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Musical Stairs: Encouraging Physical Activity through Persuasive Technology

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“Musical Stairs: Encouraging Physical Activity through Persuasive Technology”

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ABSTRACT

This study examined persuasive technology and its effect on participants' motivation to engage in physical activity. A set of musical stairs was built using infrared proximity sensors, designed to make the experience of climbing the stairs more "fun". The software was written in such a way that each step a participant took on the stairs provided a musical response. The experiment tested three conditions: the control condition (without sounds), a condition with piano note sounds, and a condition with guitar chord sounds. The results suggest that more participants interacted with the stairs during the conditions with sound compared to the condition without sound.

INTRODUCTION

According to the Centers for Disease Control and Prevention, 69.0% of adults age 20 and over were overweight, including those who were obese, in 2011-2012 [1]. Attention to the obesity epidemic has extended beyond academic literature to the popular press (see, for example, [2] and [3]). Given the frequency of this coverage, it seems likely that many, if not most, Americans are aware of the obesity issue. While many may be aware of the epidemic, the general public may not be entirely conscious of the potentially fatal consequences of obesity. Diseases such as cardiovascular disease, liver disease, hypertension, and many forms of cancer are some of these fatal repercussions [4]. With the percentage of obese Americans at an all-time high [4], it's time to identify the sources of the problem and implement solutions to keep Americans healthier and living longer. While many factors such as diet, portion size, and nutrition contribute to obesity, the main culprit is physical inactivity [5]. Efforts toward reducing obesity must include strategies to increase physical activity in those who are currently overweight, as well as strategies to prevent obesity in children, adolescents, and adults [4].

Since the late 1990s, technology has emerged as a powerful tool used to motivate healthy behavior by employing persuasive techniques [6]. In fact, using technology to change behavior has become extremely prevalent in American society. In his book "Persuasive Technology," B.J. Fogg, of Stanford University, has laid the foundation for using technology as a tool for persuasion by outlining different persuasive strategies and presenting numerous examples for each methodology. Fogg defines persuasive technology as "any interactive computing system designed to change people's attitudes or behaviors" that does not use coercion, but implies a voluntary change [6]. Fogg presents seven different types of persuasive technology tools, which include: reduction technology (persuading through simplifying), tunneling technology (guided persuasion), tailoring technology (persuasion through customization), suggestion technology (intervening at the right time), self-monitoring technology (taking the tedium out of tracking), surveillance technology (persuasion through observation), and conditioning technology (reinforcing target behaviors) [6]. In the related work section, I will outline several past studies that have employed these techniques. As the studies show, many of these techniques have been studied and executed with the goal of motivating healthy behavior by increasing physical activity (see related works).

As the search for innovative ways to encourage healthy behavior has continued, more persuasive techniques have been identified. An example of this is the “fun” strategy, which, as identified by the Fun Theory (an initiative by Volkswagen), stems from the idea that “something as simple as fun is the easiest way to change people’s behavior for the better” [7]**.** This means that people are more likely to engage in a behavior if it is made more “fun.” Dan Lockton presents this concept in his “Design with Intent Toolkit” as “playfulness”, or something that is designed to “play” with it’s users, thus provoking curiosity or turning user interactions into a game [8]. In this study, I aim to employ the “fun” strategy to motivate students to engage in physical activity through interactive musical stairs that emit musical responses as users ascend and descend the staircase.

RELATED WORK

As mentioned previously, many persuasive technologies have been developed with the goal of encouraging physical activity, and changing human behavior towards a healthier lifestyle. Most of the strategies identified by Fogg have been used in scientific studies related to the effectiveness of persuasive technology that encourages physical activity, and often researchers combine multiple strategies to achieve the desired behavior change. Persuasive technology designed to motivate physical activity has been integrated in all types of situations using a diverse set of computing systems. It is useful to point out that in a 2014 review of existing research, researchers examined 95 studies on persuasive technologies, and concluded that persuasive technologies indeed seem to persuade people to demonstrate various behaviors [9]. What follows is a discussion about how this has worked in recent studies.

One particular strategy identified by Fogg is self-monitoring, which is a type of technology that allows people to monitor themselves to modify their attitudes or behaviors to achieve a predetermined goal or outcome [6]. This technique appears to be a prevalent tool for encouraging healthy behavior, and has been studied frequently (see [10], [11], [12], [13], [14]). Ideally, self-monitoring tools work in real time, according to Fogg [6], and give users ongoing data about their physical state. Self-monitoring technology has been shown to be a powerful tool in the field of persuasive technology, as seen by the popularity of the “FitBit” [15], a device used for tracking health statistics such as: steps taken, calories burned, and distance traveled. One study employed a similar self-monitoring technique by asking participants to wear pedometers throughout the day. They combined the self-monitoring technique with the use of social media, and showed that a significant increase in step activity occurred when participants could read each other's step data and make comparisons and comments [11]. The group of participants that could see each other's step data took, on average, 4000 more steps per day than the group of participants who could not share their data.

In another recent study, researchers designed a virtual coach that gave exercisers different forms of feedback while they rode on a stationary bicycle and also wore heart rate monitors [16]. This type of technology employed the "intervening at the right time" strategy and the "tunneling" strategy by giving the participants feedback based on their current heart rate [16]. This study differed from the study reported above because it only gave feedback during the actual physical activity, and not throughout the day. Researchers who conducted the virtual coach study presented the design in this way to isolate a specific type of motivation, called intrinsic motivation [16]. Psychologists have distinguished between two categories of motivation: intrinsic and extrinsic motivation. Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable, while extrinsically motivated activities are done to receive a reward, or avoid punishment [17]. Many years of research show that the quality of experience and performance can be very different based on which type of motivation is driving the behavior [17].

While the participants were cycling, the virtual coach gave verbal feedback on the participants' performance based on data gathered from a heart rate monitor [16]. The virtual coach gave positive feedback and support, and after the participants finished cycling they were given a questionnaire to measure intrinsic motivation [16]. Results of the questionnaires showed that participants had a significantly higher interest and enjoyment during the condition with the virtual coach, and they also reported feeling more competent [16]. Results of the heart-monitor data showed that significantly more people biked in the optimal heart rate zone with the coach than without. This study demonstrated persuasive technology's effect on exercise behavior, and showed that persuasive technology can be used to promote optimal exercise for weight loss during the actual time of physical activity [16].

The remainder of this paper presents my exploration of the use of persuasive technology to encourage college students to exercise as they move to and from classes. This study involved the design, implementation, and evaluation of a set of musical stairs. The design of my prototype stems from a study done in Stockholm, Sweden, where a group sponsored by Volkswagen built a touch sensor piano staircase, located directly next to an escalator in a subway station. Although no tests of significance were reported, the researchers report data that shows "66% more people than normal" voluntarily chose to use the stairs over the escalator [7]. The designers were successful in persuading users to take the stairs over the escalator by making the choice of taking the stairs more "fun." This is the same technique I will use in my own research.

All of the studies described above aim to use technology in order to change attitudes or behavior, but other research has shown that behavior change, or long term persuasion, is an incredibly complex process due to the number of factors involved in a meaningful behavior change [18]. Most of the persuasive technology studies reviewed in this paper involve short-term experiments and small groups of participants, without demonstrating the long-term effectiveness of the persuasive technology. In a paper on how to evaluate technologies for health behavior change, researchers suggest that shorterterm studies are valuable contributions, but they should focus on efficacy evaluations "tailored to the specific behavior-change intervention strategies embodied in the system" in order to gain a better understanding of people's experiences with technology [18].

My study does not intend to conclude that any participants truly changed their habits, but instead aims to focus specifically on the persuasive and technical strategies employed to understand user motivation to engage in physical activity. By using a set of stairs that include three steps up and three steps back down to nearly the same starting point, this study will evaluate the effectiveness of the "fun" persuasive strategy on participants' motivation to spontaneously exercise while walking to and from classes in an academic building. This type of motivation can be classified as intrinsic motivation, because participants will choose to interact with the musical stairs because they feel that it is fun, or find enjoyment and pleasure from the interaction, rather than to receive an external reward. Although the musical responses produced by the stairs are external from the activity itself, they will contribute to the participants' inherent enjoyment of the activity. The studies mentioned above (see [1], [16]) employ two or more persuasive techniques to encourage physical activity, whereas my study focuses solely on the "fun" strategy.

Although the "fun" strategy has been put forward by Volkswagen's Fun Theory Initiative [7], and briefly mentioned in Dan Lockton's "Design with Intent Toolkit", it hasn't been frequently used in persuasive technology studies. There has been some research conducted on using computer and mobile phone games as a persuasive technique to encourage healthier behavior. One study in particular developed a computer game aiming to prevent childhood obesity [19]. In this study, however, the game was used to make the act of learning about healthy eating habits and exercising more “fun,” rather than making the actual act of exercising more fun [19]. Many papers about studies on persuasive technology are published in the annual International Conference on Persuasive Technology, where those who have created persuasive systems present their research [20]. Based on my examination of the conference proceedings from 2006 through 2013 (more than 200 papers), only four studies have employed the “fun” strategy to encourage physical activity (see [21], [22], [23], [19]). It is also interesting to note that B.J. Fogg, one of the pioneers in the field of persuasive technology, does not include the “fun” strategy in his list of seven techniques for persuasion [6]. The minimal amount of prior research on this particular method leaves a generous amount of room for the “fun” strategy to be explored and tested for effectiveness in different situations.

EXPERIMENTAL SETUP AND PROCEDURE

Hardware and Software

As mentioned in the introduction, the stairs in this study do not lead anywhere, but are instead three steps up and three steps back down to nearly the same starting point (see figure 1). A sensing system was attached to each step, and the stairs were placed on level ground in an academic building. Participants in the study had the option to either walk past the stairs, or to interact with them. Therefore, the design of the study centered on trying to make interacting with the stairs more appealing than not doing so. The stairs were designed to be simple so that each participant would feel he or she had the ability to interact with the stairs. The design aimed to grab participants’ attention and spark curiosity by combining the familiar action of going up and down stairs with the unfamiliarity of a new object placed in an academic building. Each of the steps had a rise (height) of seven inches, a run of eleven inches, and were 30 inches wide. Each piece of wood used to build the stairs was two inches thick. The total height of the set of stairs was 21 inches, and the structure was 55 inches long.

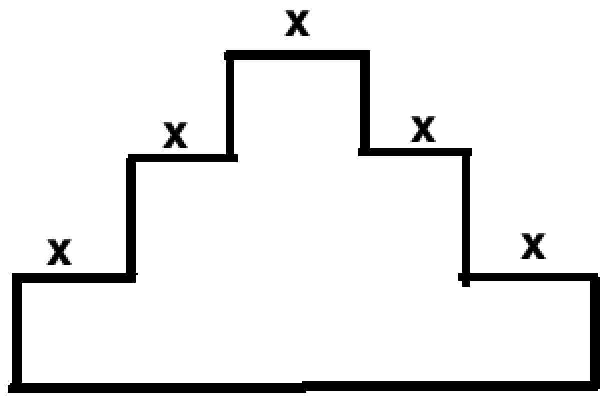

Figure 1. Design of musical stairs used in this study. Each X represents a sensing system

A sensing system was attached to each step, so that there were five sensing systems in total. The sensing systems used were programmable photoelectric tripwire devices made by Phidgets Inc. [24]. Each sensing system included an emitter, and a receiver. Each emitter was attached to the left side of its step, and each receiver was attached to the right side of its step, and each sensing system was powered by a 12VDC power supply. The wires from each sensor were hidden underneath the staircase and were not visible to participants for a better, more appealing appearance. Each emitter provided a constant, invisible infrared beam of light, which was detected in the default state by the receiver. However, an object (a participant's foot) could break the beam, which allowed the receiver to signal that the participant was standing on the corresponding step. Each receiver was connected to a digital input on a Phidgets Inc. interface kit, which was in turn connected to a Macbook laptop USB port in order to send signals to the software system that I wrote for the study. The software used in the study was written using the Phidgets Inc. open source Java library and API in the Eclipse Integrated Development Environment (IDE). When an infrared beam on a step was broken, the digital input would change its state to “true” and the software would instruct the computer to emit a sound. A different sound was produced for each step/digital input. Figure 2 shows a user interacting with the stairs. Each time the user takes a step a different note was played.

Figure 2. Shows a user interacting with the musical stairs

The software also collected data, including the number of times each individual beam was broken, as well as the total number of beams broken (total number of steps taken). These values were stored in integer variables that were incremented each time a beam was broken. Each sensor also had an associated Java ArrayList that stored a timestamp for each time a beam was broken. The timestamps were used for supplementary data analysis. After the sensors were finished collecting data, these variables were written to a text file. Here is an example of the data file for one sensor:

sensor 1 (step 1)

times beam broken: 3

timestamps:

2015-03-08 14:59:30.252

2015-03-08 15:00:30.252

2015-03-08 15:02:30.252

Experimental Setup

The study consisted of three conditions and a debriefing session, each taking place in the Percy Lavon Julian Science and Mathematics Center located at DePauw University. The first session served as the control condition. During the control condition, the stairs were placed in the academic building with the sounds disabled. Data was collected during the three conditions; however, the last session did not involve data collection but served the purpose of debriefing. Debriefing normally occurs after participation, and is used to insure that participants are able to receive a fuller explanation both of the purposes and results of the research [25]. During each of the first three sessions, the software collected the data described in the software section, while I watched from the second floor of Julian to observe and count the number of times a participant interacted with the staircase. For the purpose of this study, “interacting” with the staircase was defined as a person placing at least one foot on at least one step. If the same person interacted with the staircase two separate times, they were counted two times.

A confederate assisted with this study to mitigate the possibility that the control condition might have desensitized participants in the later conditions. If a participant walked on the stairs (or observed someone else walking on the stairs) in the first condition without hearing music, then the participant may not have interacted with the stairs in subsequent conditions. The confederate interacted with the stairs at four predetermined times during each session. Each time the confederate interacted with the stairs, eh or she ascended the stairs, descended the stairs, turned around, and ascended and descended the stairs again.

The control condition was held on a Monday, the second condition on a Wednesday, and the third on a Friday. Many classes at DePauw meet at the same time on Monday, Wednesday, and Friday, meaning the class traffic was similar on these days. Each condition was conducted during two separate sessions, the first from 10:00AM-10:20AM, and the second from 1:20PM-1:40PM. These times were carefully selected because on Monday, Wednesday, and Friday all morning classes end at 10:10AM and the next classes start at 10:20AM, and one of the class periods in the afternoon ends at 1:30PM and the next class period starts at 1:40PM. Therefore, these twenty-minute increments are at the time with the highest amount of traffic in the Julian atrium because one class is ending, and the next class is starting, so students are navigating both in and out of the building. Data was collected separately for each individual session. The stairs were left in the Julian atrium in between sessions, without data being collected. The sounds were also disabled during these times. The sessions are described below:

Control Condition: In the initial session, the stairs were placed in the Julian Atrium on March 9, 2015 from 10:20 AM-10:40 PM and 1:20-1:40 PM, without the musical response hooked up to each step; however, each step still had its sensing system attached to it. During this condition, I observed from the second floor and counted the number of times a participant interacted with the staircase. The software running the sensors collected the following data: number of times each individual beam was broken, and the total number of beams broken during the twenty minutes. The confederate ascended and then immediately descended the steps twice at minutes: 0, 5, 10, 15.

Second Condition: During this session, the stairs were placed in the Julian Atrium on March 11, 2015 from 10:20 AM-10:40 PM and 1:20-1:40 PM, with the musical response programmed to the sensing system attached to each step. During this condition, each time a beam was broken on a step, a speaker placed underneath the stairs emitted the sound of a piano key being played. Each step had a different note, and the sounds were audible to the person on the staircase as well as to other participants in the vicinity of the atrium. During this condition, I observed from the second floor and counted the number of times a participant interacted with the staircase, and the software running the sensors collected the following data: number of times each individual beam was broken, and the total number of beams broken during the twenty minutes. The confederate climbed the steps at minutes: 0, 5, 10, 15.

Third Condition: During this session, the stairs were placed in the Julian Atrium on March 13, 2015 from 10:20 AM-10:40 PM and 1:20-1:40 PM, with a different set of musical responses programmed to each sensor on each step. During this condition, each time a beam was broken on a step, a speaker placed underneath the stairs emitted the sound of an acoustic guitar chord being played. Each step had a different chord, and the sounds were audible to the person on the staircase as well as to other participants in the vicinity of the atrium. During this condition, I observed from the second floor and counted the number of times a participant interacted with the staircase, and the software running the sensors collected the following data: number of times each individual beam was broken, and the total number of beams broken during the twenty minutes. The confederate climbed the steps at minutes: 0, 5, 10, 15.

Debriefing: For debriefing, the stairs were left out in Julian at a separate time after all the data collection sessions had finished, with a sign posted next to them saying: "Did you interact with these stairs between March 9-13? These piano stairs were here for an IRB approved study to be used as part of an Honor Scholar Senior Thesis on persuasive technology. The study aimed to find out if participants would spontaneously engage in physical activity if the activity is made more "fun" through the use of technology. Please feel free to contact Meagan Combs or Dave Berque." The sign also included email addresses and phone numbers so that participants could use to request more information. No data was collected during this time.

RESULTS

Table 1 shows the number of participants who interacted with the musical stairs during each session, the total number of beams broken (or steps taken) during each session, and then the average number of steps each participant took while interacting with the stairs. The data in table 1 includes the number of times the confederate interacted with the stairs, which was a total of four times each session. The total number of steps taken also includes the steps taken by the confederate, which was a total of 40 steps each session (ten steps per interaction).

Experiment Session	Number of Participants that interacted with Musical Stairs	Total number of beams broken (steps taken)	Average number of steps per person
Control Condition First Session	4	46	11.5
Control Condition Second Session	6	55	9.6
Piano Condition First Session	27	242	8.96
Piano Condition Second Session	30	303	10.1
Guitar Condition First Session	14	120	8.57
Guitar Condition Second Session	21	194	9.24

Table 1

Figure 3 shows how many participants interacted with the musical staircase for each session. This number was obtained from my observation during each session. This data includes the number of times the confederate interacted with the stairs, which was a total of four times each session.

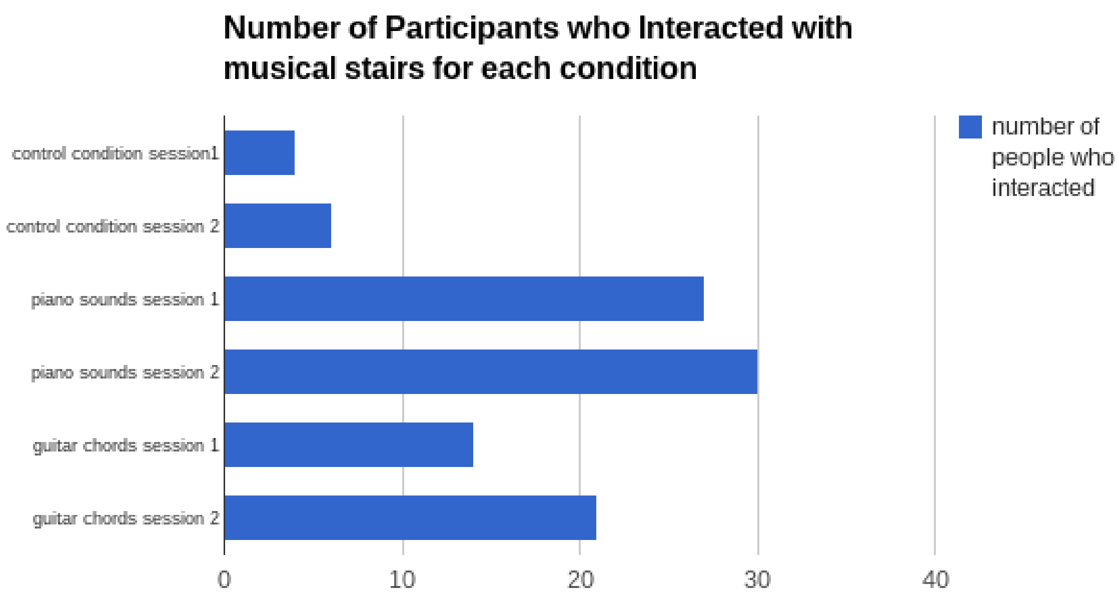

Figure 3

Figure 4 shows the number of times each individual beam was broken during the session one (10:00AM-10:20AM) for each condition. This data represents the number of times someone took a step on each of the five steps. This data includes the steps taken by the confederate.

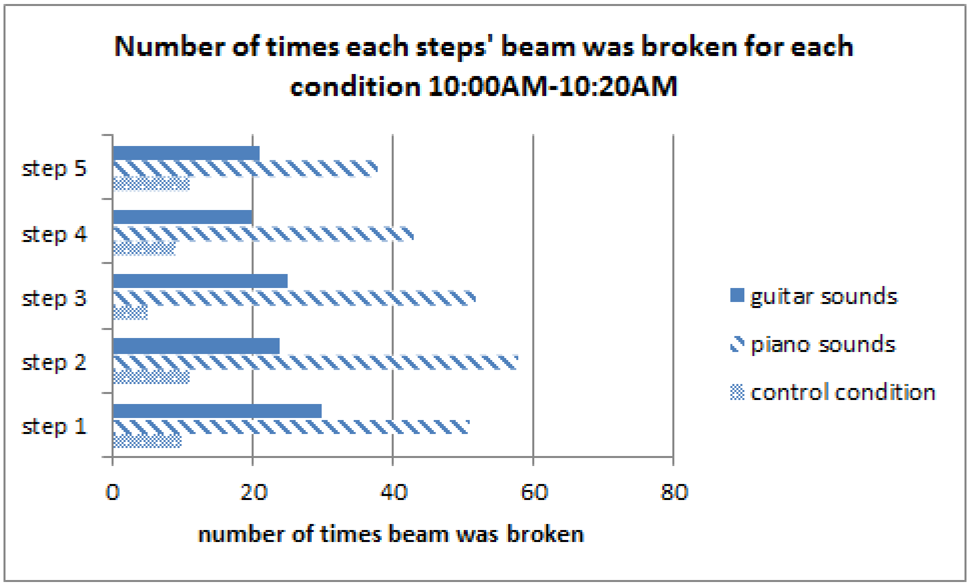

Figure 4

Figure 5 shows the number of times each individual beam was broken during the later session (1:20PM-1:40PM) for each condition. This data represents the number of times someone took a step on each of the five steps. This data includes the steps taken by the confederate.

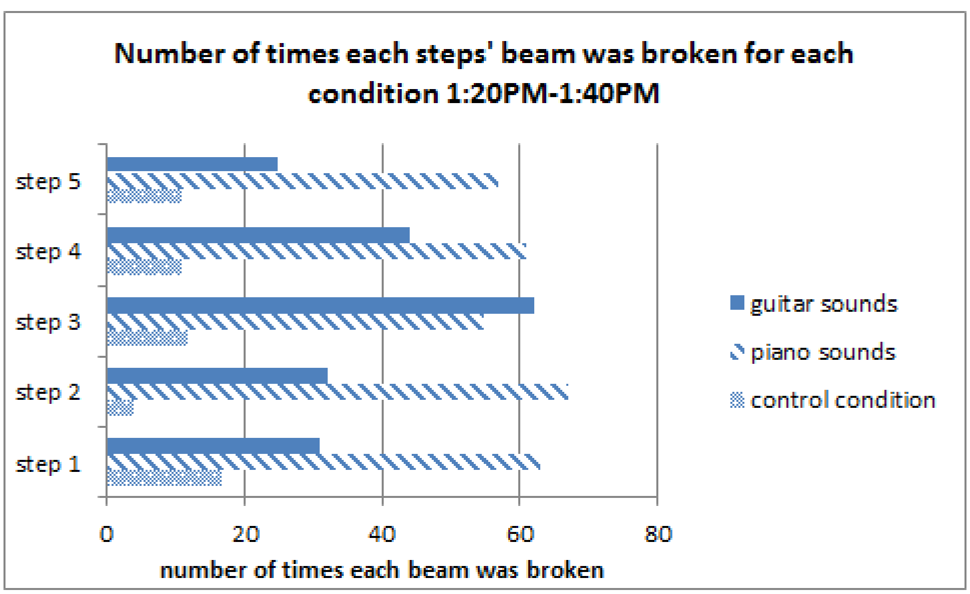

Figure 5

DISCUSSION

Because the data was collected for each session in aggregate, rather than for individual participants, and there were only a few sessions of data collection, there are not enough data points to test for statistical significance. However, the data in table 1 and figure 3 suggest that more participants interacted with the musical stairs during the conditions with sounds compared to the condition without sound. Because these data sets include the data from the confederate, we can see that during the first session without sounds, in fact zero participants interacted with the musical stairs, and during the second session without sounds only two participants interacted with the stairs.

Table 1 and figure 3 also suggest that more participants interacted with the musical staircase during the piano sound condition compared to the condition with guitar sounds. The reason for this result, however, is unclear. One possible explanation is that the novelty of the musical staircase had already worn off by the second condition, making the stairs seem less exciting to participants (see conclusion and future work). It is also possible that the traffic in the academic building was lower on Friday. According to the DePauw schedule of classes, there are two classes in the Julian academic building that only meet on Monday and Wednesday, meaning there were about 50 fewer people that might have walked through the atrium [26]. Or perhaps the guitar sounds were simply less enjoyable than the piano sounds.

Table 1 also shows the average number of steps taken during each interaction with the musical stairs, which ranges from 8.57-11.5 steps. Although the average is included, I did observe a wide variance in the number of steps participants took during each interaction. Some participants only placed one foot on one step, while others took about 20 steps during one interaction. It would have been interesting to know the actual number of steps each participant took during each interaction, however the software was unable to distinguish between different participants. This means that the software could not actually count the number of steps each participant took during each interaction, but I was able to compute the average by manually counting the number of people who interacted with the stairs. I also observed that in some instances, two participants interacted with the stairs at the same time, which would have made computing the number of steps taken by each person very challenging. It is interesting to note that although fewer participants interacted with the musical stairs during the guitar condition, the average number of steps taken stayed fairly close to the average number of steps taken during the piano condition.This suggests at least a possible explanation. This might mean that the guitar sounds were as enjoyable as the piano sounds, since students took around the same number of steps for each interaction.

Figures 4 and 5 show the number of times each individual beam was broken during each session. These figures suggest that in the conditions with sounds, the first two steps' beams were broken more than the remaining steps. These two steps were the ones facing the main entrance to the academic building, so it is possible that participants were more likely to interact with the staircase on their way into the building compared to on the way out.

Because I was observing during each condition of the study, I was able to note some of the interesting behaviors that occurred while participants were interacting with the musical stairs. I noticed that many participants approached the musical stairs in groups, and took turns interacting with them. A few times I also noticed a participant would interact with the musical stairs, and then go and get a friend and bring he or she back to see the stairs. In one situation, two participants held hands and ascended and descended the stairs together, simultaneously. These observations suggest that the musical stairs took on a social aspect. A few students tried to play a song during the piano condition by skipping steps and repeatedly stepping on the same step. I also noticed that some of the same participants interacted with the stairs multiple times and during different conditions.

CONCLUSION AND FUTURE WORK

This study aimed to encourage students to engage in physical activity on their way to and from classes by placing a musical staircase in the atrium of an academic building during passing periods. By employing the “fun” strategy, the action of ascending and descending the stairs was made more fun and pleasurable through the programming of musical responses on each step. In this context, the data provides evidence that students were more likely to climb the musical stairs during the conditions with sound compared to the condition without sound. This suggests that the “fun” strategy is an effective intervention strategy for persuading students to engage in physical activity in between classes. Although this conclusion can be drawn, the results of this study suggest the “fun” strategy deserves more attention and further research within the field of persuasive technology.

Due to the time limitations of this study, a longitudinal experiment was not conducted. Thus, we cannot conclude that the participants would continue to use the musical stairs day after day, week after week. This study, however, provides an interesting avenue for further research. Since the formation of habits is a long and complex process [18], a long-term study, perhaps over the course of a year, would help to evaluate if new, healthier habits could be formed using this product. A future long-term study should also disable the sounds near the end of the study to evaluate whether the intrinsic motivation upholds even without the musical responses.

Another potential avenue of further research would be to evaluate the social theories at work during this study. As mentioned in the experimental setup and procedure section, a confederate was used in this study, but only for the potential situation in which the control condition might have desensitized participants to the later conditions. A future study might examine the effects of social influence on participants' willingness to climb the musical stairs.

As mentioned in the discussion section, it is possible that fewer participants interacted with the stairs during the guitar condition compared to the piano condition because the novelty of the musical stairs had worn off. Future work on this topic might examine the novelty effect of the musical stairs over the period of a month, by changing the sounds emitted by the stairs each week of the study. Using this strategy, researchers could see if the number of participants who interact with the stairs might be fewer by the end of the week, and then might increase when the sounds are changed the next week. A future study might also incorporate the control condition at a second point in the study to see if disabling the sounds would make the musical stairs seem novel again once the sounds are enabled again after the control condition. This would help researchers understand how long the novelty of the musical stairs stays with them.

As mentioned in the discussion, the confederate may have played a role in a social influence component of this study, although the confederate was not used for that purpose. It would be interesting if a future study were to remove the confederate from the experiment to see how important he or she was in influencing other students to interact with the stairs. If researchers were to discover that the confederate was very important in influencing other participants to interact with the stairs, another study might try putting the stairs in a more social environment, for example the dining hall.

It would also be very useful if future studies on the topic of the "fun" strategy could explore the limits of this persuasive technique. In this musical stairs study, participants were persuaded to climb five stairs, which is not a lot of exercise. Future studies might incorporate more exercise, perhaps by using a musical staircase with ten stairs. The "fun" strategy should also be studied using different types of exercise equipment, for example it may be incorporated into a stationary bike or elliptical machine, to see if students would stop to engage in different types of physical activity on their way to and from classes.

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