggests narratives may provide a means to positively nudge even those individuals ordinarily facing barriers to motivation. Along similar lines, the Entertainment Overcoming Resistance Model (EORM) proposes that because narratives are entertaining, they reduce cognitive resistance [15, 63] and overcome negative psychological reactance [29, 78]. Such models additionally indicate that the degree of motivation depends on how much the audience identifies and empathizes with a story's characters (e.g., in terms of challenges, goals, or behaviors) — especially vulnerable characters [15], as this elicits a stronger emotional response, more enjoyment of the story, and an associated reduction in selective avoidance due to fear [63, 81]. Other particularly motivational narrative elements include fictionalization, structure, and progression [3, 26, 79].

Psychology of Behavior Change

Beyond the psychology of narrative, our work is informed by several other behavioral theories as well. First, goal-setting theory [56] identifies two key factors that contribute to attainment of a goal: personal importance and self-efficacy, which can be increased by supporting commitment, role-modeling, and feedback about progress. The transtheoretical model (TTM) [77] of behavior change similarly outlines various affective, cognitive, and evaluative strategies that influenced our design choices: dramatic relief (eliciting emotional arousal about the health behavior), reinforcement management (rewarding positive behavior and reducing rewards that come from negative behavior), and stimulus control (providing behavioral cues and nudges). Our system specifically targets people in or entering the TTM's contemplation, preparation, and action stages.

Also worth considering is Goffman's theory of Presentation of Self in Everyday Life [36] on how individuals manage the impressions they desire others to have of them. HCI research on ambient displays has confirmed the value of designing to support impression management needs, particularly to enable a user to control what personal data is tracked and how it is used [16]. Lastly, research on the power of mindset suggests that health behaviors and outcomes can be substantially influenced by one's attitude about the process of exercise [24, 92], which can be seen as "cringeworthy" (e.g., depriving or boring) or "craveworthy" (e.g., pleasurable or even indulgent) [23]. Personalized narratives that positively frame exercise in terms of enticing and playful challenges presented through aesthetically pleasing interfaces may therefore promote a more craveworthy mindset and, in turn, more physical activity.

Ambient and Narrative Technologies for Healthy Behavior

To date, technologies aimed at tracking and reflecting personal behavior have largely focused on health [66]. Early systems such as Houston [16], Laura [5], Chick Clique [86], Shakra [2], and the Lifestyle Coach [35] used pedometers, mobile phones, and software applications to encourage individuals to reflect on, socialize around, and increase physical activity. Technologies such as Breakaway [43] and ViTo [68] were conversely framed around minimizing inactivity and sedentary behavior. Personal informatics researchers continue to build on these foundations to develop digital tools for monitoring and managing various aspects of health [30, 65, 88].

While such applications delivered notifications or required a user to launch an application, other systems have communicated health-related behaviors and goals via more passive ambient displays, often in tandem with visual metaphors such as flowers [16, 21] or sea life [50, 54] that reflect physical activity or other personal metrics. Interestingly, though such interfaces were not necessarily designed to provide a narrative experience, research has found that users did perceive a "story" embedded in these visualizations of their behavior and that this was a key factor in motivating their engagement with the application [33]. When systems more intentionally pursue the inclusion of story elements, it is typically as part of location-based quests [1, 45, 85] or avatars in a serious game [34, 53], though recent work has also explored how technology can generate or help users tell stories as a way to make sense of personal data or motivate behavior [11, 31, 75, 80].

On the positive side, research has found that these strategies can be successful in improving users' happiness and self-esteem [40], making physical activity more enjoyable [94], and persuading behavioral changes [21, 33]. However, such interventions have not fully explored the use of narrative [47, 55, 64], and more work is necessary to develop theoretically-grounded, personalized systems that instantiate effective and engaging storytelling techniques to motivate activity [4, 19].

WHOISZUKI SYSTEM & DESIGN PROCESS

Drawing on these narrative theories, the persuasive design literature, and design strategies identified by the prior HCI work on which we build, we created our WhoIsZuki system.

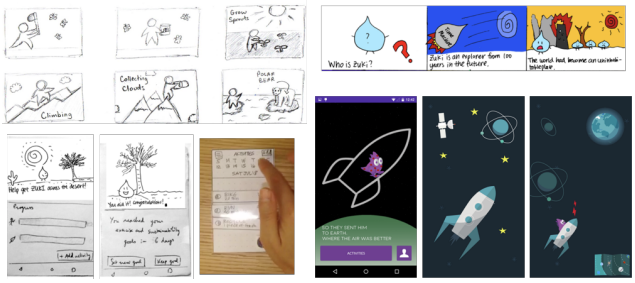

Figure 2. A sampling of design artifacts, including early storyboards (top), paper prototypes (bottom left), and progressively higher fidelity digital interfaces (bottom right).

Here we describe WhoIsZuki's main features[1], including how the system supports tracking of activities and goals and reflects back progress through personal data-driven narratives that are ambiently displayed on the lockscreen and homescreen wallpapers of a user's smartphone, as overviewed in Figure 1.

To craft the storyline, hone the interface's look and feel, and resolve issues related to functionality and usability, we progressed through an iterative user-centered design process. In addition to helping us gather feedback on design concepts, these studies also investigated people's basic expectations for a narrative-based interface, assessed their willingness to use such a system as part of efforts to increase physical activity levels, and collected reactions to various narrative representations of personal data. We engaged with both large and small samples of people online, in the lab, and in the field. The Stanford Institutional Review Board approved all procedures.

Initial design steps involved construction of personas from N=300+ surveys, storyboarding, prototyping, and testing at various fidelities including paper. Figure 2 shows a sampling of such artifacts. We focus here on describing steps and outcomes that contributed the most directly to key features or that surfaced non-obvious and noteworthy design insights.

Activity Tracking and Goal Setting

We support both automated and manual logging to reduce tracking barriers and maximize capture of progress, while also enabling individuals to maintain control over their data. Specifically, we use the activity inference supplied by Google Fit to automatically detect walking, biking, and running. We chose the Google Fit platform given its flexibility and stability; the Fit API also makes it easy to retrieve data from a wide variety of third-party apps as well as any companion wearables, and a user's fitness data persists when devices are upgraded.

By launching the WhoIsZuki app, users can edit and delete recorded activities, manually add new activities, and set any number of weekly exercise goals across various subcategories (e.g., flexibility, strength training, walking, etc). We support two units of measure for goals: duration (e.g., "Bike for 90 minutes this week") and number of times (e.g., "Run 3 times this week"), as these metrics are applicable to any type of goal and align with the information made available by Google Fit.

[1] Auxiliary materials provide full size design artifacts, the complete narrative, and app screenshots: http://hci.st/zuki-chi2020

To support efficiency, the app provides shortcuts to quickly add and review activities and goals. By providing access to historical data, the app also facilitates self-reflection about past behavior as it relates to long-term goals.

To store user data and log interaction events, WhoIsZuki makes use of the Firebase mobile development platform, which provides a realtime database as well as useful services such as Remote Config, Cloud Messaging, Cloud Functions, and Analytics. For example, we can use the Remote Config service to control A/B testing in a controlled experiment or to customize app experience based on user characteristics. To improve the app's offline performance, two chapters are fetched every time the platform syncs with Firebase cloud storage; if no internet is available while fetching the narrative resource, a local version is used as a backup. This allows the app to use local storage efficiently and enables updates to be made to the narratives if necessary.

Multi-Chapter Graphic Narratives

We then visualize this fitness data as a multi-chapter story on the phone's lockscreen and homescreen. This ambient display (and a user's many glances at it throughout the day) keeps her passively aware of activities and goal progress. Achieving weekly goals unlocks the next chapter, where a new sequence of images is visually and textually narrated. An overarching plot links together the full set of chapters (13 chapters, each with 5 parts). Figure 3 shows the first scene of each chapter.

To clarify terminology, we define a "multi-chapter narrative" to have an episodic plot structure that is comprised of a series of chapters linked together by the same character and theme but distinguished by their individual plots, purposes, and subtexts. Additionally, we use the term "ambient" given our lock and home screen interfaces display information in a glanceable fashion, are designed to be subtle and non-distracting, and can exist in the periphery of attention [17, 33, 61, 76].

Our narrative is told in the third person and adopts an episodic structure including an exposition, rising action, climax, falling action, and conclusion. Specifically, five opening screens serve as exposition to tell the backstory of the protagonist, Zuki, an alien who ventures to Earth on a mission to collect biosamples to save his dying homeplanet as well as find his brother who was lost on a prior voyage. Chapters 1–11 then deliver rising action, as Zuki encounters diverse scenes, characters, and sub-challenges. The climax is reached in Chapter 12, falling action occurs in Chapter 13, and finally an exit screen serves as the story ending, when Zuki rescues his brother as resolution.

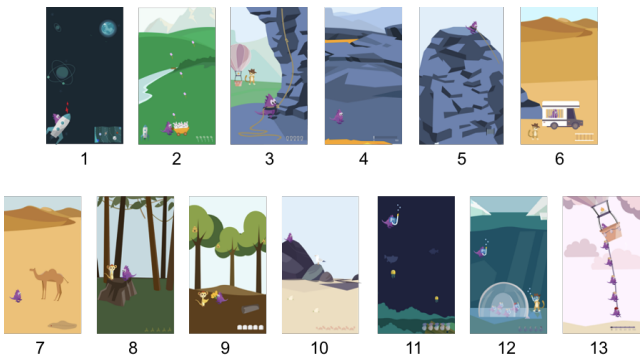

Figure 3. The opening scene of each chapter in the WhoIsZuki narrative.

Crafting the Narrative

We worked in close consultation with narratology experts from the English department to develop this structure and refine the story to enhance its allure, comprehensibility, and overall likelihood to impact behavior. For example, framing the story as a mission helps build a connection with the reader [83] (the user), who is similarly facing challenges (to be physically active). The user's progress towards goals drives the narrative to advance, incrementally disclosing plotlines. By tying Zuki's experiences to user behavior, we integrally involve a user in the story in a way that the narrative persuasion literature shows enhances the saga's personal relevance, motivational internalization, and absorption power [37, 39, 41].

The use of characterization — and in particular characters facing hardship and vulnerability [15] (Zuki and his brother) — also promotes empathy, emotional stimulation, and, in turn, deeper immersion and motivation [9, 38, 67, 69]. We incorporate "helper" characters (monkeys, bunnies, fish) who offer assistance and hints to Zuki to further develop the plot as well as an antagonist character named Gryff, a government agent trying to catch Zuki for experimentation, who adds tension and uncertainty to further increase engagement [42, 57].

The story additionally fosters a sense of suspense by making information provided in early chapters relevant to solving problems later on [63, 91]. This also keeps the logic of the storyline consistent and increases realism, which is linked to a reader's enjoyment and fulfillment [8, 9]. Finally when the user has reached the last scene of a given chapter, a preview of the newly unlocked chapter serves as a hook to encourage continued engagement with the upcoming story [28, 58].

User Testing the Stories

To ensure our narratives were understandable and engaging, we conducted two rounds of user studies where participants, recruited via email and word-of-mouth, viewed a slidedeck with images of every chapter and were asked to think about the story in relation to personal fitness goals. In the first study, N=5 participants (aged 18-50, all female) visited our lab to participate in 60 minute one-on-one sessions, where they reviewed our initial versions of the story and provided feedback. Several key insights emerged. First, participants felt it necessary for there to be a more logical relationship between their personal fitness goals and Zuki's own goals. We therefore rewrote chapters where this disconnect was identified (e.g., Zuki leisurely riding a camel without physically exerting himself or facing much hardship). Next, participants wanted to feel a stronger emotional attachment with Zuki, and they also thought the plotline could be made less predictable to create more anticipation and desire for future content. Based on participants' suggestions and after consulting with our three narratology experts, we addressed both of these issues regarding empathy and suspense by shifting the primary backstory to be that Zuki is journeying to Earth to search and rescue his brother, given the motivational value of familism in narrative.

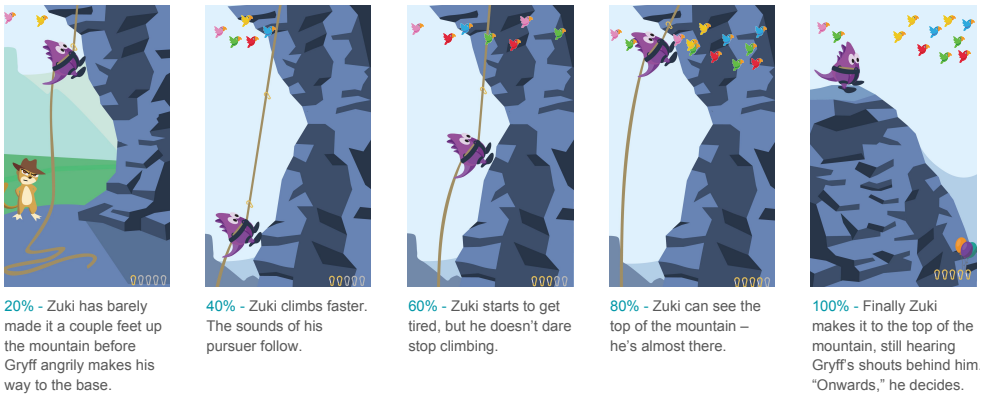

Figure 4. A weekly storyline, illustrating incremental progress of the main character, Zuki, towards his goal for that chapter (here, climbing to escape his antagonist), which parallels the user's progress. The glanceable display uses visual elements to give feedback about tracked activities (e.g., birds – top of screen) and progress towards weekly goals (e.g., carabiners – bottom right), accentuated with celebratory overlay (e.g., balloons) at 100%.

In addition, participants helped us recognize ways to improve the clarity and noticeability of the visuals and transitions between chapters (e.g., by adding a preview of the upcoming plotline), which we also incorporated into updated narratives.

To confirm the narratives had been improved and solicit any further feedback, we next conducted a second round of 60 minute in-person interviews with N=7 additional participants (aged 20-43, 4F/3M). Specifically, we measured engagement based on five dimensions from the Narrative Engagement Scale: empathy, cognitive perspective taking, narrative involvement, ease of cognitive access, and narrative realism [9]. We found that all participants could successfully describe Zuki's goal, the reasons why he had undertaken it, how he achieved it, and the ultimate outcome of the story. All but one participant could empathize with what Zuki was going through emotionally, noting that they were able to experience happiness, worry, and fear in parallel with Zuki and calling out moments when they could imagine being in Zuki's shoes. Further, all participants reported that the story was easy to follow and that its unfolding made sense to them.

We also found the visual components of the narrative mattered most, with people wanting the visual of the story to be largely comprehensible on its own, without having to read lengthy text. Participants also pointed out that storylines dependant on text for context hindered the glanceability of the display. This motivated us to improve the standalone legibility of the visuals and make accompanying text more succinct. To further enhance glanceability, our activity icons and progress indicator are located at the top and bottom of the screen, respectively, to avoid competing with other visual elements as much as possible (e.g., to minimize occlusion with a user's notifications, which appear in the center of the lock screen).

Real-Time Positive Feedback of Progress

WhoIsZuki provides four types of real-time positive feedback to reflect completion of activities and progress towards goals.

Visually Encoding Activity

First, logged activities are stylized as small icons thematically related to the storyline of the current chapter, as shown at the top of the screens in Figure 4. Each time a user logs a physical activity, a new icon is populated at the top of the screen. Activity type is encoded with different colors: blue for biking, red for running, yellow for walking, and purple for other user-logged types of activities. Activity duration is encoded with icon size: activities lasting less than 30 minutes, 30–60 minutes, and over 60 minutes are represented by small, medium, and large icons, respectively.

We arrived at this icon design scheme by recruiting N=200 participants via Mechanical Turk to test various options for the icons' color (all the same color vs. different colors to represent different activities), size (all the same size vs. different sizes to represent different activity durations), and positioning (icons appearing in a fixed position vs. "growing" in a path from left to right across the screen). To determine which options created the most visually noticeable indication of activity progress, we sequentially showed participants two screenshots from the same chapter: a baseline screen containing a set of icons and then five seconds later a new screen with the same set of icons plus one new icon from one of the eight conditions (2 color x 2 size x 2 position). After two additional seconds, the screen would disappear and respondents would be asked questions about what difference, if any, they noticed between the two images they just saw. We found that a design using color to encode activity type and size to encode activity duration communicated more information and was rated as more aesthetically appealing. We also found that presenting progress in a growing path from left to right made it more noticeable.

Indicating and Celebrating Milestones

Second, achievement towards weekly goals is reflected in a plotline-relevant progress indicator in the bottom right corner of the screen. For every 20% completion towards the goals a user has set for the week (calculated over all the user's weekly goals, aggregated and weighted equally), the indicator advances. When the user reaches 100%, an additional overlay is displayed, such as balloons (as seen in Figure 4), confetti, or fireworks, to celebrate goal attainment. We added this overlay based on feedback from participants in the aforementioned N=7 lab study, who described a desire for more explicit visual rewards to call out and celebrate their achievements.

Third, this completion of all weekly goals unlocks the next chapter, which will then be available at the start of the next week (which we treat as Sunday, guided by prior work [20, 64]). If users fail to complete their set goals by the end of the week, they return to the start of the same chapter when the next week begins. Finally, notifications are sent at every 20% milestone to complement the visual narratives and assist the transition between chapters.

Gauging Receptivity to the Glanceable Feedback

To examine reactions to these refined features of the interface as a whole, we collected N=108 responses from individuals recruited on Mechanical Turk. Respondents were presented with each chapter's 60% goal progress screen in a random order, followed by 1–10 Likert scale questions about how much they liked the image as well as their openness to and actual likelihood of using it as their phone wallpaper.

85% of respondents reported that they would be moderately or very likely to use the app, with 46% very likely to use it. All chapters showed a score of 6/10 or above regarding how much respondents liked the visuals and how receptive they were to using it as their phone wallpaper, and 60%–80% of respondents liked the visual design of all chapters at least moderately. Respondents did consistently express a preference for the same four chapters, where Zuki is perilously navigating his spaceship to Earth, working to escape a villain, seeking help from a friendly animal, and rescuing his brother and other lost aliens from precarious danger — which helps confirm the promise of employing narrative principles, especially antagonism, characterization, dramatization, and suspense.

FIELD STUDY

Having refined WhoIsZuki through these iterative phases of design, we next conducted a 3-week pilot deployment to explore people's use of the system in everyday life, ways it affected both physical activity attitudes and behaviors, and the overall experience of interacting with narrative-based feedback.

Important to call out is that this deployment was not intended to "prove" behavior change, which is not necessarily possible or even desirable when evaluating novel technologies in this context and stage of HCI research [48]. A longitudinal study would be required to test sustained effects of the system. Instead, we are interested in collecting in-situ data to establish the system's practical viability in the wild, including to discover ways it is used (and potentially breaks) outside the lab. Considering WhoIsZuki as a research probe, we are also concerned with better understanding people's reactions to the novel behavior change design strategies we have embedded in the system, by gathering natural, qualitative information day to day. Our approach mirrors influential work on developing mobile behavior change tools [16, 21, 33, 64].

Participants and Procedure

Via email, word of mouth, and snowball sampling, we recruited N=16 participants (10 female, 6 male, aged 18–75 years old with a median age of 34). Given the exploratory, descriptive nature of our study, we focus on a small-scale sample representative of the general population, which is standard for CHI papers with similar goals [10].

For onboarding, participants visited our lab for a 60 minute session, during which we conducted an interview to understand personal practices and perceptions related to fitness, apps, and narrative. Participants also completed an entry survey to report on physical activity levels [22], barriers [70, 71], and attitudes [60], as well as demographic information. Finally, we installed and confirmed WhoIsZuki functioned properly on the participant's phone and answered any questions.

During the course of the study, participants completed a 1–2 minute daily survey to provide open-ended feedback about their ongoing experience with WhoIsZuki as well as a 5–10 minute weekly survey to gather thoughts and screenshots about that week's narrative and interface. The daily and weekly surveys were hosted on Qualtrics, and participants were sent a text message with the link each evening and each Saturday, respectively; compliance rates were 90% and 100%, respectively. We additionally captured analytics data about fitness behaviors (type, timing, duration, and edit history of activities and goals) as well as lock and home screen view events and WhoIsZuki app launches.

At the end of the study, participants again visited the lab for a 120 minute offboarding session, during which they completed an exit survey and we conducted an interview about their overall experience with the WhoIsZuki system, their motivations to be active during the study, and to clarify any unusual survey or usage data we had observed. Participants received up to $225, using a compensation structure that incentivized providing feedback (e.g., completing interviews and daily and weekly surveys) rather than artificially motivating physical activities and achievements. Entry and exit interviews were audio-recorded, transcribed, and de-identified. On these data as well as all open-ended survey responses, we conducted a thematic analysis [7] to generate initial codes, which were iteratively refined and combined into higher level themes that helped us make sense of people's experiences with the system.

Study Groups

To investigate reactions about and effects of various motivational mechanisms in the WhoIsZuki interface, we randomly assigned participants into one of four between-subjects groups that varied chapter length (multi-chapter or repeating single-chapter) and notification delivery (notifications or no notifications). Specifically, users who received the multi-chapter version experienced the first 3 chapters (given the 3 week study duration) of the narrative described in the *WhoIsZuki System & Design Process* section; and users who got notifications received them after every 20% progress milestone.

Users in the single-chapter group also received the WhoIsZuki backstory and narrative — but rather than progressing onto the next, new chapter once 100% of weekly goals were met, the same chapter would be replayed each week. This experience resembles what the UbiFit [18, 21] and UbiGreen [33] style interfaces support, and it allowed us to investigate how episodic structure within a single chapter versus across multiple chapters impacts experience with the system and ongoing motivation. To avoid artificially deflating the inherent engagement potential of the single-chapter version, we used the chapter shown in Figure 4, which ranked second highest

in terms of likelihood to use and preferred visual design in our previously described N=108 survey. (Rather than using the top rated chapter, we opted for this one given it includes Gryff and therefore provided an opportunity to study reactions to the antagonist character across all participants). We varied notification delivery so that we could examine whether these alerts did in fact boost engagement with the narrative as well as awareness of personal behavior and progress towards goals. Participants were blinded to the existence of the different groups.

Overall, we expected that the ambient display would motivate participants using all versions of the WhoIsZuki interface, with the multi-chapter narrative including notifications leading to the greatest engagement and thus more positive change over the course of the deployment.

FINDINGS

Here we report on insights from the 3-week field trial. Again, while future work will focus on how the system impacts sustained behavior change, our goal at this stage of the research process is assessing feasibility and investigating how people react to and act on our narrative-based strategies for motivating physical activity, including to surface unexpected uses of the technology, whether positive or problematic. Specifically, we focus here on descriptive findings related to people's everyday fitness behaviors and how the WhoIsZuki system affects these activities and attitudes, people's engagement with the story and interface, and reactions to various attributes of narrative-based feedback. To help illustrate participants' experiences, we contextualize quantitative results with quotes and qualitative interpretations derived from our thematic analysis.

Fitness Goals, Activities, and Attitudes

To begin, we describe goals set, activities tracked, and how WhoIsZuki impacted these behaviors and motivations.

Types and Achievement of Goals

Participants set goals for biking, running, walking, general cardio, pilates, yoga, general flexibility, and strength training; one participant also set a 60 minute goal to clean. Target durations for weekly goals ranged from 20 minutes – 7 hours per week. Regarding progress towards those goals, multi-chapter participants did seem to fare better. Specifically, during Week 1, 2, and 3 of the study, 2/8, 6/8, and 6/8 of participants who saw the multi-chapter narrative achieved 100% of their goals, respectively; while only one single-chapter participant in Week 1, a different single-chapter participant in Week 2, and those two same participants in Week 3 reached all of their goals.

Interestingly, at least two participants who received the multi-chapter narrative sometimes deliberately deflated their goals — though the reason is actually encouraging, as these individuals explained it was their engagement with Zuki that drove their desire to know the next piece of the storyline — e.g., *"I was pretty active today, and I was looking forward to seeing how Zuki would progress so I manipulated my goals a bit to include the activity that I did."* (P10). Promisingly, such "fudging" was not also associated with diminished activity levels for multi-chapter participants, as we describe next.

Types and Amounts of Physical Activity

Overall, participants logged a total of 1065 activities — 81.6% of them automatically and 18.4% manually. Per participant, the number of recorded activities ranged from 31–150, with a mean of 67 and median of 58 activities. On average, these activities lasted 21.2 minutes / 16.2 minutes (mean/median), ranging from 9.8–180 minutes. The 180 minute activity was a manually-logged cleaning session, the next longest activity was a 150 minute manually-logged yoga session, and several ∼2 hour walks were auto-logged by various participants.

Activity levels did vary somewhat depending on whether a participant received the single-chapter or the multi-chapter narrative, as shown in the left graph in Figure 5. (No significant main effect of notification on average activity duration was found nor interaction effect between notification and chapter length, and participants didn't mention notifications impacting their activity levels). Specifically, while the average number of logged activities dropped off after the second week for everyone, single-chapter participants dropped 43.5% from Week 2–3, while multi-chapter participants decreased just 14.3%. Further, while the duration of activities progressively decreased each week for single-chapter participants, multi-chapter participants remained relatively stable across the study, even climbing ever so slightly from Week 2–3. Multi-chapter participants were also active more often: multi-chapter participants logged activities a median of 17 days, with 2 participants logging everyday and another 2 participants missing only 1 day or 2 days. Participants with the single-chapter story were active for a median of 13 days, with the majority of those missed days occurring after the first week of the study, once no novel storyline was delivered to help maintain engagement.

Both multi-chapter and single-chapter participants noted that the ambient interface enticed them to populate the icons at the top of the screen, which helped to nudge activity — e.g.,*"I wanted to get a red star so I went for a short run even though I didn't feel like it."* (P4). Similarly, though manual logging was more burdensome for people than the automated activity tracking, participants mentioned that they did enjoy logging activities by hand from time to time, as an excuse to look at the interface and watch the icon appear as an immediate reward.

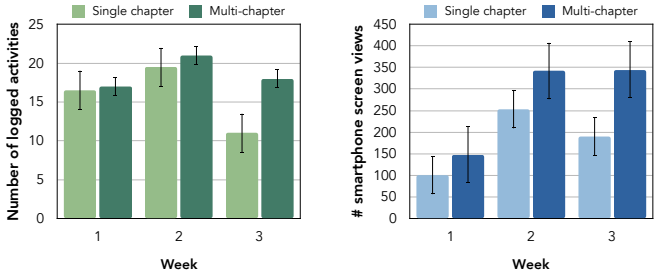

Figure 5. Weekly trends over the course of the field study in the median number of activities logged automatically or manually (left) and in the median number of smartphone screen views (right) by participants who received single-chapter or multi-chapter versions of the narrative.

Psychological Attitudes and Shifts

Beyond trends in participants' physical activity, we were also interested in changes or differences among participants in terms of psychological attitudes, which can moderate the relationship between exercise and health [24]. Analyzing survey questions that assessed progression through the stages of behavior change [60], which conceptualize an individual's awareness of the need to change behavior and readiness to undertake such steps [77], we found that half of multi-chapter participants advanced at least one stage; specifically, 2 moved from contemplation to preparation, 1 from preparation to action, and 1 from action to maintenance. On the other hand, only 1 single-chapter participant advanced (from contemplation to preparation), while 5 showed no change, and the remaining 2 participants actually showed reverse psychological progress (from preparation to contemplation and from action to preparation) in terms of their readiness to change behavior.

While this study is not yet aimed at proving psychological change, these findings do suggest the promise of multi-chapter narrative feedback to positively shift personal awareness and intention regarding healthy behavior. Interview data further illustrate that the narrative engagement dimensions our design embeds (especially, it seems, cognitive perspective taking and narrative involvement) led several participants to feel *"ready to move to the next step"* (P5). We additionally suspect that for individuals in earlier stages of behavior change (e.g., preparation or contemplation), a narrative scaffolding like WhoIsZuki may be most motivating, while people in a later stage (e.g., action or maintenance) likely need more instrumental support and will depend more on features of our system such as the notifications or in-app screens for drilling down into activity and goal trends. Indeed, one participant who began the study in the action stage was confident that *"I need more data, rather than the story. I needed the numbers and charts."* (P16).

Engagement with WhoIsZuki's Interface and Narrative

To measure users' engagement with both WhoIsZuki's interface as well as story, we collected screen on-off events and administered the Narrative Engagement Scale [9].

Interface Glances

Regarding phone use, we find that participants who received the multi-chapter narrative glanced at their phone (and in turn WhoIsZuki's ambient display) 38%, 30.2%, and 24.2% times more on average than single-chapter participants across Weeks 1, 2, and 3, respectively, as illustrated in the right graph in Figure 5. In addition, while the amount of these smartphone screen views increased week to week for multi-chapter participants (albeit much more modestly from Week 2 to 3), screen glances of single-chapter participants decreased during the final week of the study. These screen checking rates do fit with recent reports that find people check their phones an average of 80–200 times per day [32, 93].

In interviews, single-chapter participants explained dwindling interest in the interface once it *"recycled"* (P6) the same set of content because *"I already know what's going to happen"* (P6) and *"you get immune to that story"* (P13). In contrast, multi-chapter participants described wanting to periodically check in on how Zuki the character was doing — e.g., *"just to see how he is, what he's doing"* (P3) as well as regularly see whether they had reached the next phase of narrative imagery. They mentioned looking forward to such updates and how the glanceable graphical changes increased self-awareness.

Narrative Engagement

Beyond engagement with the interface, we also assessed participants' engagement with the narrative. Specifically, in their weekly diaries, we asked participants to rate (1–10) how much they liked the past week's wallpaper as well as the past week's story. While no significant difference can be observed between visual ratings, participants who viewed the multi-chapter version rated the story as significantly more appealing. When we followed up in exit interviews, participants explained that in the single-chapter version, the visuals remained aesthetic even when the plot stagnated.

In addition, we included the Narrative Engagement Scale in the study's exit survey to assess five key dimensions associated with motivational effects: empathy (understanding, mirroring, and/or being concerned for a character's emotional experience), ease of cognitive access (ability to follow and stay focused on the story), cognitive perspective taking (being able to locate oneself within the mental model of the story), involvement (immersion in the story and a desire to know how events will unfold), and realism (perceptions of how logical the story is and why its plots unfold as they do) [9]. As indicated in Table 1, with the exception of realism, participants who experienced the multi-chapter version reported greater engagement with WhoIsZuki's narrative across all dimensions.

	Single	**Multi**
Empathy	11.9	13.3
Ease of Cognitive Access	10.6	10.9
Cognitive Perspective Taking	18.8	19.6
Involvement	15.4	18.3
Realism	9.6	9.5

Table 1. Mean scores in narrative engagement for participants who received single-chapter versus multi-chapter versions of the narratives.

Further, we learned that an existing disposition towards engaging with narrative media (e.g., books, video games) held by some participants ("story people") typically translated into a favorable response to WhoIsZuki. Yet we were encouraged how a few participants without such proclivities found value in the narrative-based feedback — e.g., *"I don't really play a lot of games or read a lot of science fiction or anything. So I was suspicious that I wouldn't be super motivated by [WhoIsZuki]. But I found it was obvious and helping me keep track of activities I was doing. That surprised me."* (P11).

Reactions to Feedback Design & Delivery Alternatives

Finally, we found variability in consensus regarding different design dimensions of WhoIsZuki's feedback, especially in terms of its visual and aesthetic styling, its attentional demand, and the degree to which it helped summarize past behavior and provide opportunities for self-reflection.

Visual and Aesthetic Preferences

Similar to people in our previously described N=7 lab study, participants in the field study appreciated that feedback was heavily imagery-based and *"let the visuals do the talking"* (P1). One participant explained how the afforded visual variety encouraged her to try new activities — e.g., *"I already had a lot of yellow and purple and turquoise [icons]. But I didn't have a red one. So I wanted it - I wanted there to be colorful butterflies there, so I was motivated to go for a run."* (P4).

We did observe differences in aesthetic preferences across participants though, especially with respect to the cartoon-like quality. Similar to some MTurk survey respondents who commented that the visuals might be too *"juvenile"*, three participants perceived the graphics as more appropriate for a younger demographic — e.g., *"It is so cutesy that, at my age, I'm a little embarrassed to have my phone out and have that."* (P12). Most others, however, found the styling playful and fun, with many likening the graphics to a comic book rather than a childish cartoon. A few participants said they warmed up to the aesthetic over time — e.g., *"I really like the wallpaper. It wasn't as cutesy and sort of emasculating as I thought it might be. Having it when I open the phone is nice."* (P1). Some also explained that the cute graphics made the feedback feel *"approachable"* and *"non-confrontational"* (P16).

Ambient vs. Overt Information Delivery

People additionally expressed a variety of reactions regarding the delivery mechanism of the feedback and the attentional demand that it required. For example, the majority of participants who received notifications appreciated them as reminders to be active, signs of recognition, or to ensure new content was discovered — e.g., *"Without notifications, it's a bit harder to notice the story updates"* (P10). However, the remainder called out the disruptive and intrusive nature of notifications and noted their preference for the more persistent, glanceable, and subtle feedback provided by the ambient display. One participant summed up the tension: *"There's a balance between [notifications] being a distraction and being a reminder."* (P3), suggesting the value in more intelligent notification delivery routines that know the difference.

On the other hand, a quarter of participants expressed concerns about the ambient wallpaper. One person mentioned it was *too* subtle and that he needed more overtly *"in your face"* (P16) reminders to be active — a behavioral shove rather than nudge, if you will. The same participant explained how the wallpaper added a layer of interpretation and that less reflective and more actionable behavioral guidance would be helpful. Finally, a few participants took issue with WhoIsZuki *"taking ownership of my screen"* (P12), especially those who liked to set their wallpaper to graphics of family, friends, art, or topical content (e.g., a major sporting event). Suggestions were made to integrate or provide views to such information within the narrative display so that users would not have to miss out on their favorite pieces of ambient content.

Rewards and Self-Reflection

By and large, participants appreciated receiving positive feedback for completing activities and achieving goals. Rewards such as the celebratory overlay on the progress indicator were found to be quite encouraging. However, we additionally learned that nearly all multi-chapter participants thought completion of the culminating chapter provided insufficient fanfare. Based on this feedback, we are ensuring that the next iteration of the narrative concludes with more of a flourish and sense of dramatic resolution.

Next, a lack of progress towards goals simply translates to a lack of progress in the story and sparse activity icons, as WhoIsZuki avoids punishment considering prior findings that positive reinforcement is more motivational at least in a U.S. culture [21]. Similar to some UbiGreen users [33] though, two participants did express a desire for more negative reinforcement, suggesting story arcs where Zuki experiences conflict, setbacks, or loss when the user's own motivation dwindles or progress backslides (e.g., activity icons being erased, having to restart a chapter from scratch, or failing the mission and reaching a "game over" state). It is worth noting, however, that these suggestions came from participants in the single-chapter group, potentially as a strategy to introduce more dramatics (even if adverse) into the somewhat static plotline.

Finally, participants described appreciating the glanceable summary of completed activities and progress. However, one participant mentioned *"feeling bad about all the birds going away after finishing the chapter"* (P1), another asked *"What happened to my roses?!"* (P12), and others expressed a desire to somehow retain views into historical data and previously encountered narrative content, perhaps in a revisitable journey map and journal, which we are working to implement next.

DISCUSSION

In this research, we have explored how narrative-based ambient smartphone interfaces can address problems with conventional behavioral feedback formats, including to address calls from the HCI community to investigate novel ways to create more qualitative experiences with personal data [84, 89]. In doing so, we have aimed to identify best practices to design visual narratives that promote engagement in healthy behavior.

Fictional Elements and Functions

When designing narrative technologies for motivating behavior, a primary aim should be helping users transport themselves into the fictional world, become immersed, and avoid reactance. Towards this, WhoIsZuki incorporates elements of characterization and episodic structuring. Characterization is a powerful literary device that builds the foundation of a story and helps make the narrative world feel believable and real. Our work with narrative experts and users suggest that key characters to include in narrative technologies are a protagonist (in our case, Zuki), antagonist (Gryff), sought-for objects (biosamples) and sought-for people (Zuki's brother), and helpers (bunnies, fish, monkeys). Intertwined with its use of characterization, a narrative's episodic structure further helps propel the plot forward. In addition to implementing the sequencing of exposition, rising action, climax, falling action, and resolution described in our *Multi-Chapter Graphic Narratives* section, we found that framing the story as a quest, inviting suspense, and showing previews of upcoming content enhanced our participants' fulfillment and enjoyment.

In particular, we found that the emotional attachment cultivated by these narrative elements was a main driver of motivation to stay engaged with both the system and one's goals. Incorporating an empathy-building backstory and refining content to invite more anticipation and cliffhangers helped keep our participants caring and curious about Zuki, while adding characters who oppose and aid him served to raise and resolve conflict and maintain that emotional richness for users.

We saw that this emotional bond created a motivating sense of accountability to Zuki, though this means it is important to consider design strategies for minimizing negative reactance brought on by a potential sense of guilt, when a failure to meet fitness goals is perceived as also failing a struggling and suffering Zuki. Also worth pointing out here is that a multi-chapter narrative approach does benefit from novelty effects, yet our research indicates that to achieve and maintain meaningful engagement, it is still essential to carefully craft textual and visual story content that is compelling and appealing, by integrating behavior change theory with narrative theory to inform thoughtful user-centered design and empirical work.

Creating a Coherent Narrative Experience

Another key insight that emerged was the importance of the narrative to be coherent both internally and externally. By internal coherence, we mean that the interface must contain consistent themes and aesthetics throughout. For example, early designs for some of our chapters used generic progress indicators (e.g., a bar with tick marks) or activity icons (e.g., basic shapes or the same birds in more than one chapter), and participants noted that these elements fell flat. As a result, we revamped icons and imagery in several chapters to be more thematically cohesive (e.g., a carabiner progress meter for the mountain climbing chapter, prickly pear activity icons for the desert chapter, etc). While seemingly small design details, we were surprised by how much they mattered to participants and genuinely impacted their experience of the narrative.

By external coherence, we mean a resonance between the user's actions and progress in real life and Zuki's actions and progress in the narrative. We found that participants needed a logical connection between the two; and when inconsistency between plotlines and personal behavior was perceived, it had substantial negative impacts on empathy, involvement, and overall engagement with the narrative. For example, participants demonstrated a strong aversion to early chapter designs where Zuki's tasks were not seen as particularly taxing — especially for participants who felt quite challenged by their own activity goals. After redesigning Zuki's own sub-missions to require climbing, flying, jumping, and swimming — physically exerting actions that resonated better with the user's personal fitness mission, we observed that people responded more favorably to the narrative and felt more camaraderie with Zuki. Moving forward, our field study also indicated the value in acknowledging the personal constraints a user may face (e.g., getting ill or injured or living in a place with low walkability), perhaps by placing similar temporary or persistent obstacles into the protagonist's path to promote experiential coherence, or by designing features that accomodate flexibility or forgiveness into the system.

Opportunities and Future Work

A natural and necessary next step of this research is to undertake large sample, longitudinal deployments. Our system's 13 chapters would translate to a field study lasting at least 3 months, to exceed the timeframe by which most existing apps are abandoned [13, 51, 66] and the average minimum sticking point for habit formation [49]. As part of such evaluation, it will also be desirable to compare the efficacy of narrative-based strategies against other forms of feedback (e.g., the quantitative reports most apps deliver) in changing physical activity behaviors and beliefs.

Further, there is an opportunity to explore more complex narratives that support additional principles from narratology (e.g., designing and testing around genre, writing style, and social inclusion), depending on the target populations and contexts of use. For instance, narrative feedback may be especially salient for groups that have a strong oral tradition [44] and introduces opportunities to study cultural differences and develop designs that are sensitive to the needs of diverse users. While we focused on a general user base for this formative exploration, it is important to consider differential outcomes for specific groups, including to investigate the generalizability of our findings. As other examples of future steps, our field study participants indicated the value in supporting more interactivity (e.g., extending Zuki from a character in the story to an interactive agent that directly engages with the user) or incorporating additional personalization (e.g., to adaptively recommend goals). As part of developing these systems, it will also be important to identify methods for creating content in a scalable way (e.g., by user-sourcing or automatically generating narratives).

CONCLUSION

This paper presented a novel system that uses data-driven narratives ambiently displayed on a user's smartphone to motivate fitness behavior. Our design process was guided by theories from narratology and psychology as well as the persuasive design and HCI literatures, with user perspectives gathered through both online and in-lab studies informing iterative refinement of our interfaces and narratives. Through a 3-week in-situ deployment, we then explored people's use of the WhoIsZuki system in everyday life, finding that multi-chapter narratives can boost physical activity levels as well as engagement with both the system and its story. Based on our experiences designing and testing the system, we identified creative strategies, obstacles, and recommendations for developing narrative-based motivational technologies. Overall, we hope insights from our research serve as a useful basis for other HCI scholars aiming to help people make the behavioral changes necessary to improve their health and wellbeing.

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