Efficacy of a Smartphone System to Support Groups in Behavior Change Programs

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ABSTRACT
Smartphone platforms provide an excellent opportunity for projecting existing or new behavior-change methods into everyday life at great economies of scale. In this paper we present an experimental test of a new behavior-change smartphone platform and application called Fittle, which delivers ecological momentary interventions and group support to help people progressively master healthy habits. An 8-week field study involving 19 participants demonstrated the engagement and efficacy of Fittle across three classes of behavior (diet, physical activity, and stress-reduction). Individual adherence to the behavior programs was found to be associated with group membership. Content analysis of intragroup interactions suggests that high performance groups were generally more social, more supporting of each other on program goals, and shared more.

Categories and Subject Descriptors
H.5.3. Group and Organization Interfaces, H.5.m. Miscellaneous.

General Terms
Design, Experimentation, Human Factors, Theory.

Keywords
Health; wellness; behavioral change technology; persuasive technology; mobile app; physical activity; stress, nutrition.

1. INTRODUCTION
It is no longer news that healthcare costs to the U.S. economy will be staggering, and that a major driver of these increases are unhealthy behaviors such as physical inactivity, increased food intake, and unhealthful food choices [42]. Smartphone platforms provide an excellent opportunity for projecting existing or new behavior-change methods into everyday life at great economies of scale. Smartphone platforms also provide an excellent opportunity for collecting rich, fine-grained data necessary for a new generation of behavior-change science and technology. In this paper we present an experimental test of a new behavior-change smartphone platform and application called Fittle.

Our eventual goal is to develop an effective smartphone-based behavior-change platform that supports long-term lifestyle change for large populations with good economies of scale. However, the immediate purpose of this paper is to establish the short-term efficacy of Fittle across three classes of behavior (diet, physical activity, and stress-reduction), demonstrate the power of these effects, and explore how different kinds of group activity are associated with these behavior outcomes.

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2. RELATED WORK
2.1 Theoretical Foundations
Behavior-change interventions generally adopt the approach that a new, healthier lifestyle is created by weaving new habits into everyday life. Fogg [17,18] has recently provided useful summaries and practice-oriented methods for decomposing larger lifestyle changes into "tiny habits" (behaviors) to be changed, and for matching target behaviors with solutions for achieving those behaviors.

The formation of new habits or the extinction of old ones has long been a focus of scientific psychology, and arguably these were the central objects of study for mid-20th century behaviorism (e.g., [25]). The cognitive revolution of the 1960s in psychology, including Social Cognitive Theory (e.g., [4,5]) has led to modern individual-level health behavior theories [6] that include cognitive constructs (e.g., beliefs, motivations, goals, and plans) as well as social ones (e.g., norms and social models) [6]. These include the Transtheoretical Model [9], the Health Belief Model [23], Goal Setting Theory [30], and the Theory of Planned Behavior [1]. There is considerable overlap amongst these theories [6], but none are specified at a level that would support fine-grained predictive dynamic models of behavior. Applied techniques, such as altering the environment [17,18, 38, 43] to no longer trigger old unhealthy habits or trigger healthier habits, or psychological therapies such as Motivational Interviewing [31] and Cognitive Behavioral Therapy (e.g., [15]) build upon these theoretical foundations.

2.2 Ecological Momentary Intervention
Smartphones provide an obvious platform for projecting behavior-change support into the ecology of everyday life. The standard practice in preventative or therapeutic practices is for clinicians to meet with individuals or groups on a weekly basis for a short time (e.g., 1-2 hours) during which assessments are made, feedback is provided, and clients are encouraged to set positive goals, practice skills, participate in activities, and complete "assignments" between meetings [27]. Ecological Momentary Intervention (EMI) is a framework for treatments characterized by the delivery of interventions as people go about their daily lives [24]. These interventions may range from unstructured SMS text messages providing recommendations [32] to smartphone notifications to comply with some agreed-upon action. The key feature is that 1) the interventions are integrated into everyday life and are consequently ecologically valid and 2) the interventions are provided at specified moments to maximize impact.

Fittle embellishes the basic message-delivery approach of systems such as mDiet [32] with numerous additional interaction techniques, and online social interaction to promote long-term engagement. In Fittle, the use of challenges provides a more general capability to support progressive mastery in different classes of behavior (e.g., diet, activity, stress-reduction).

2.3 Behavior Change Strategies in Fittle

In the literature, different behavior change strategies have been studied. It ranges from more prescriptive ones, such as prompting [13, 19, 22, 32], feedback and reward [29, 14, 33], tracking and logging [8, 14, 28], to less prescriptive ones, such as social influence [5, 21]. While each of the individual strategies have been well studied and proven to be effective, it is not clear how to best integrate these different strategies because mobile apps typically include only a minority of the behavior change strategies [36]. Fittle is designed to integrate these behavioral change strategies and we are interested in learning the efficacy of the integration.

Progressive "Goldilocks" Goals: The TPB construct of perceived behavioral control (or self-efficacy) guides the design of Fittle challenges, along with Goal Setting Theory [14]. Perceived behavioral control predicts that people will be more successful if they adopt goals that they are confident they can achieve. Thus the goals need to be perceived as being "small enough" or "easy enough" to accomplish. Goal-setting theory posits that more challenging goals yield higher levels of performance and motivation. Thus the goals need to have a kind of "Goldilocks" property: not too easy and not too hard.

In Fittle there are a few goals everyday (Fig.1, c). Further, behavior-change challenges in Fittle are designed to progress from goals that are perceived as easy by the user to those that are perceived as difficult. The objective is to maintain and reinforce perceived self-efficacy with goals that are not too difficult, and improve motivation and ability with goals that are not too easy.

Tracking, Prompting and Reminding: Once goals have been set for an individual, it has been shown that reminding people of their goals and concrete plans (implementation intentions) can be very effective in increasing the likelihood that the behavioral goal will be achieved [20, 34, 35]. In addition, logging and monitoring of behavioral achievements and outcomes is typically associated with long-term maintenance (e.g., [45]). In Fittle, users can report whether each goals have been accomplished or not and users can review their progress (Fig.1, d).

Feedback and Reward: Goal Setting Theory [Locke, 2002] suggests that, in addition to perceived behavioral control, goal-setting effects are moderated by expected outcomes and social commitments. Fittle employs a badge system to reward and incentivize people, and employs team interaction and team-based feedback to support social commitments.

Group: Social support has health benefits in its own right [10]. It increases participation in exercise programs [11, 37] and influences group members' health beliefs and behaviors [5]. However, building successful groups to support health-related interventions is not automatic [41]. Understanding the detailed effects of online social support on behavior change remains largely unexplored, and we use this initial Fittle as an opportunity for some initial analyses.

In this paper, we seek to 1) understand the efficacy of Fittle across three classes of behavior (diet, physical activity, and stress-reduction), 2) study how groups affect behavior change and 3) explore how different kinds of group activity are associated with these behavior outcomes.

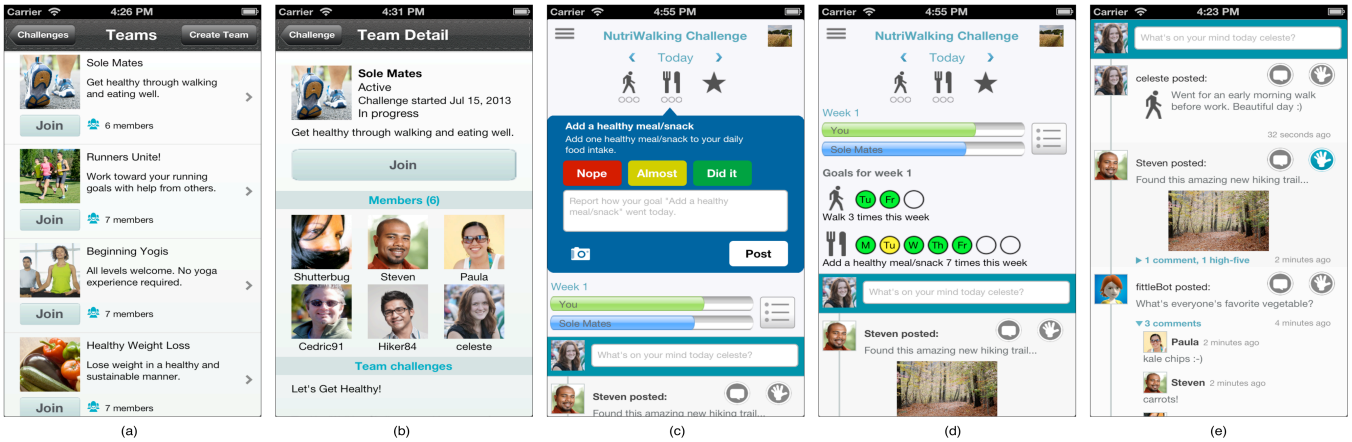
3. Fittle

Figure 1 shows several screens of Fittle. The initial experience starts with a presentation of a selection of available challenges. These challenges are either conversions of existing programs that have been developed over the years or new programs all currently created by professionals, but the intention is to eventually open content creation up to everyone (under some quality control review process). After the challenge selection, the user can either join an existing team(Fig 1, a) or create a new one and invite teammates via email. The selection of a challenge and membership in a team opens the primary Fittle dashboard (Fig 1, c).

Activities in Fittle: The Fittle dashboard consists of three parts. The top portion shows the activities (or goals) as part of the challenge that the user should complete today.

Progress Tracking: The middle section of the dashboard provides visual analytics showing the user's and the team's goal accomplishment this week. The weekly activity set view, as illustrated in Fig. 1(d), shows the user all of the activities that Fittle will schedule for them this week with visual completion details.

Team Interaction: An always present in the dashboard activity-posting bar provides a means for the user to always share multi-



(a) (b) (c) (d) (e)

Figure 1. Fittle mobile application(a) teams available, (b) the details of a team, (c) activity information, (d) overall goals for this week, and (e) the team-based social activity feed.

media posts with the team (Fig. 1 e). Users can share information with the team. Users may also communicate directly with each other through a peer-to-peer messaging system.

Fittle currently features two eight-week challenges developed in collaboration with two certified experts in personal training and nutrition consulting. The Fittle challenges promote three classes of behavior: nutrition, walking, and stress busting.

These challenges consist of a beginner level program to get people moving more called *NutriWalking(NW)* and a more advanced workout focusing on relieving stress called *Stress Busting(SB)*. Both challenges contain four nutrition activities: eat slowly, add a serving of vegetables (or a different vegetable if a vegetarian), add a small healthy meal while reducing the others, and keep a food diary. These activities were offered for two-three weeks each with overlap in the transition week from one habit to the next.

NutriWalking also focuses on getting participants to walk more starting with 15 minutes 3 times a week on flat surfaces and ramping up to 45 minutes 5 times a week on inclined surfaces with some exercises (e.g., jumping jacks) or short jogging sessions added to the walk.

Stress Busting also focuses on three workouts during the week. On Mondays, an upper body workout consists of 5 exercises with easier alternatives that focus on strengthening the upper body and core. On Wednesdays, a full body workout consists of 5 exercises with easier alternatives that focus on muscle endurance. On Fridays, a lower body workout consists of 5 exercises with easier alternatives that focus on strengthening the lower body and core.

4. METHOD

To test our research questions, we conducted an 8-week field study in which participants formed groups to participate in two 8-week challenges provided in Fittle.

4.1 Participants

An email was sent to the mail list of a research center on the west coast of U.S recruiting employees and their family and friends. Twenty-three people formed groups on their own and signed up for the study. Most of the participants had their own iPhone or iPad. Participants who did not have an iPhone, iPod Touch or iPad, got an iPod Touch from the research team. 2 participants emailed the researchers and dropped out from the study in the first week and 2 participants could not finish the study because of technical issues. Data from the remaining 19(10 male, 9 female) participants were included in the analysis.

Participants who completed 90% (on average) of their weekly challenge goals for 7 out of 8 weeks earned a $50 gift certificate. At the end of the study, a prize raffle was held. The prize pool consisted of 5 Apple iPad Minis.

Procedure

Before the study, an information session was held to help participants install the Fittle app and teach them how to use Fittle. The study ran for eight weeks (April 29th-June 23rd 2013). Pre- and post-test instruments were used to assess healthy eating, physical activity, and stress levels. These were used to assess net habit-change associated with Fittle use. Pre- and post-test instruments were developed to assess individual levels of behavior-change intentions, based on TPB. These were used in our analyses to control for individual differences in motivation. We also archived the Fittle usage logs, and conducted a small set of interviews. These were used in analyses of the role of group interaction factors in improving behavior-change.

4.2 Measures

Behavior Reporting. As part of the routine use of Fittle, participants were asked to report their achievement of assigned goals everyday as "Did It", "Almost" or "Nope". These reports provide behavior-change compliance (or achievement) data for individuals and groups. Based on the behavior reporting, participants' and teams' ***7-week average compliance*** rate is calculated (the first week was intended as a trial period).

Healthy Eating. A 10-item, 7-point healthy eating scale was adapted from [39] to measure participants' pre and post healthy eating behavior (Cronbach's α=0.86).

Perceived Stress Level. A 10-item, 5-point stress level scale was adapted from [12] to measure participants' pre and post stress level (Cronbach's α=0.89).

Physical Activity Level. Participants' pre and post weekly physical activity level were measured using the 6-item, short version of the international physical activity questionnaire [26]. The score shows the average amount of time a person spends on physical activities every week measured in minutes.

*Weight***.** Neither of the two programs were designed to help participants lose weight, but given the fact that weight is an important parameter in describing people's physical conditions, participants' weight information was collected. Participants were asked to weigh themselves and reported their weight before and after the study.

TPB Measures. Three TPB questionnaires were developed for the three promoted behaviors (nutrition, walking, stress-busting). TPB measures for both challenges were developed. TPB measures on the nutrition habits and the walking habits were assessed for participants in the NW challenge. Similarly, TPB variables on the nutrition habit and the stress busting habits were measured for participants in SB challenge.

Usability. The 10 item, 5-point System Usability Scale (SUS) was used to measure the usability of the Fittle app [7].

Interviews. At the end of the study, 6 semi-structured interviews with participants from 4 different groups were conducted to understand participants' feelings about using Fittle. The interviews lasted from 20 to 30 minutes. These participants were chosen because they had different levels of performance (measured by *7-week average compliance*) during the study.

Table 1. Groups in the study and average compliance rate

Group	Challenge	Participants (M/F)	7-week Avg. Compliance
SB01	SB	4 (3/1)	91.16%
SB02	SB	2 (2/0)	50.68%
SB03	SB	3 (2/1)	41.04%
SB04	SB	2 (0/2)	28.06%
NW01	NW	1 (1/0)	22.79%
NW02	NW	7 (2/5)	76.87%
Total		19(10/9)	

5. RESULTS

Table 1 shows the distribution of the participants in the challenges. The 19 participants were distributed in 6 groups, with 4 groups in the SB challenge and 2 groups in the NW challenge (NW01 started as a 2-participant group, but 1 participant had technical issues, and it ended up being a 1-participant group). The groups were self-organized without intervention from the research team. The average age of the participants is 43 years old (SD=13),

ranging from 23 to 77 years of age. Participants consisted of researchers, engineers, administrators, HR people, assistants etc. 9 of the participants are White, 7 Asian, 1 Black, 1 Hispanic and 1 participant did not reveal their ethnic background.

Table 2. Overall pre and post measures (*N*=19).
: p<.05,:p<.01*

Variable	Pre	Post
Healthy Eating (range: 1 - 7) **	4.10	4.61
Stress (range: 1 - 5) *	2.61	2.28
Activity (min/week)*	260.28	356.84

5.1 Fittle Efficacy

Table 2 presents pre- and post-test measures for the three behavior-change classes addressed in the Fittle challenges. ANCOVA analysis was conducted to compare the pre and post measures (time variable). We choose attitude as a covariate because attitude was found be correlated with participants' compliance rate as we will show in Fig. 2.

Healthier Eating. Analysis of covariance (covariate: attitude toward healthy eating) showed a main effect of time, $F(1, 16) = 15.74$, $p = .001$, and the effect of the covariate attitude towards healthy eating is marginally significant, $F(1, 15) = 4.15$, $p = .06$). Effect size analysis shows that Cohen's $d = 0.85$. Further analysis showed that participants in both programs all had improved healthy eating scores (Table 3). For NW participants: $t(7) = -3.63$, SD=0.64, $p = 0.008$, $d = 1.28$; for SB participants: $t(9) = -2.08$, SD=0.66, $p = 0.06$, $d = 0.50$.

Table 3. Pre and post measures by programs
*-: p<.1; *: p<.05,**:p<.01*

Variable	Prog.	Pre	Post
Weight (lbs)	NW	187.25 (35.78)	186.63 (35.53)
	SB	169.20 (30.44)	167.30 (30.32)
HealthyEat (1-7)	NW**	3.81 (0.84)	4.63 (1.0)
	SB -	4.33 (1.02)	4.58 (1.22)
Stress (1-5)	NW	2.41 (0.75)	2.46 (0.55)
	SB **	2.75 (0.55)	2.15 (0.45)
Activity (min/week)	NW *	115.63 (88.78)	272.5 (162.04)
	SB	376.00 (186.29)	418.18 (187.94)

Reduced Stress Level. Analysis of covariance (covariate: attitude toward stress busting) showed a main effect of time, $F(1, 8) = 13.35$, $p = .005$. Effect size analysis shows that Cohen's $d = 0.61$. NW participants' stress showed no change (Table 3), $t(9) = 1.34$, SD=0.64, $p = 0.2$, but SB participants' stress reduced $t(9) = 3.65$, SD=0.53, $p = 0.005$, $d = 1.16$.

Increased Physical Activity Level. Analysis of covariance (covariate: attitude toward walking) showed a marginally significant main effect of time, $F(1, 6) = 4.41$, $p = .08$. Effect size analysis shows that Cohen's $d = 0.58$. NW participants' physical activity (Table 3) level increased significantly $t(7) = -2.57$, SD=172.5, $p = 0.03$, $d = 0.91$). SB participants' physical activity level increased slightly (Table 4), but not significantly $t(9) = -1.014$, SD=160.61, $p = 0.3$). This is reasonable given the fact that in this program the expected physical activity duration is about 20 minutes every other day and participants in SB were already very active before the study (PreAct=376.00, S.D=186.29, Table 4).

Weight Reduction. Although the Fittle challenges were not designed to help people lose weight, 12 of 17 participants who reported their weight lost weight over the eight weeks, which is significant by Sign Test, $p < .05$. However, participants' average weight (measured in lbs for $N = 17$) only decreased slightly from mean = 177.22 lbs prior to the study to 175.89 lbs post-study and this was not significant, $t(16) = 1.58$, SD=3.38, $p = 0.13$.

5.2 Group Effects

In interviews with participants, many mentioned the importance of groups. Participants mentioned that a) being in a group could be supportive and motivating, b) they could be held accountable when in groups, c) team members can help each other and d) being in a group could be inspirational. We examined the role of groups in quantitative effects on individual performance.

An individual's *weekly completion rate* is defined by the total number of activities that have been reported either as "Did it" or "Almost", divided by the total number of activities in that week. SB01 and NW02 were the two groups that had a high compliance rate (See Table 1).

We investigated the degree to which individual weekly completion rates were associated with group membership and individuals' pre-study beliefs as assessed by the TPB measures. To do this we conducted a multilevel modeling analysis in which the participants were nested within groups.

Informed by the Theory of Planned Behavior (TPB), we explored whether TPB variables, including (1) *nutrition attitude*, (2) *nutrition subjective norm* and (3) *nutrition perceived behavioral control* (PBC) and the use of Fittle (*Fittle Usage*, the number of messages and high fives participants posted each week) are correlated with the participants' nutrition challenge compliance rate, controlling for groups and activity types (nutrition, walking and stress busting). In addition, we also include the participants' perceived *usability* of Fittle as a covariate.

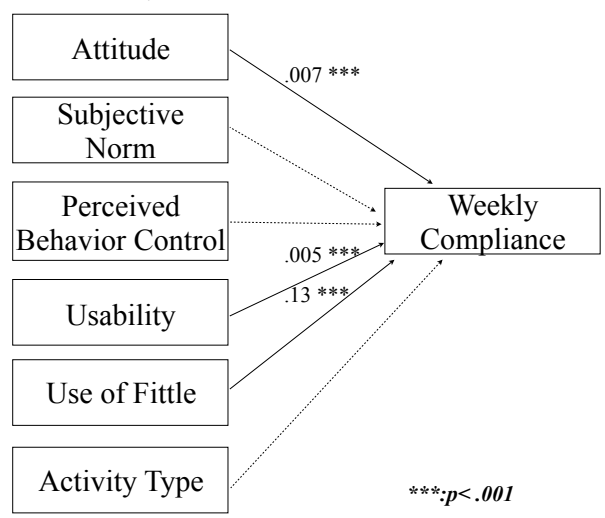


Figure 2. Relationship between TPB measures, usability, use of Fittle, activity type and participants' weekly compliance

In our hierarchical model, individual's weekly completion rate was modeled as a function of theory of planned behavior variables (attitude, subjective norm, and PBC), Fittle Usage and Usability, controlling for groups and activity types (nutrition, walking and stress busting). Prior to analysis, all predictors were centered at the grand mean. A 2-level multilevel model was used to account for people nested within groups by estimating a random intercept for each group. Effect sizes were estimated with semipartial R^2 [16].

The multilevel model allows us to use the intraclass correlation coefficient (ICC) to analyze the degree to which participants'

completion rates were independent of other group members' completion rates. Complete independence would mean that group membership had no effect on individual performance. The ICC in our model was significant, $\rho = .37$, suggesting that the individual members' weekly compliance rate were not independent. 37% of the variance in their compliance rate could be explained by group membership and confirming that a multilevel analysis was necessary for these data.

There was a significant, small main effect of attitude on weekly completion rate, $b = .007$, $SE = .057$, $t(239) = 12.02$, $p < .001$, semi-partial $R^2 = 0.07$. There was a significant, large main effect of use of Fittle on completion rate, $b = .13$, $SE = .02$, $t(239) = 6.41$, $p < .0001$, semi-partial $R^2 = .14$. There was a significant, small main effect of usability on completion rate, $b = .005$, $SE = .001$, $t(239) = 3.70$, $p < .001$, semi-partial $R^2 = .06$. See Fig. 3.

We calculated pseudo R^2 for the model at each level according to the recommendations of Snijders & Bosker [40]. At the lowest level, the model reduced prediction error of nutrition completion rate by a large amount for any given participant, pseudo-$R_1^2 = .48$. At the group level, the model reduced prediction error of compliance rate by a large amount for any given group, pseudo-$R_2^2 = .65$. Both pseudo-R^2s showed a large effect size was gained.

Table 4. Examples of the messages posted by category

Types	Examples
Activity	"Did 33 minutes in the elliptical. Burned 300 calls and did 2.70 miles. "
Social	"Hola!", "Very quiet here", "Happy Father's Day!"
Support	"Get well soon!", "Very nicely done!", "At the top of your wall, under today, there are your two goal items. Click on i to get more details." "Happy Cinco de Mayo everyone! Last day of week one. Let's finish strong. Go!"
Issues	"Hamstrings are still sore from squats on Friday.", "Easier said than done especially on eliminating the processed foods", "Do peanuts count as vegetable? Does it matter if they're covered in M&M chocolate?"
Sharing	"One of my first job interviews after graduating college was to be a manager at 24 Hour Nautilus … I could have owned my own gym by now if I had taken that job. ;)"
Misc.	"You must grow a beard and sleep with it in your mouth overnight. Oh, wait that is how you become a wolfman."

5.3 Group Performance and Intra-group Message Types

We explored how different intra-group interactions might account for the differences in group performance observed in Table 1. A card-sorting technique was used to categorize messages posted by individuals. Each message was read, and assigned a descriptive label. The messages were then clustered into similar groups. Two researchers categorized the messages independently (intercoder reliability: 0.7). After that, the two researchers read the messages together and solved the discrepancies. The messages were clustered into five main categories: *social*, *support*, *sharing*, *activity*, *issues*, and *miscellaneous*.

Activity messages are ones to report the things they have done. **Social** messages refer to social chat, teasing etc. **Support** messages provide informational, emotional or motivation support to others. **Issues** are messages that report problems, asking questions or making suggestions. **Sharing** are messages that share information, personal feelings and experiences etc. Messages that are not related to Fittle or the wellness challenge are categorized as **miscellaneous** messages. Examples of each category can be found in Table 4.

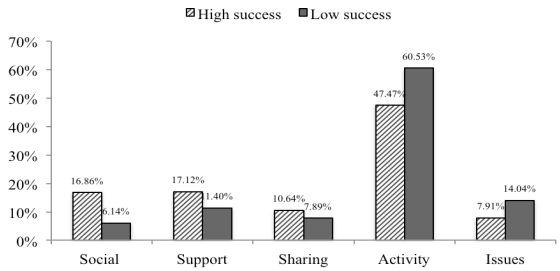


Figure 3. Contrast between high success and low success groups on types of messages posted

We compared the messages posted by the high success groups with the low success groups. The average compliance rate for all the groups is 63%. Groups with >63% average compliance rate are categorized as high success group (SB01 and NW02), and the rest of the groups as low success group. 783 of the messages were posted by participants from the high success groups and 117 messages were posted in the low success groups. It was found that participants in the high success group posted more social, support and sharing messages, while people in the low success group posted more activity messages and reported more issues (14.04% in the low success group vs. 7.91% in the high success group, χ^2 (4, N=885)=17.80, $p < .001$, Fig.3. Miscellaneous messages were excluded from the chi square analysis because there are not enough messages of this type).

6. DISCUSSION & CONCLUSTION

Over the 8-week Fittle pilot study, the gains on test scores of healthy eating, physical activity, and stress all showed medium to large effect sizes (Cohen's $d = .58$ to $.85$). Our hierarchical model shows participants' attitudes towards the behavior, use of the Fittle during the study, and perceived usability of the Fittle app are correlated to participants' weekly compliance.

Further, our results demonstrated that groups have a positive impact on individual members' compliance. 37% of the variance in individual members' weekly compliance rate could be explained by group membership. Groups who exhibited more social, supportive, and sharing interactions performed better. Future studies are needed to understand the underlying mechanisms by which group interactions affect individual performances. For example, whether positive team interactions can be engineered and whether and how group size influences individual members' compliance in health wellness activities.

There are some limitations with the current study. First, we did not have a control group to which we can compare the results. We used TPB measures as covariates to control the effects of participants' motivations. To fully understand the effectiveness of Fittle, a control group in which participants do not use Fittle is needed. Another limitation of this study is that these measures were self-reported (although using validated tests), which need to be cross-validated with other measures such as activity sensors (pedometers).

In conclusion, the present work will suggest ways that HCI researchers can explore the domain of mobile health and wellness. Using the groundwork laid down in this study, future data

collection and analysis could contribute to extending our theoretical understanding and practical ability to increase the efficacy and effectiveness of mobile behavior change systems.

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