MobileHealth: Learning on the move

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Report on a study conducted with Gunny "Cory" Lee

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Abstract

A study examined the effects of receiving weight management information in small, context-appropriate doses, measuring retention and application of that information to another context. Eight participants were asked to use a mobile phone-based application for ten days. During that time, half received paragraphs selected from a passage about weight management, the other half were given the entire passage at the end. Whereas on the immediate post-test, those participants who received messages in the context of their own weight management intervention scored poorly on questions relating the passage's content to new situations, one week later their scores matched those of those participants who received the entire passage at once.

Introduction

Because of the "always present, always on" nature of mobile phones, technology developers see great promise for creating a variety of applications that may potentially change users' behaviors. Mobile phones afford frequent, low-impact interactions as well as opportunities to provide context-appropriate feedback to users in situ. Yet as Bransford et al. point out "…[telling people new information] provides no guarantee that people will develop the kinds of sensitivities necessary to use relevant information in new situations" (Bransford, 1989).

We decided to test whether delivery of context-appropriate information can be shown to improve learning even outside of that context. In this study we focused on a weight-management application, in which users enter food intake and exercise information whenever appropriate during the day. The application was developed based on that problem statement that "One reason [that only 12% of Americans have "good"

eating habits] is that common educational strategies … do not link the dietary message with the behavior at the time and place the behavior needs to be changed" (Intille, 2003). We believe that a better educational outcome would be for that behavior to be changed even when the user is away from the context of the original learning application.

The users' input, uploaded to a central server every twenty-four hours, was used to inform messages sent by e-mail to half the users during the course of the study. The other users were given the same information all at once, in one passage at the end of the study. To measure learning, participants answered ten questions asking for factual recall and application of concepts to new situations on two separate post-tests.

Description of Experiment

Participants were asked to use the MobileHealth application for ten days. Half were given context-appropriate pieces of a weight-management passage during the study, based on their input to the system. After using the application, all users were given unread parts of the passage. In order to measure which group learned more, we administered a post-test of cued-recall questions as well as questions requiring application of the concepts by inference to new situations. A second post-test on the same types of questions was administered by e-mail one week later.

Methods

Subjects

Eight friends and family members were recruited to participate in "a study of a new health management system for busy people." They were randomly assigned to two conditions, manipulation and control. Due to technical difficulties retrieving data online, conditions of subjects 1 and 8 were swapped at the beginning of the intervention.

Subjects varied in age, gender, weight management goals, and their comfort with technology (Appendix A).

Design

The experiment had two conditions. One condition (n=4) was sent five unsolicited e-mails giving information about weight management during the course of the study, while the other condition (n=4) did not receive any health information other than the feedback that was part of the MobileHealth application.

Materials and Process

MobileHealth is an application that allows users to enter food and exercise information on a cell phone. Their input is then uploaded to a server once each day. The application gives users immediate feedback on caloric values of food and exercise and estimates progress toward a weight loss goal of -500 calories per day (Figure 1). In addition, a web-based interface allows case managers to observe daily progress.

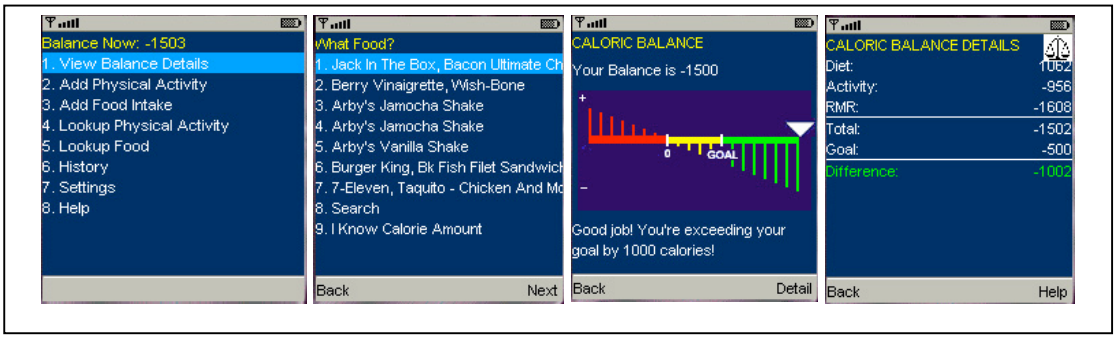

Figure 1. Screen shots of the MobileHealth application. Main menu, food entry, balance chart, daily balance details

Participants were asked to use the MobileHealth application for ten days. They were given a Motorola RAZR phone with the application installed and configured with their own most common foods and activities. At the time of configuration, they also

completed a questionnaire about their background, attitudes toward technology, and weight management experience, and a test of calorie estimation (Appendix D).

During the study, data from the MobileHealth application automatically uploaded to the server every twenty-four hours. Half the participants received five personalized e-mail messages containing paragraphs out of a passage explaining various aspects of caloric consumption, focusing largely on Resting Metabolic Rate and its application to weight management (Appendix C). The context-appropriate messages were chosen by the researchers based on the data uploaded to the server. A timeline of users' phone use, message reception, and testing is in Appendix B.

After returning the mobile phone, those participants who received the e-mail messages received two more paragraphs to read on paper (paragraphs 1 and 4 in the passage). The other participants received all seven paragraphs. Both groups then completed a questionnaire (Appendix E) covering usage and design issues, as well as another test of calorie estimation. The final ten questions tested recall and application of facts from the passage. Over one week later, subjects responded to an e-mailed test of the same fact-based questions, with three new questions applying the concepts to new situations (Appendix F).

Results

Preliminary Analysis

We were interested in determining if participants learned as a result of this study, and if so, whether that learning could transfer to new contexts. We examined the results of the passage-based questions and found a difference in scores between the two groups, but whereas we had hypothesized a benefit for the manipulated group due to the

connections formed between advice and the conditions of the cell phone use, on average it was the control group that scored better on the first post-test. Further analysis showed that the manipulation group's scores were lowered by the inference-based questions, while their scores on the fact-based questions were equivalent to the control group's scores. The difference between the groups disappeared on the delayed post-test a week later, when on average both groups scored higher than on the first post-test. Analysis of the inference-based questions revealed that no particular question was responsible for these results.

Detailed Analysis

Answers to the passage-based questions were scored on a scale from zero to two, where a score of zero indicated a response that was missing or unrelated to the passage, a score of one indicated a response that was related to the passage but incomplete, and a response that was thorough and grounded in the passage received a score of two.

When analyzing the scores on the passage-based questions we excluded two participants. One was too expert as demonstrated on pre-test measures and borne-out by results. The other, due to personal reasons, was not able to complete the first post-test until a week after completing the mobile phone study, two days before the second post-test. Unfortunately, both excluded subjects were in the manipulation condition. This left only two subjects to be analyzed for the intervention.

First Post-test: Fact recall and application

The results of the passage recognition-recall and inference questions asked on the first post-test were indeed different for the two groups. However, the results showed

much lower scores for the participants in the manipulated condition than for the control condition (Figure 2).

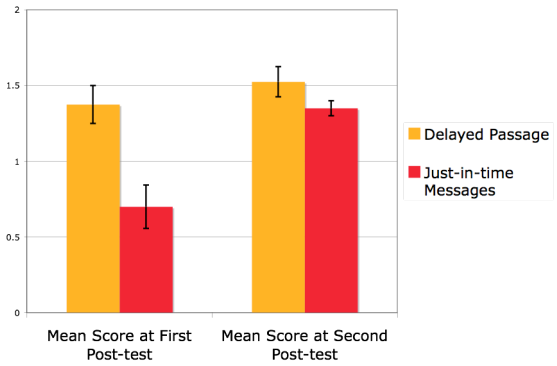

Figure 2. Mean scores (SE) by condition at first and second post-tests

Second Post-test: Fact recall and application

It is possible that the difference on first post-test was due not to a difference in understanding but rather to a recency effect; the control group had read the passage not long before. A second post-test over one week later aimed to determine whether the control group's scores would be lower after they, too, had time to forget. Surprisingly, on average both groups did better on the delayed post-test than on the original post-test, and the manipulation group's scores were at a level comparable to the control group.

Question analysis

The tests were designed to have two types of questions: those referencing facts from the passage, and those requiring reasoning based on those facts to apply to a new situation. When the two types of questions were examined, a finer distinction appeared between the groups. On the first post-test, the participants in the manipulation condition scored at a level comparable to the control group on the fact-based questions, but lower on the inference-based questions. The second post-test showed no such difference (Figure 3).

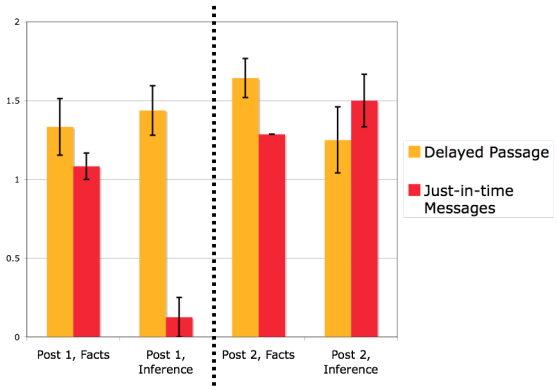

Figure 3. Mean scores (SE) by condition at post-test 1 and 2, by type of question

An analysis of the inference-based questions showed no one question driving the results (Appendix F). However, the difference between conditions was more pronounced for the questions "How does eating breakfast within an hour of waking encourage weight loss?" and "Why do older people often have lower RMR?" Unfortunately, the questions on the delayed post-test did not test the same concepts of the thermic effect of food and muscle mass.

Discussion

Learning information in the context of their own weight management using MobileHealth did not lead to participants' transfer of that understanding to new situations. Instead, those participants who received a well-organized passage relating concepts to each other appear to have an advantage over those who received the passage in pieces. On the first post-test, both conditions performed at equivalent levels on average on fact-based questions, but the manipulated condition scored poorly on inference-based questions. However on the second post-test, both groups showed improved scores on average.

It is curious that participants in the manipulation condition scored so much better one week later. One explanation is that the questions might have been easier on the

second post-test. Unfortunately, different concepts were tested by the inference questions on the first and second post-test, so we have no measure of change in the participants' ability to apply any particular concept to new situations.

Another explanation for the higher scores at the second post-test could be that the participants, who had received no feedback on their answers to the first post-test, felt they had an uncompleted task of organizing and applying the concepts in the passage (Zeigarnik, 1927). If so, their improvement on the second set of inference-based questions might indicate that the first set of questions served to prompt the organization of concepts that support transfer to new situations.

A complication arose in that the context shift was not only from applying facts in one's own weight management to extrapolating to a new situation, but also from one medium to another. The pen-and-paper questionnaire can be seen as being presented in the same paper context as the passage for the control group, whereas the manipulation group received the passage paragraphs via e-mail. When re-tested over e-mail, the manipulation group performed as well as the control group. An argument against this interpretation is that the paragraph about muscle mass was one of the two presented to the manipulation group at the end of the study, and yet this paragraph did not support transfer to the question about aging (Appendix G).

Having only two subjects represented in the manipulation condition analysis calls the results into doubt. These two participants were also the only participants who reported no change in their habits during the study. This suggests that a motivating variable such as an attitude toward weight management may have influenced their experience, perhaps leading them to disregard message content.

We should note that two of the participants in this study were married to each other but were assigned to opposite conditions; although they were asked not to talk to each other about the study, one was aware she was receiving e-mails while her husband wasn't. She interpreted this as criticism that she wasn't losing enough weight, and as she found this obnoxious, she may have discounted the message content.

A final difficulty in the delivery of the personalized messages was the delay in seeing users' input on the server. This led to messages that were perhaps not relevant to the participants' perceptions of their input. Of the participants in the manipulation condition who responded to a question of how relevant the messages were to their input, all three reported low applicability.

General Discussion

This study set out to determine whether learning within the context of mobile phone use would also inform transfers of understanding to new situations. The results showed poor application of context-appropriate messages to new situations. Indeed, a well-organized passage seemed more effective in supporting transfer of its concepts. Further investigations might examine the effect of "quiz" questions in helping users to organize concepts for transfer.

Context-appropriate learning may yet be beneficial, however. The weaknesses of this study may have obscured a positive effect of this intervention method. Because the messages were perceived as minimally applicable to participants' experience, one might challenge their appropriateness to the user's context. A future study would address the need for more tailored information, as well as more timely delivery. Ideally, information would be sent on the mobile phone itself to tie the information more closely to the

intervention. Measures would be improved by testing within the same delivery context, and ensuring that both post-tests test transfer based on the same concepts.

"Ubiquitous computing" is on the forefront of current technology development, and many claims will be made of benefits to users. Although learning in one context may be benefit enough for many applications, learning for transfer sets a higher standard. It seems worthwhile to examine the benefits of this type of interaction for learning, and to recognize both its advantages and its limitations.

References

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Appendices

A. Description of Participants, scores
B. Intervention timeline
C. Passage
D. Pre-test questionnaire (paper)
E. Immediate post-test (paper)
F. Delayed post-test (e-mail)
G. Inference question variability and scoring

Appendix A Participant Details and Scores

Participants

Subject number	Condition	Age	Gender	Weight Goal	Is tech scary?	Days used
1	0	23	F	-5	No	3
2	0	66	M	-20	No	10
3	1	66	F	-5	Somewhat	10
4	0	26	F	maintain	No	12
5	1	31	F	maintain	Somewhat	9
6	0	56	F	-60	Somewhat	8
7	1	26	M	+5	No	12
8	1	26	F	-10	Somewhat	10

Scores

Subject number	Condition	Mean score pretest 1 (10 questions)	Mean score pretest 2 (10 questions)	Post-test 1 fact test (6 questions)	Post-test 1 inference test (4 questions)	Post-test 2 fact test (7 questions)	Post-test 2 inference test (3 questions)*
1	0	1.4	1.7	1.3	1.5	1.7	1.7
2	0	1.3	1.7	1.5	1.0	1.9	1.3
3	1	0.8	1.4	1.2	0.3	1.3	1.7
4	0	1.7	1.6	1.7	1.8	1.7	1.3
5	1	0.6	1.3	1.0	0.0	1.3	1.3
6	0	1.1	1.1	0.8	1.5	1.3	0.7
7 ('expert')	1	1.7	1.9	1.8	1.5	1.9	2.0
8 (delayed)	1	1.3	0.9	1.2	1.5	1.0	0.7

* One of the "inference" questions was recoded as a "fact" question.

Intervention timeline

ID	Date: Nov/Dec																				
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7
1						*Phone application not working*								1								2
2								XX	X	X	X1											2
3											1											2
4														1								2
5						X		X	X	X	X			1								2
6													1									2: 12/11
7						X		X	X	X	X			1								2
8								X	X	X	X	X								1		2: 12/8

Shaded area: mobile phone use
X: message received by e-mail
1: post-test 1
2: post-test 2

Understanding Weight Management

Many people struggle to manage their weight. They follow the latest diet, but afterward they fail to maintain their goal weight. While weight loss or gain can be explained simply as a matter of balancing calories in with the calories out, understanding the way the body works can help dispel some of the misconceptions of "pop nutrition" and explain why fad diets fail in the long term.

The food you eat provides *calories* to your body. Calories provide energy for your body to make and break substances, transmit nerve signals, keep the heart beating, repair and maintain organs; essentially, they keep you alive. Carbohydrates and protein both provide 4 calories per gram, while alcohol contains 7 calories per gram, and fatty foods 9 calories per gram. When you take in more calories than your body needs, the extra calories may be stored as fat. Losing one pound requires taking in 3500 fewer calories than you expend.

Up to seventy percent of the calories burned are determined by the *resting metabolic rate* (RMR). RMR is the amount of calories the body needs to stay alive and maintain your current weight. Your RMR burns calories 24 hours a day, and does not slow down or stop while your body is sleeping. Many factors affect your RMR, including genetics, muscle mass, amount and frequency of food intake, and physical activity.

Resting metabolic rate is largely determined by genetics; some people have naturally faster metabolisms, and burn more calories. The RMR can also be increased temporarily by certain drugs, fever, and illness, but the most effective way to alter it in the long term is to increase *muscle mass*. Muscle takes a lot of calories to build and to maintain, whereas fat takes no calories to maintain. If you increase your muscle mass, you will increase the number of calories your body burns all day long. The higher your muscle-to-fat ratio, the more calories you burn just resting.

One way to keep the RMR higher is to eat more frequently. Burning calories by eating is called the *thermic effect of food.* Eating regularly (every 3 hours at the least) maximizes the amount of energy burned by consuming and digesting food, and keeps RMR elevated over a longer time span. Waiting too long between meals will signal your body to become more efficient on fewer calories, lowering your RMR.

Ironically, your RMR can be increased by consuming more calories. The RMR will increase to attempt to accommodate the new level of intake. Of course, at some point the extra calories will lead to weight gain. When you eat less, and begin to exercise and burn more calories more than you are consuming, your metabolism slows down and becomes more efficient.

Physical activity has two benefits for weight management. Most activities burn calories, and some increase muscle mass. Walking a mile burns just as many calories as running a mile, so any activity that you can maintain and enjoy is the best form of exercise to incorporate into your life. Resistance training is needed to build more muscle mass, and is often overlooked by people interested in losing weight. Cardiovascular activity is excellent for heart health, but does not have a long-term effect on the RMR. Weightlifting for example not only builds muscle (assuming enough calories are consumed to build the tissue), but also raises the resting metabolic rate for approximately 48 hours after the exercise session.