Determining the Determinants of Health Behaviour Change through an Online Social Network

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Abstract. The ABC framework provides determinants for leveraging the motivational power of online social networks with the determinants for promoting health behaviour changes. We designed VivoSpace, a medium fidelity prototype of an online social network to promote healthy behaviour changes based on the guidelines for incorporating these determinants. We evaluated the determinants of appeal, belonging and commitment using both direct and indirect methods with 36 adult subjects. Indirect evaluation methods included a helping game experiment, adopted from experimental behavioural economics to measure indirect reciprocity evoked by VivoSpace, which is an important factor in developing belonging. Similarly, an in-group experiment was adopted to evaluate group commitment. Our results show that VivoSpace's design based on the ABC framework result in a strong degree of agreement with the appeal determinants with evidence for the promotion of belonging and commitment. Thus, we have evidence for the effectiveness of design elements for evoking behaviour change to improve health using an online social network.

Keywords. Laboratory experiments, health behaviour change, VivoSpace, ABC framework.

1 Introduction

Designing technologies to promote health behaviour change has become an area of interest both in research and for commercial products. Various technologies that promote health behaviour change have been developed and evaluated. These systems include: *Houston* a mobile phone application that shares step counts with friends [4]; *UbiFit* a mobile phone application that provides a garden display for one's exercise performance over time [5,6]; and *MAHI* a mobile phone application for diabetics that allows entry of experiences and reflection with health educators [14]. This is complimented by an increased interest in the use of online social networks for health behaviour change [15], which is not surprising as one's social networks greatly influence health behaviour [7]. Furthermore, there are numerous applications available commercially to assist users in leading healthy lifestyles. These commercial applications are available in many modalities including: online applications[1], online social

[1] Examples include SparkPeople (www.sparkpeople.com) & DailyBurn (www.dailyburn.com).

M. Bang and E.L. Ragnemalm (Eds.): PERSUASIVE 2012, LNCS 7284, pp. 1–12, 2012.

network games[2], console games[3] and pervasive/wearable systems[4]. Many of these commercial applications include social aspects to provide social support to users in making health behaviour change. Few attempts have been made to articulate design principles by harnessing the popularity of online social networks to encourage healthier living based on theoretical results from combining health and online social network literature. One such framework, the ABC (Appeal, Belonging, Commitment) Framework, has been proposed that establishes a set of determinants that can be addressed in an online social network designed for changing health behaviour [11].

In this paper, we investigate and measure whether the determinants of the ABC framework are met in an online social network designed to motivate health behaviour change. For our investigation, we have developed VivoSpace an online social network, based on the design principles that can be extrapolated from the determinants of the ABC framework. We then evaluate VivoSpace in a laboratory setting with the aim to determine if the online social network system can motivate health behaviour change, based on the determinants of the ABC framework. The determinants in the Appeal dimension can be evaluated through direct inquiry; however, challenges surface when evaluating Belonging and Commitment. Therefore, we use two indirect methods: 1) a helping game is employed to evaluate belonging; and 2) a group performance exercise is used to evaluate commitment.

The key contribution of this paper is the use of the ABC Framework to evaluate the design of an online social network, VivoSpace. Furthermore, this paper uses triangulation of direct and two indirect methods in evaluating an online application's ability to influence human behaviour.

2 Related Work

There are several persuasive technologies that have been designed and evaluated to change health behaviour. The *Houston* system is a mobile phone application that tracks and shares progress towards a step count goal with a group of friends [4]. This study evaluated the determinants of *goal setting* and *sharing information*. They found that over a short period of time those that shared data met their goals more than those that did not share their data. Both *goal setting* and *social factors* are considered in the ABC framework, as being some of the determinants of behaviour change; however, there are many other determinants, including *self-efficacy*, *knowledge* and *attitude toward the behaviour* that also need to be considered.

UbiFit is another mobile phone application that has been designed and evaluated [5,6]. The *UbiFit* was initially designed based on the *Goal-Setting Theory*, and evaluated based on where the goal comes from: the user, guidelines, medical/health expert and group set [5], and these were evaluated qualitatively. The user set and expert set conditions were the most popular. This study employed the *goals* and *knowledge*

[2] An Example is the facebook application HealthSeeker (`healthseekergame.org`).
[3] Examples include Wii Fit (`wiifit.com`) and EA Sports Active (`www.easportsactiveonline.com`).
[4] Examples include fitbit (`www.fitbit.com`) and NikePlus (`nikeplus.com`).

determinants, which are important in the ABC framework, but there are several other determinants, such as *self-efficacy, attitude towards the behaviour*, and *social norms* that also need to be considered to truly change health behaviour. The *UbiFit* system was also designed based on the Goal-Setting Theory, Transtheoretical Model, Presentation of Self in Everyday Life and Cognitive Dissonance Theory to develop design principles, which were then evaluated [6]. Although, the determinants from these theories were not drawn out in the work, the use of several theories to design and evaluate the system provides greater depth in understanding the motivations for changing health behaviour.

The *MAHI* system is a mobile phone application that was developed for diabetics to monitor their health and reflect upon it through social interaction with diabetes educators [14]. The *MAHI* system was used on individuals that have lived with diabetes for a long time [14]. The qualitative evaluation was based on the textual entries made by users of *MAHI*; they found that the system provided a forum for "constructing identities". Although not explicit in this study, this study does reveal the *shared identities* determinant for using social systems, which is defined by the ABC framework.

3 ABC Framework

Existing theoretical models provide the determinants for the motivations for using online social networks and the motivations for changing health behaviour. The theoretical models for use of online social networks include: the Uses and Gratification Theory [12], Common Identity and Common Bond Theory [18], Social Identity Theory [8], and the Theory of Organizational Commitment [2,12]. The theoretical models for motivating health behaviour change include: the Health Belief Model [10], Social Cognitive Theory [3], Theory of Planned Behaviour [1], the Common Sense Model [13], and the Transtheoretical Model [17]. Extracting the determinants for behaviour change from these theoretical models reveal three dimensions for online social networks that motivate health behaviour change: appeal (individually based), belonging (socially based) and commitment (temporally based) [11]. Together these dimensions provide the foundation for the Appeal Belonging Commitment (ABC) Framework illustrated as a text cloud in Figure 1 that fully describes how online social networks can be used to motivate health behaviour change. The figure shows that health behaviour change and use of online social networks are complex and are defined by a multitude of factors that have significant interplay.

Since the ABC framework is based on a review of existing theoretical models, we argue that the application of the ABC framework in the design and evaluation of online social networks will reveal a system that will have a high likelihood of influencing long-term behaviour change. Therefore, we are evaluating the design of VivoSpace based upon the determinants of the ABC framework. Based on this framework, online social network first needs to Appeal to users on an individual level in order for

the system to be used. The determinants for use then promote the determinants that ensure that the new health behaviours Appeal to users. Once, the online social network is appealing, it also needs to promote Belonging, which then promotes social norms to alter health behaviour. Finally, Commitment needs to occur to ensure habitual use of the online social network, and maintenance of newly acquired health behaviour also needs to occur.

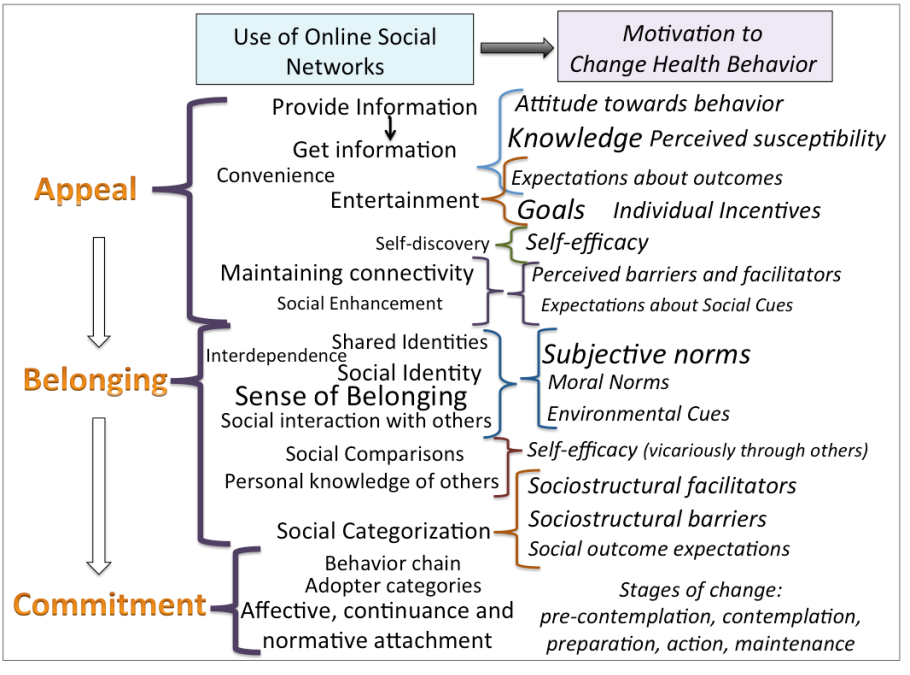

Fig. 1. Appeal Belonging Commitment Framework for using online social networks for health behaviour change showing the major (large text) and minor (small text) determinants for behaviour change and the interplay between the determinants (brackets)

4 The VivoSpace Health Social Network

We have developed a medium fidelity prototype called VivoSpace, which is an online social network that is designed to motivate health behaviour change. The design strategies were drawn from the determinants of the ABC framework. The main activity page for VivoSpace's medium fidelity prototype is shown in Figure 2. This medium fidelity prototype was developed using HTML, CSS, Javascript and jQuery with the vision to present a realistic interactive representation of our system. In total there were 32 HTML pages, 1 css file, and 2 javascript files.

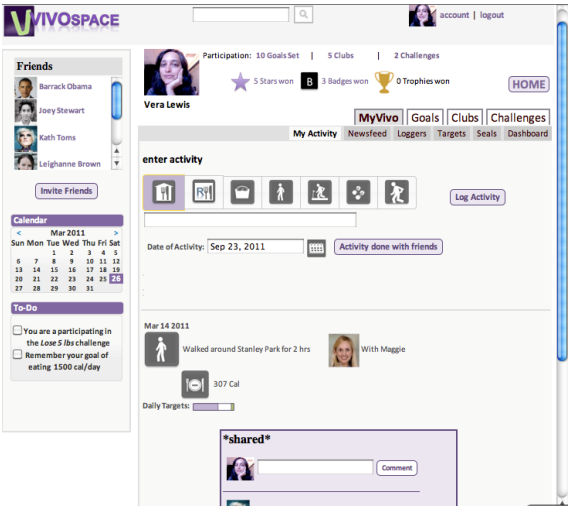

Fig. 2. A screenshot of the VivoSpace prototype, this page is the main activity page

There are 6 main functions that the medium fidelity prototype provides:

1. **Entry of meals and physical activity.** Provides a means to enter meals or activity (Figure 2); cumulative daily values for each of the nutrients are displayed with any evidence-based seals if it meets set criteria. The user can change the types of activities that s/he may log, the nutrients that are displayed, and the daily targets.
2. **Newsfeed.** The newsfeed page shows activities and accomplishments that friends shared. Any logged activity above can be shared with one's social network, and then it will appear on their friends' newsfeed page, and they can comment on it.
3. **Dashboard.** The dashboard page shows a summary of how the user is doing in terms of the nutritional intake based on the daily targets that are set. Time series charts are also provided along with a green checkmark for those nutrients where the target is met, and a red "*high*" or "*low*" where the target is not met.
4. **Personal goals.** The goals section provides the ability to track and create new health goals, and to view rewards for successes. The current active goals are shown with the nutritional intake compared against the target goals; charts and definitions of nutrients are also provided. New goals can also be created from a library of goals such as lose weight and healthy heart. Stars are earned when goals are successfully completed; users can view their own stars and their friends' stars.
5. **Group goals (clubs).** Clubs are similar to goals with the exception that user's friends are invited to participate in the club. When viewing current clubs users can see how other members of the club are doing. Members of the club can comment on people's progress in the club. Badges are earned when members successfully complete the requirements. Users can view and comment on their friend's badges.
6. **Competitive goals (challenges).** Challenges are similar to clubs with the exception that there are competitive and there is only one winner. Challenges display a leaderboard. The winner of challenges earns a trophy.

5 Experiments and Results

VivoSpace was evaluated based the determinants of the ABC framework, which involved using multiple laboratory experiments. The purpose was to determine if the design of VivoSpace provided the determinants for use of the online social network and motivation to change health behaviour. A total of 36 adults participated in the experiments (described in Section 5.1). They were recruited through university listserves, posters located around campus and through advertisements on Craig's list.

The determinants of appeal were measured directly through questionnaire feedback after the participant completed specific tasks on the medium fidelity prototype. Some of the *belonging* determinants were also enquired directly, and these methods are explained in detail in Section 5.2. However, measuring *belonging* cannot truly be measured through direct inquiry, as self reports about belonging are unreliable as actual sense-of-belonging are often divergent from how an individual perceives their belonging to a group. For this reason, we turned to the field of behavioural economics and adopted the *helping game experiment* [19] to evaluate if VivoSpace evokes indirect reciprocity. The methods and results for how this experiment was adapted for the evaluation of the medium fidelity prototype is described in Section 5.3. Similarly, *Commitment* is a temporal dimension and difficult to measure in a 1-2 hour experiment; however, the *in-group experiment* [9] is an indirect means to evaluate if VivoSpace promotes group commitment (described in Section 5.4).

18 of the 36 participants (Participant A) completed all three experiments. These 18 participants first complete the individual task experiment, which takes approximately 1 hour to complete. Participant B (18 total) then joins Participant A, and they complete the helping game and group commitment experiments together in pairs, which takes another 1 hour to complete. Each participants in the A group were remunerated $10 and each participant in the B group were remunerated $5.

5.1 Participants

In the Participant A group, 10 were male and 8 were female. There were 7 aged 19-24, 5 aged 25-34, 5 aged 35-49 and 1 was aged 50-64. The distribution for self-reported ethnic identity for this group was as follows: 10 were Canadian, 3 were West Asian, 1 was Chinese, 1 was Hispanic, 1 was First Nations, 1 was European and 1 was Australian. The majority were students: 5 were undergraduate students and another 5 were graduate students. Of the remaining participants, 4 were unemployed, 1 was a canvasser, 1 was a cleaner, 1 was a postdoctoral fellow and 1 was a physician.

In the Participant B group, 10 were male and 8 were female. There were 12 aged 25-34 and 6 aged 35-49. 8 were Canadian, 3 were West Asian, 3 were European, 1 was South Asian, 1 was Australian, 1 was Chinese and 1 was American. 6 were graduate students and 3 were software developers. The occupations of the remaining 9 were: employment assistance worker, postdoctoral fellow, professor, college teacher, researcher, software development manager, scientist, education program manager, and administrator.

This demographic distribution of participants shows that a good degree of gender, age, ethnic and occupational distribution was achieved. This purpose of achieving diversity is to provide an understanding of how a broad population would be motivated to use VivoSpace and through its use be motivated to change their health behaviour.

5.2 Individual Task Experiment

The individual task experiment methodology is drawn from traditional usability tests. During this experiment, each participant is asked to complete a group of tasks on VivoSpace. There are six groups of tasks for each of the prototype's functions described in Section 4. After each task group, the participant is given a questionnaire to complete, which contains statements that correlates to determinants from the ABC framework. The participants provide their level of agreement or disagreement to each statement using the 7-point likert scale, where 1 is strongly disagree and 7 is strongly agree. Most of the questions enquired about determinants from the appeal dimension, but there are also some from the belonging dimension.

Examples of the questions and the corresponding determinant from the ABC framework are the following:

"I would be able to gain information about myself and my capabilities by using a system like this" (Appeal: self-discovery)

"The newsfeed would allow me to view how my friends and family are staying healthy" (Belonging: social comparison)

The results of the 7-point likert questionnaire provide an understanding of how each of the 6 task groups promoted the appeal determinants and some belonging determinants of behaviour being sought through VivoSpace.

The results for the first task group (entry of meals and physical activity) show that the entering activity task group most strongly endorses the following determinants (mean > 5.0): *self-discovery*, *get information*, *convenience* and *health outcomes*. The design does not favor the determinant *to provide information* (mean=3.67). The remaining determinants, *entertainment*, *social enhancement*, and *environmental cues*, are neither strong nor weak (4.0<mean<5.0). Factorial ANOVA analysis on these three determinants was performed, where the factors were gender and age group. There was a statistically significant difference between gender for finding this task group *entertaining* ($F(1,12)=4.6$, $p=0.05$), where the mean difference between male and female is -1.4 with females finding it more entertaining then men. The results from second task group (newsfeed) show very good agreement to both the *appeal* and *belonging* determinants with a mean for all responses of over 5.0. The results from third task group's inquiry (dashboard) shows strong agreement for many of the *appeal* determinants especially *get information*, *self-discovery*, *convenience* and *knowledge* (mean>=5.94). There is less agreement in the dashboard providing any value to *perceived barriers & facilitators* and it also does not provide a very strong *incentive* to live healthier (mean < 5). The results from fourth task group (goals) show good agreement with the appeal determinants, but it was not very *entertaining* (mean=4.89), and they would not use it to *enhance their social position* (mean=4.11).

Figure 3 shows results for the fifth (clubs) and sixth (challenges) task group. There was good agreement that the design of the clubs' pages with the appeal and belonging determinants, but the design of the challenges' pages scored lower for almost all determinants. Further, the design did not support *social enhancement* especially for clubs. Further analysis factorial ANOVA found that there is a statistically significant difference in the challenges task group between male and female in *social enhancement* ($F(1,12)=5.777$, $p=0.033$) with a mean difference between male and female of 1.8. Statistically significant difference in the interaction between gender and age groups for *subjective norms* ($F(2,12)=4.22$, $p=0.041$) was found showing that different genders in different age groups felt that challenges promoted *subjective norms*.

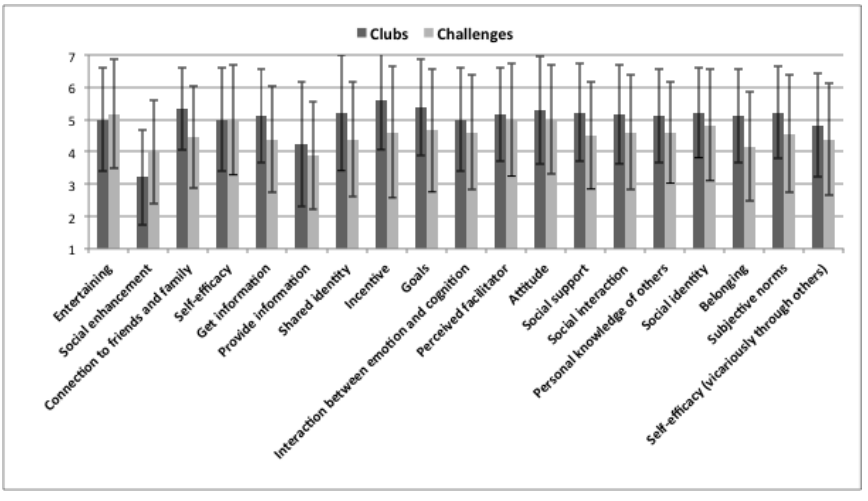

Fig. 3. Appeal and belonging determinant 7-point likert responses for the *Clubs* and *Challenges* task group

5.3 Helping Game Experiment

The determinants in the belonging dimension of the ABC framework are difficult to measure through direct inquiry methods such as those described above in the individual task experiment. Therefore, we utilize indirect experimental methods to better understand if our design contributes to belonging and triangulate the findings from the experiment above. Indirect reciprocity is a critical factor that facilitates belonging, and other related determinants such as social categorization and group comparison. The Helping Game Experiment originates from experimental behavioural economics has been shown to provide an understanding of indirect reciprocity and group belonging [19]. This experiment is based on the "repeated helping game" developed by Nowak and Sigmund [16]. This experiment evaluates indirect reciprocity, which is necessary for online social networks to develop social interaction and cooperation through group participation, feedback and discussion. We adopted the experiment described by Seinen et al. [19] to be applied to the evaluation of VivoSpace in a laboratory setting. In the Seinen et al. experiment, there was no actual activity that the

randomly assigned pairs were helping each other on. We adapt this experiment to be applied to providing help in completing tasks on VivoSpace.

In our experiment, after Participant A has completed the individual task experiment, s/he is joined by Participant B. A and B do not know each other. Participant A is now an expert on VivoSpace and understands how to use it, and Participant B is a novice. This set-up provides a good backdrop to apply the Helping Game Experiment, as Participant B must now complete the tasks and Participant A decides to help or not. Prior to starting a task, Participant A must decide if s/he will help Participant B at a cost of $1 or $5 depending on the cost of the task. Every time A helps B, s/he earns a point. There are two conditions: in the first condition, A is told that B already has 17 points; in the second condition, no information is provided on B's points.

The mixed design experiment has 2 variables with two conditions in each variable. Therefore, the 4 conditions in this mixed design are: 1) information provided and high cost, 2) information provided and low cost, 3) no information provided and high cost, and 4) no information provided and low cost. We hypothesize that the effect of helping on VivoSpace will produce different results from the Seinen et al. [25] experiment, which found that having information about their partner's points resulted in a statistically significant difference in providing help.

A mixed design factorial 2x2 ANOVA is run on the results of the Helping Game Experiment. The dependent variable is the percent of times Participant A helped Participant B. The within subject variable is the cost (cheap or expensive) for the tasks. The between subject variable is information provided or no information provided about Participant B's score. The results show that there is a significant difference between the cheap and expensive tasks ($F(1, 16)=5.54$, $p=0.032$). The mean difference between the cheap and expensive is 23.86%. This is not surprising and consistent with the Seinen et al. experiment [19], which shows that there is validity to the use of fake money as the cost of the tasks played a role in participant's decision to help or not help. The results for having information of B's score in the 2x2 factorial ANOVA reveals divergent results from the Seinen et al. experiment [19]. Interestingly, there is no statistically significant difference between the two conditions: information and no information ($F(1, 16)=0.51$, $p=0.386$). The top graph in Figure 4 shows the estimated marginal means and standard deviation for the percent of tasks that Participant A helped in the mixed design helping game experiment.

5.4 Group Commitment Experiment

Although measuring commitment to VivoSpace and new health behaviour is not possible in a laboratory experiment, group commitment has been measured in the laboratory by social psychologists. If VivoSpace can invoke group commitment, it will assist in developing commitment to the VivoSpace system and commitment to new health behaviours. The group commitment experiment has been adapted from Ellemers et al. experiment [9]. The premise of the experiment is that group commitment can be measured by creating groups, where the group boundaries are permeable, and a situation is imposed where group status is provided and compared to other groups.

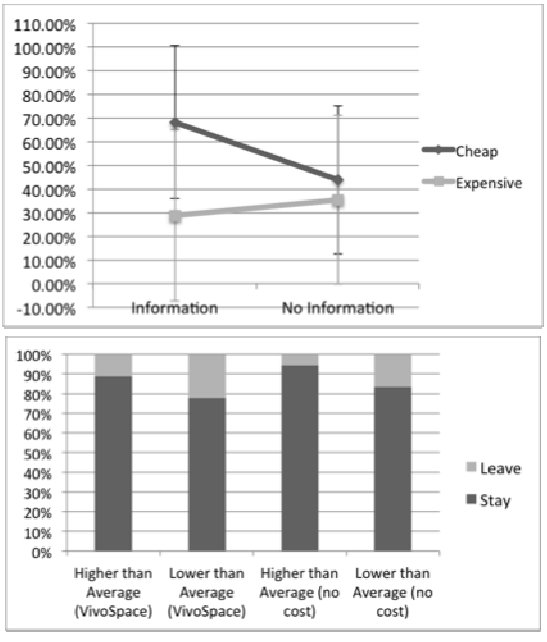

Fig. 3. Top – Helping game experiment's estimated marginal mean values and standard deviation for percent of tasks helped (n=9 per condition). Bottom – Group commitment experiment's percent willing to stay or leave with their partner (n=18 per condition)

Again, we use a mixed design experiment. The same partners from the helping game experiment are now told that they are team, and must complete a 10-question multiple-choice test on VivoSpace, where questions are not readily evident in the VivoSpace prototype. After the test, the participants are separated and provided with their score and the overall average score for this test. One person is told they scored 70% and the average for the test is 50%, and the other person is told they scored 70% and the average for the test is 90%. The two conditions are counter balanced between participants A and B. Each participant is then given the option of group mobility with two separate hypothetical caveats (within subjects): 1) they will not be able to use VivoSpace, and 2) it would cost them $50 to leave. This mixed design experiment has four conditions: 1) above average stay with VivoSpace, 2) above average stay at no cost, 3) below average stay with VivoSpace, and 4) below average stay at no cost.

The results of the group commitment experiment reveal that participants were inclined to stay with their groups rather than leave. The results are shown on the bottom graph of Figure 4. Statistical analysis was run on this 2x2 mixed design through Chi-Square test of association. The results show no statistically significant results between the test performance condition (higher and lower than average) and the choice to stay for VivoSpace (Chi-Square(1)=1.639, p=0.200). Furthermore, there was no statistical difference between the test performance and the choice to stay with the group at no financial cost (Chi-Square(1)=1.172, p=0.279).

6 Discussion

The ABC framework provided a foundation to measure the determinants for use of an online social network and its ability to lead to health behaviour change. When the determinants of *appeal* were enquired through questionnaire responses after interacting with the system, it was found that many of the determinants were met through the design of VivoSpace. However, there was variation in the responses between the clubs and challenges components of the design especially between male and females. For this reason the design can be iterated to combine goal, clubs and challenges into a single component that allows for participants to decide to invite friends and make it competitive or collaborative. The *individual task experiment* also revealed the weakest area of the design: motivation to *provide information*, which is an integral part of the system. Without data being logged, the other components in the design become less meaningful as only partial health information may be logged. Therefore, the design should be iterated to ensure stronger motivation to provide information.

The *helping game experiment* provide evidence that the VivoSpace prototype promotes indirect reciprocity and by extension group belonging. Since there was no statistically significant difference between having and not having information about their partner's score (status), we can assume that VivoSpace played a part, which is because in the Seinen et al. experiment, knowledge of their partner's score did play a statistically significant difference than those who did not have this information [19]. Although there are many variables that could interfere with this experiment, these are encouraging results. By showing that there was no statistically significant difference, the motivation to help or not help would be based on the design of the prototype rather than their partner's score.

The *group commitment experiment* shows that VivoSpace can provide group commitment. Participants were willing to stay with their groups even those participants that performed worse than average. Furthermore, when the cost to leave the group was the loss of use of VivoSpace or financial, there was still no statistically significant difference. Showing that VivoSpace does promote commitment as much as economic gain. Although the answers to these questions were made privately, there is a risk that participants are not willing to admit their desire to leave the group.

7 Conclusion

A medium fidelity prototype for VivoSpace was evaluated based on the ABC Framework. We measured *appeal* and *belonging* through an individual task experiment, where each participant was asked about components of the design based on appeal and belonging determinants. It was found that VivoSpace did meet most of the appeal determinants; however, the design could be improved to ensure that all users would find the components of VivoSpace appealing. Furthermore, the motivation to provide personal information was not as appealing as required in order for VivoSpace to be useful. The design of VivoSpace does promote indirect reciprocity, which can lead to group belonging, as can be interpreted through the *helping game experiment*. Finally,

the design of VivoSpace does promote group commitment, as participants of the *group commitment experiment* were willing to stay with their partners despite half the participants learning of poor scores.

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