Designing Mobile Snack Applications for Low Socioeconomic Families

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Abstract—We developed two mobile phone prototype applications formed by theoretical models of behavior change to improve the snacking habits of low socioeconomic status (SES) families. Eight primary caregivers and seven secondary caregivers from low SES backgrounds used [...]

shifts based on the living environment, family is a constant influence [13]. Moreover, many studies affirm the positive influence that family has on individual health. Gillman et al. [14] showed that children who ate dinner with their family included more fruits and vegetables in their diets. Similarly, Taveras et al. [15] found that the frequency of eating family dinner was inversely related with children's overweight prevalence. Given these benefits, researchers explored how technology can leverage the family-based context to improve individuals' health [16, 17, 18]. Colineau et al. [16] designed a family-based health portal to study how family members reflected on their lifestyles to improve their health. Results showed that families were more motivated when they were presented with a collective goal paired with appropriate feedback. We leverage this research by empowering families to compare, communicate, and collaborate through the mobile phone applications to gradually improve their snacking.

In this paper, we explore both gaming and non-gaming designs to identify   We also found that caregivers wanted to manage their family health with technology [20]. Our subsequent study examined their everyday health habits where we found that snacking was an issue [13].

A. The Bridge Project

We conducted this study in collaboration with the Bridge Project, a community outreach program that provides academic support to K-12 children in 500 ethnically diverse families in Denver public housing neighborhoods. In 2011, 80% of the children qualified for free and reduced lunch. We selected this population because a study showed that 87%

| (a) Home Screen | (b) Snack Suggestion | (c) Snack History | (d) Family Snacking |

Fig. 1. Snack Manager

of the children in this community were at risk for a chronic illness [21]. We volunteered over 100 hours tutoring children at the Bridge Project to build a rapport with the community.

B. Prototypes

We designed the HTML and Flash based prototypes for Internet-enabled touchscreen-based mobile phones because the low SES caregivers wanted mobile phone-based technological interventions. The prototype designs were informed by applied psychology behavioral-change theories. Each prototype provided users with the ability to: (1) enter snacks; (2) receive feedback on snack healthiness; (3) view an individual's snacking history; and (4) view family snacking healthiness. The first two prototypes discussed are non-gaming, while the last two are gaming applications. The prototypes were internally evaluated and modified using multiple cognitive walkthrough iterations [22].

1) Snack Manager: Snack manager was based on social cognitive theory (SCT) that describes how individuals' perceived self-efficacies, coupled with socio-structural factors and outcome expectations, affect the individuals in achieving their goals and inducing behavioral change [23]. The Snack Manager design incorporated SCT by providing users the ability to view the snack healthiness of their family members and send messages to each other to encourage healthy snacking habits. The Snack Manager prototype design was informed by our prior work where we found that the low SES families did not want to waste food and risk money on new food items [19, 13]. Based on these findings, the prototype provided suggestions to users within a price threshold to replace their current snack with a healthier snack. The healthier snack was either within the same product category as the current snack, or it was a snack that the low SES families preferred.

The home screen, shown in Figure 1a, lets users navigate to different screens of Snack Manager. First, the users selected the family member whose snacks they wanted to manage and then they entered a snack for that profile. If the snack was unhealthy, the snack suggestion screen (Figure 1b) displayed the healthiness of the current snack and suggested snacks in

a star rating system. The stars, which were paired with the snack prices, were used to abstract health information since prior work showed that participants did not understand dietary nutritional values (e.g., proteins, carbohydrates). Finally, the users could view their snack history (Figure 1c), their family's snacking healthiness (Figure 1d), and a convenient shopping list with all the snack suggestions provided by Snack Manager.

2) Snack Educator: The Snack Educator prototype, shown in Figure 2, was based on SCT, the health belief model (HBM), and elaboration likelihood model (ELM). According to HBM, individuals change their health behavior based on four beliefs: perceived susceptibility of acquiring an adverse health condition; perceived condition severity; perceived barriers to adopt a healthy behavior; and perceived benefits of acquiring the healthy behavior. The Snack Educator incorporated HBM by displaying unhealthy snack's potential negative impact on the user's heart, body, and teeth, and comparing it with a healthier snack. The Snack Educator also used ELM which suggests that individuals are persuaded by peripheral and central routes. Central route decisions are long-lasting and take place after much reflection about the message contents. Peripheral route decisions are short-lived, include little deliberation about the message, and are often triggered by message attributes. We designed the Snack Educator to capitalize on central route decision-making by visually categorizing an individual's long-term snack consumption into healthy, average, and unhealthy.

In Snack Educator, after the user entered a snack, the system displayed the snack's potential impact on the user's heart, body, and teeth. The following screen, shown in Figure 2a, suggested a healthier snack and compared the three health indicators for both the entered snack and the suggested snack. The user could view his overall snack history (Figure 2b) and compare his snack healthiness with his family members (Figure 2c). The aggregated snack healthiness in the family snack comparison screen was represented by a bar that consisted of different colors corresponding to the healthiness of the snack with green and red being healthy and unhealthy, respectively.

3) Lifespan: The Lifespan prototype, shown in Figure 3, was a gaming application based on SCT, transportation theory

(a) Snack Suggestion   (b) Snack History   (c) Family Snacking

Fig. 2. Snack Educator

(a) Game character reacts to unhealthy snack selection   (b) Snack History   (c) Family Snacking

Fig. 3. Lifespan

[24], and the precaution adoption process model (PAPM) [23]. Transportation theory suggests that narratives can affect individuals' beliefs. When an individual experiences an immersive narration, she makes some decisions in the narrative world that induces a change when she returns to her origin world. The Lifespan prototype used an animation-based narration to encourage healthy eating where the player selected a game character whose progress in life was related to the healthiness of a player's snacks. The character went through different stages of life, which was informed by the stage-based PAPM that categorizes an individual's behavior in seven different stages: (1) unaware; (2) unengaged; (3) deciding about acting; (4) decided not to act; (5) decided to act; (6) acting; and (7) maintenance.

In the Lifespan game, we translated the PAPM stages to the game character's progressive life stages. The game goal was to gain enough health points to have the character get an education, job, house, and car. Since past study participants were African Muslims, we designed culturally sensitive characters, such as one wearing a hijab. Once the player entered a snack, she would view the game character's reactions (Figure 3a) followed by an animation highlighting the character's progress in life. Players moved to the next stage by eating healthy snacks and gaining a predetermined amount of health points. Once the players reached the final stage, they had to maintain healthy snacking; otherwise they would fall back to the previous stage. As shown in Figure 3b, players could view their snacking history with pictures of snacks and health points. Players could also compare the snack healthiness of different family members by viewing the snapshots of their family members' characters (Figure 3c).

4) *Health Heroes:* The Health Heroes prototype, shown in Figure 4, was a gaming application based on SeT and transportation theory. The user selected a health hero character who defended a city against the onslaught of Taco Belly - the main villain. The game started with Taco Belly causing destruction in the city, shown on the home screen in Figure 4a, where ruined buildings needed to be rebuilt. The Health Heroes gained superpowers by eating healthier snacks to fight the villain (Figure 4b) and rebuild the city. The Health Heroes prototype also had a multi-player mode where different family members played the game and coordinated to form a team of Health Heroes to fight Taco Belly. The players could view their individual snacking points breakdown and team status (Figure 4c). Once the city was rebuilt, the players had to keep eating healthy snacks to counter a surprise attack.

C. Methods

After obtaining Institutional Review Board approval, we recruited participants with the assistance of the Bridge Project personnel. While working with this population, we identified two gateways to family health: the parents, who were the primary caregivers, and the older teens who were secondary caregivers. In most of these families, the teens often cooked and looked after their younger siblings - thus we defined this role as a secondary caregiver. To qualify for the study, the participants needed to be able to communicate in English.

In a prior study with this population, we found that although primary caregivers readily provided feedback, the secondary caregivers were hesitant in communicating with us. Therefore, for this study, we asked the Bridge Project personnel to pair the teens so that they felt more comfortable talking to researchers.

(a) Home Screen   (b) Health Heroes fght Taco Belly   (c) Family Snacking

Fig 4.. Health Heroes

After collecting the demographic information, the participants were provided a task list and a scenario. Participants had to (1) set up the application, (2) enter multiple snacks, (3) view individual snack history, and (4) view family snack history. We used a Motorola Droid touchscreen mobile phone for the study. Prototypes were presented in random order. Since the secondary caregivers were in pairs, we asked them to alternate using the mobile phone after each prototype.

We asked questions to understand which prototype features they liked or disliked, the reason behind their choices, and how we could improve the prototypes. Following the four prototypes, we provided the participants a post-study questionnaire where we asked them to rank the various prototypes and rate the importance of the application features. Participants could provide the same rank to multiple prototypes.

All study sessions were conducted at the Bridge Project facility. Each session was video recorded with participants' consent and lasted for 90 minutes. A ffeen dollar retail store or supermarket gif card incentive was provided to the participants at the end of the session.

D. Analysis

The quantiative data was analyzed in Excel, while the prototype evaluation recordings were transcribed and coded in NVivo 9 qualitative analysis sofware using Grounded Theory principles [25]. The transcriptions were frst open coded to identify concepts in the empirical data, followed by axial coding where we identifed central ideas and events. The authors discussed codings until a mutual consensus was reached. Finally we elaborated on the central themes and categories through selective coding.

E. Participant Demographics

We recruited 26 participants, including 8 primary caregivers and 18 secondary caregivers. The primary caregivers included 7 females and 1 male - their average age was 36.1 years (s.d.= 9.4 years). Five of the primary caregivers were African American, while the remaining 3 were Hispanic. Five primary caregivers owned a computer and all of the primary caregivers had used a computer and had access to a computer elsewhere. Six primary caregivers owned a mobile phone (5 smartphones) and used it daily. The 2 that did not own mobile phones, however knew how to use them.

Fig 5.. Comparison of Primary (P) and Secondary (S) Caregiver Prototype rankings (SM= Snack Manager; LS= LifeStyle; SE= Snack Educator; HH= Health Hero; Diamond = Mean; Median= Mean rank; in a reverse 4 point scale where 4 is the highest rank and 1 is the lowest)

The 18 secondary caregivers were equally split gender wise: 9 males and 9 females. The average age of secondary caregivers was 14.6 years (s.d.= 1.6 years). Thirteen secondary caregivers identifed themselves as Africans, 3 as Hispanic, and 2 as African Americans. Thirteen secondary caregivers had a computer at their home; all of them had access to a computer elsewhere. Five secondary caregivers owned a mobile smartphone. All secondary caregivers mentioned that they knew how to use a mobile phone.

III RESULTS

Overall, we found that primary caregivers preferred applications that were well-organized and provided them a straight-forward mechanism to manage their snacks, whereas secondary caregivers favored applications that were game-like and engaging. The semi-structured interviews provided interesting insights into reconciling these two approaches for a family-based intervention. We further expand on these ideas starting with the fndings fom the post-study questionnaire.

A. Caregiver Preferences

1) Primary versus secondary Caregiver Preferences: The post-study questionnaire results (Figure 5) highlighted key diferences between the two types of caregivers. Most of the primary caregivers preferred Snack Manager, which lay in stark contrast to secondary caregiver rankings where

75% gave it a low ranking. The Lifespan prototype was consistently preferred by both types of caregivers. In contrast, Snack Educator received mixed rankings from both primary and secondary caregivers. None of the primary caregivers favored Health Heroes, however half the secondary caregivers preferred it.

2) Gaming, Non-Gaming, or a Combination of Both?: In the post-study questionnaire, we also asked participants whether a snack management application should be a game, non-game, or a combination of both. The primary caregivers did not want a gaming application and preferred either a non-gaming (N=4) or a hybrid (N=4) approach. This is in line with the prototype rankings where there was a tendency among primary caregivers to favor non-gaming applications, specifically Snack Manager and Snack Educator. On the contrary, only 1 secondary caregiver wanted a non-gaming application, while the rest favored having a gaming component.

B. Snack Manager

During the prototype evaluation sessions, we discovered that primary caregivers preferred Snack Manager over the other applications because of its well organized interface, family messaging capabilities, and intuitive visualizations to understand snack healthiness as P9 summarized, *" I just see more organized and has better way and to better understand of...with your trying great [goal]..."*

1) Messaging: The primary caregivers emphasized the importance of sending messages to other family members. When asked whether she would want family messaging capability, P7 replied, *" I would just to let the [child] know what somebody watch might it [' s] snacks [id] document for a reason [or] a laugh [es] a way so want to know how you frami is eating."* P4 thought messaging could be useful to remind children about healthy eating: *" I think it a good idea you know, because a lot of kids are be sit in the country and some if moms wanna send the [kids] less a of net of the kids cel phone school what ever at health snack."* Secondary caregivers also found value in messaging since they felt it was important to help other siblings reach their snacking goals. Some secondary caregivers, however, were skeptical about the family messaging feature and said that the parents might get mad if they receive too many messages about healthy eating.

2) Snack Health Representation: Of all the snack health visualizations we implemented in the prototypes, the star representation of snack healthiness was well received by the primary caregivers. They identified it as a classical reward system: *" Maybe the child who would always got a star for doing good. And so a... As a token of appreciation and is on to them on it reward better their is psychologically in that be spuit to a head in low est it kid le."* P4. While the secondary caregivers understood the star representations, they did not find it interesting.

3) Importance of Family Snack Dinput: The primary caregivers believed that viewing the entire family's health was essential. P7 said, *" It shel p for a uif she h i [persona] was me and he we may child [rl eanu gh w d] u lbde watching et what up my gt he mo ru th."* Similarly, P9 said, *" I like overall flams in ay h k al th in eraage. You know it would prove a point that the whole family needs to eat better."* This is understandable since primary caregivers are the principle conduits for family health. On the contrary, secondary caregivers were generally more interested in individual health.

4) Is Price Important? While the primary caregivers favored most of the Snack Manager features, they thought displaying snack prices was irrelevant because snack healthiness was more important. When asked why she did not want prices, P9 said, *" [Price couldn't be because all doesn't have any thing to do with snacking."* Giving another reason, P4 said, *" I think should be. b. e caus she is going to be a nation which if go, or deal vlay ii ens very tate ...it coul be a discourage from buying you know of fruits and vegetab."* Primary caregivers were not the only ones to criticize displaying snack prices, secondary caregivers also reverberated similar thoughts, S16[2] said, *" I does matter what the price is, if something of do you or broth they no u got a part of the price."* S15 noted that snack prices could be discouraging if healthier snacks are expensive: *" They might see it an be like honest, he a lot they more expensive than what al ame at in row sol c and ff ors bl won't."*

C. Lifespan

The Lifespan prototype was consistently preferred by both primary and secondary caregivers. Participants enjoyed the application's overall message of a healthy lifestyle. P5 said it best: *" You propose for hme al th y in you ulrif expectancy might be as long as ny d you can get al th e h i nt gh say to u want a you live on the greit t. That's how I see it ... it expresses of how you prosper in the way your lifesty le of eat iam g living."*

1) Motivation through Competition: Apart from the overall message of the application, the participants highlighted that Lifespan could be useful in encouraging healthy competition. Thinking aloud, P4 elaborated, *" ...it compare ya know who has the height position of the al th ay c Skos h [eus em igh t upsif the broth ie ra ti be gt th dme or he ris t... she might wann cah all a ges ted of a bett el think ding th e ocia als pet co ti wi l [lal sma]k ie t more ti mula ting for dul."* Similarly, P3 mentioned, *" I like a vitn gh points because like a competitiyp io fp ner swo an m poi nl tis k, e, woo d go fiv po i not ro o o h go t em po i nitns, s, t æ fa d. s you at 3e 00 0O al or."* While the primary caregivers identified competition as a useful motivator for their children, none of the secondary caregivers resonated with this idea. If we were to leverage a points-based system to encourage competition, we would have to avoid the use of negative numbers because a majority of the participants had trouble understanding them.

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[1] P[N]: Primary Caregiver [Participant Number]

[2] S[N]: Secondary Caregiver [Participant Number]

obesity and body image. This is especially relevant for low SES populations since they are at a higher risk for obesity [1]. Therefore, if we are to induce healthy behavior change, our designs must accommodate for these perceptions of self-image. This may in turn increase adoption of health and wellness technologies in low SES populations.

Another important design consideration was the overall application message. The caregivers indicated how Lifespan propagated a hidden message of well being that would encourage them in using the application. In particular, the secondary caregivers related to Lifespan and inferred that healthy eating leads to successful life outcomes. This unanticipated result of *health as a value* [28] can be fostered to establish healthy lifestyles in secondary caregivers. Therefore, while researchers should have traditional design goals to motivate users to adopt healthy habits, we must also reflect on how the overall application message can nurture health values in the population.

V. LIMITATIONS

We acknowledge that the primary caregiver participants were predominately female - with only 1 male and 7 females. While this does not account for different gender perspectives, we and other researchers [29] found that in low SES families, primary caregivers are predominately female.

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