CYPRUS UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF COMMUNICATION & INTERNET STUDIES

Bachelor's Thesis

"DO ACTIVITY TRACKERS LEAD TO A DEPENDENCY EFFECT?"

Victor Drenea

Limassol, May 2020

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Acknowledgments

This year was a hard year for me and my family as I have lost one of my greater supporters, my dad. Therefore, I want to dedicate all my effort to finish this paper to him. Furthermore, I want to thank my mother and brother who stood by my side, supported me and made the creation of this paper possible. Moreover, I want to thank my supervisor, mister Evangelos Karapanos, for all his support, all the knowledge he gave me in order to write this paper. Also, I want to thank Loukas Konstantinou for his assistance with the programming, giving me tips and ideas on how I can improve the app. Last but not least, I want to thank Vassiliki Hadjicharalambous, Antreas Michael, Andria Pratsou and the Webarts team for their moral support.

ABSTRACT

According to World Health Organization (2018), there is an 8% increase in the death rate over the past decade, attributed to Non communicable diseases (NCDs), that are defined as long term, not transmissible diseases whose evolution is generally slow (WHO, 2018). One of the leading risk factors from non communicable diseases is physical inactivity. Physical activity trackers have shown been promising to fight physical inactivity (Hoy, 2016). However, recent studies have shown that by using physical activity trackers brings some side effects such as reducing the enjoyment of walking (Etkin, 2016). Furthermore, another side effect that could appear by using a physical activity tracker is a dependence effect (Attig, 2019). Dependence effect according to Attig (2019) refers to the need of users to be awarded by the activity tracker so he will do physical activity (e.g. Go for a walk). Although in Etkin (2016) and Attig (2019) studies, the dependence effect was measured through self-reports. The scope of this thesis is to examine the likelihood of dependency effect when using activity trackers, through a four-week quasi experimental study using objective behavioral metrics. Specifically, the goal of this thesis is to examine whether by giving participants notifications whenever they have to stand up and take a walk, will over time reduce the capacity to regulate their behavior. If this reduction of monitoring themselves will appear that means that a dependency effect on the activity trackers to do physical activity is developed. In order to do this, an app will be developed that will enable the option to make interventions as well as monitor users behavior. In the following chapters we will first motivate the need for this research, then we will introduce the theoretical framework which is self-regulation theory, after we will perform a literature review on the topic. Lastly, we will describe the methodology as well as the process we used to design and develop the app that is required for the interventions

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1 Introduction

1.1 Health and physical inactivity

According to World Health Organization (2011), Noncommunicable diseases (NCDs) are the leading cause of death with approximately 71% of all deaths worldwide in 2018 (WHO 2018). Over the past ten years we have seen an increase of 8% of the death rate by NCDs. NCDs represent a true epidemic that is increasing due to the aging of the population and the current way of life that accentuates a sedentary lifestyle and a poor diet (WHO, 2018). Some of the most common diseases included in the category of NCDs are heart diseases, cancer, chronic respiratory disease and stroke. The risk factors for Noncommunicable diseases are poor diets, excessive use of alcohol, tobacco use and physical inactivity.

Physical inactivity is the primary cause for NCDs and the second highest risk factors for deaths worldwide (WHO 2018). According to World Health Organization (2018) one out of four people doesn't meet physical activity guidelines. Moreover, jobs promote a sedentary lifestyle due to the nature of the workplace with approximately 37.7% of the jobs in 2016 requiring low physical activity expenditure (Bureau of Labor Statistics, 2007).

1.2 Global Recommendations on Physical Activity for Health

The World Health Organization (2010) guideline of physical activity suggest that the minimum recommended physical activity of adults between 18 and 64 years old is at least 150 minutes of moderate intensity aerobic physical activity (e.g. fast walking, cleaning house and dancing) per week or at least 75 minutes of vigorous intensity aerobic physical activity (e.g. moving heavy loads, swimming, cycling and running). Furthermore, the guideline emphasizes that each session of physical activity has to be at least 10 minutes of continuous activity to have a positive effect. For an ideal physical activity, basically, they recommend doubling the amount of the minimal physical activity. So the moderate intensity aerobic activity is increased to 300 minutes per week or 150 minutes of vigorous intensity aerobic physical activity per week (WHO, 2010).

1.3 Sedentary behavior and its impact on health

It’s important to make the distinction between the sedentary lifestyle with someone that is physically inactive, so we can better understand what are the benefits of breaking sedentarism and how we can break it. On one hand, according to Pate (2008), when a person is having a sedentary lifestyle, it means that she or he is spending most of the day sitting, sleeping, watching television or lying down. On the other hand, a person that is categorized as being physically inactive means that the person is not meeting any of the physical activity guidelines, as example the guideline mentioned before. A person might do enough physical activity so she will meet with the minimum required physical activity per week but still considered sedentary, if the rest of the day she spends it sitting or lying down at work, for study, at home or for travel (The department of health, Australian Government. 2017). According to Ku Et Al. (2018), continuous sedentary time and the risk of all-caused mortality in adults are log-linearly associated. That means that as a higher time of continuous sedentary time is, the higher the risk of all-caused mortality in adults will be. Furthermore, in persons with the same amount of time doing physical activities in one day, but having different sedentary times (e.g. one being sedentary for 3 hours in one day and the other being sedentary for 8 hours), differs the risk factors of all-cause mortality based on how often they break sedentarism.

There are a lot of benefits that a person may observe after breaking the sedentary lifestyle such as improving metabolism significantly, without increasing energy expenditure (Jalayondeja et al., 2017), specifically for people that are affected by obesity or overweight (Broadney et al., 2018). According to Keadle Et Al. (2017), interrupting sedentary lifestyle and following physical activity guidelines may lower the mortality rate from NCDs, between 28% and 42%. The percentage is affected by how many times per day someone breaks the sedentarism and by how much time someone does physical activity. Furthermore, breaking sedentarism and meeting the physical activity guidelines may help lose weight or maintain it according to how many times the sedentarism has been interrupted, how much physical activity someone does and the metabolism of the person (Keadle Et Al., 2017). Moreover, Biswas Et Al. (2015) support that independent of physical activity, prolonged sedentary time is positively related with various harmful health outcomes (e.g. Diabetes, Cancer). In addition, the study supports that persons with less than 8 hours of lying down or sitting time per day had approximately 14% lower the risk of developing NCDs.

1.4 Behavior change technologies for physical activity promotion

According to WHO (2002) a behavior change in the environment of physical activity is any attempt to motivate or change someone's personal habit and attitude to prevent diseases such NCDs. One of the most common technologies used for behavior change in context of physical activity are physical activity trackers because of the easiness to collect data. Furthermore, as stated by Hoy (2016) an activity tracker is any computer application or wearable device that collects data of a person's physical activity (e.g. steps walked) through an amount of time, at the same time with other data associated with fitness or health (e.g. heart rate, number of calories burned). This data collection from activity trackers and computer applications started the quantified-self movement, as discussed by Lupton (2016) and Lee (2014), refers to the growing usage of technology such as physical activity trackers for collecting data about oneself. This data not only allows users to track every aspect of their lives (e.g., physical exercise, calorie intake, sleep) but also grants them the ability to learn more about themselves and adjust their actions to improve their lives. Moreover, according to Shih et. Al. (2015) activity trackers give the possibility to use notifications so it may change the behavior of the users and make them. Furthermore, Shih et. Al. (2015) studied the behavior of 26 persons and found that by notifying the participants several times through a day about their progress increases the possibility of re-engaging physical activity in the future between 12% and 29% according to how much time through the day participants received.

There are some benefits of using an activity tracker to monitor the physical activity, one of them is that it seems to increase physical activity in the first four weeks of usage between 15% and 33% (de Vries et al 2016). Moreover, according to Litman (2015), exercise app users are more likely to exercise during their leisure time, compared to those who do not use exercise apps. Sullivan et. Al. (2017) discuss two popular and effective strategies and techniques for promoting behavior changes using technology such as activity trackers and mobile applications regarding physical activity. Those techniques are goal setting and feedback or rewards, and seem to be important and effective because those techniques make someone re-engage and motivate him to be physically active. Furthermore, according to Sullivan those techniques seem to increase overall physical activity when incorporated successfully into a physical activity tracker or mobile applications and develop positive feelings or attitudes regarding physical activity as will be shown below. The importance of the previous strategies and techniques is that in general aims at long term repercussions of doing physical activity and focus on re-engaging physical activity.

Goal setting, according to Pearson (2012) refers to the creation of a plan or objective for someone aiming to attain, for example a specific amount of steps, usually in a specific time limit (e.g. in one day or in one week). According to Locke (2002), there are four mechanisms that affect performance through goals: goals conduct attention and effort to activities that are relevant to complete specific goals and away from others that may be irrelevant, goals works as a supplier with motivation and make the person perform better when goals are set higher than when the goal is set lower because of the difficulty to complete it, goals that are harder with prolonged effort expenditure could affect someone's persistence to complete the specific goal and goals can affect indirectly actions through the application or/and discovery of strategies and knowledge related to the task. Furthermore, persons through these mechanisms obtain diverse skills which empower them to modify their actions and plans to optimize goal attainment.

Mansi et. Al. (2015) used goal setting and self-monitoring to study if over 3 months the participants will have an increase of steps. They divided randomly 58 participants into two groups, the first group was asked to use pedometers for monitoring the amount of steps they have walked and used educational materials such as graphical information about the importance of walking and the benefits in health by preventing diseases, the other group used only the educational materials. Both groups were asked to increase the amount of steps walked with the difference the first groups had 2 clear goals to complete, the first one was to increase the amount of steps by 5% weekly and the second was by the end of the study they had to reach 10.000 step average per day. Comparing the baseline steps recorded (the first week) to the steps recorded after three months (the last week), the first group had an increase from 5993 step count per day to 9792, the second group had an increase from 5788 step count per day to 6551. The researchers assume that giving to someone specific goals as a short term and easy to complete goal and a long term goal, will have a big impact on the general goal (e.g. increase the amount of steps you walk).

Feedback in context of physical activity trackers, according to Ledger (2014) refers to any type of communication from the physical activity trackers to users that are used to give a specific message. Some examples of those types of communications can be when the activity tracker sends notification or when it may vibrate when a goal has been reached. Notthoff (2014) suggests that the most popular type of feedback used by physical activity trackers are notifications but it may differ in effectiveness when the information is positive or negative. An example of a positive message could be: reducing sedentarism time will improve health, and a negative message could be: not reducing sedentarism time will worsen health status. Notthoff (2014) made an experiment where he took 66 old adults over 61 years old to study if there are any difference between positive and negative messages regarding the amount of steps they will walk every week. The experiment lasted five weeks, the first week was used to get the average of steps the participants walked per week (baseline) and the next four weeks the researcher added the positive and negative messages to observe if there will be any changes on the baseline. The study suggests on one hand that positive messages (e.g. Reducing sedentarism time will improve health) increase the average amount walked by approximately 100% and persist over time, on the other hand negative messages (e.g. not reducing sedentarism time will worsen health) won't increase the average amount of steps walked. In addition, Kurti (2013) supports that rewards are also important because they give additional motivation to users of physical activity trackers to reach goals or re-engaging them. Firstly, a reward can be considered as a message (e.g. Well done and keep it up!) or monetary reward (e.g. 3$ if goals have been reached) such as the study made by Kurti in 2013. In the previous mentioned study, Kurti took a group of people and observed if by adding rewards the participants will increase the amount of steps walked and how much it will be increased depending on the amount of money earned. Participants with more than an average of 3.000 steps per day at the final of the week will earn 3 dollars and additional 1 dollar for every extra 1.000 steps. The result was an average increase of 108% in the amount of steps the participants walked compared with the first week where there wasn't any monetary reward and the two weeks where the monetary reward was stopped so they can observe if they will keep walking the same amount of steps. The conclusion of Kurti regarding the study was that on the one hand by adding any reward regardless if it is a monetary one, there will be a significant increase in re-engaging the activity and the amount of steps walked, but on the other hand when stops giving reward, the amount of steps goes back to the baseline, in other words rewards don't have a long term change of behavior.

1.5 Activity trackers can lead to side effects

There is not only a positive side of using physical activity trackers to measure the physical activities, sometimes they can lead to negative effects. According to Etkin (2016), physical activity trackers while they lead to sorten increase in physical activity, they can also lead to a decrease enjoyment of walking and reduce likelihood of re-engagement with walking. He performs two experiments regarding the enjoyment of walking and it concurs with previous studies that physical activity trackers increase the amount of steps walked but he observed that it leads to side effects such reducing the enjoyment and satisfaction of walking at the end of the day and making activities such walking be like work. In more detail, in the first experiment they separated 95 students into 2 groups, the first group was assigned to wear a pedometer and the second group was asked if they wanted to use a pedometer or not to measure how much they're going to walk. The participants at the end of the day had to complete a questionnaire about how much they have enjoyed walking. The results as expected was that participants who wore a pedometer to measure physical activity, increased the amount they have walked but by wearing it to measure steps that have walked, reduced the enjoyment of doing it, even among students who chose to wear the pedometer. Regarding the second experiment, they separated 100 students into three groups, the first group had to look several times how much they have walked through the day, to the second group they covered the screen so they couldn’t know how much they have walked and to the third group they let them free to see if they desire to know how much they have walked. At the end of the day the participants had to complete a questionnaire about how happy they felt, how much they enjoyed walking and if they considered walking to be more as a work or fun. The results of the experiment were that participants that could see how much they have walked, increased the amount they walked but reduced the enjoyment by making an enjoyable physical activity (walking) seem more like work. Furthermore, the students that had covered the screen seemed to have enjoyed the walking more and categorized the walking as a fun activity at the end of the day even if they walked less steps.

Another of the side effects that physical activity trackers may provoke in users is dependency effect. Attig (2019) found that activity trackers can also lead to a dependency effect especially when individuals exercise is motivated by extrinsic motives. At this point, it is important to define two concepts, what is extrinsic motivation and what is dependence effect. Firstly, according to Benabou (2003) motivation is what makes a person to desire achieve a specific goal and is separated into two categories, intrinsic and extrinsic motivation. On one hand intrinsic motivation is when someone wants to do something because he feels an emotional reward from it (e.g. I go every night to run because I enjoy being physically active). On the other hand, extrinsic motivation is when someone wants to do something only because of the reward and not because he likes it. For example, I go every night to run because i want to lose weight. Secondly, dependency effect in context of activity trackers refers to the need of users to be awarded by the activity tracker so he will do physical activity (Attig, 2019). For example, instead of someone thinking by himself that has to take a brief walk after a long period of sitting down, he will wait for the activity tracker to tell him when he has to do it.

2 Theoretical background

2.1 Self-regulation theory

Understanding what self regulation is and how it works will help us to predict if the participants of the study will develop any kind of reliance or dependence on the activity trackers. Firstly self regulation theory according to Baumeister (2007) refers to a system of conscious personal administration in which is involved the process to guide someone's own feelings, behaviors and thoughts to reach goals. In other words, is the process that someone passes through to decide what to do, to think, to feel and to say. In addition, Baumeister (2007) refers to self regulation as “the self altering its own responses or inner states. Typically this takes the form of overriding one response or behavior and replacing it with a less common but more desired response”. For example, when a devoted smoker has a necessity to smoke but then he doesn't light up the cigarette, he self regulates his own desire. Furthermore, according to Baumeister (2007), there are four components involved in self-regulation: The standards of the desirable behavior that someone want to reach, the motivation to meet standards, the monitoring of the situation until the goal has been reach and thoughts that precede breaking standards and the willpower to control desires.

2.2 Behavioral and Emotional Self Regulation

Furthermore, Baumeister (2007) sustains that there are two main categories of self regulation, behavior and emotional self regulation. According to Ponitz Et Al. (2009) behavior as self regulation refers to the ability to act in one way thinking about the long term benefits regardless if you feel that it's not right. For example, if you have ever felt that you don't want to wake up for work in the morning but persuade yourself to wake up anyways after remembering your basic needs (e.g. you need food to survive) or your goals (e.g. you need the money, you want a promotion or a raise) you have manifested behavioural self regulation. Moreover, Ponitz Et Al. (2009) sustain that there are multiple components in behavioral regulation as inhibitory control, working memory and attentional focusing. Inhibitory control refers to modifying or preventing responses that are considered incorrect, for example a student has to raise the hand so he can talk in class. Working memory refers to the ability to manipulate or remember information, for example remember the instructions your boss gives to you and act in consequence. Attentional focusing refers to the ability of choosing relevant or important information, for example focusing on the steps your boss gives to you so you can complete the task. On the other hand emotional self regulation as discussed by Bandura Et Al. (2003) is when someone influences or controls his emotions in a specific circumstance. For example, when someone calms himself after he lost his job. Moreover, Bandura sustains that the emotion generation is important for someone's regulation and it may make them feel in one way or another. This generation is created in four steps, firstly it starts with a situation that may be real or imagined and is emotionally relevant for that person, secondly the person will direct towards all the attention to that specific emotional situation, thirdly the person interpret and evaluate the emotional situation based on his own life experiences and beliefs, fourthly and the last step is where the emotional response is created. Those steps have to be taken into consideration whenever someone wants to reach a specific emotion through experiments or to analyze someone's feelings regarding something in specific (e.g. what makes someone like physical activity).

2.3 A model of self regulation theory

To better understand self regulation theory it is important to understand how the self regulation model works and why feedback is important. According to Klenk (2011) this model is basically a loop of 5 steps that through it someone evaluates and creates thoughts, feelings or actions regarding a specific situation. The first step is where the stimuli is presented, that stimuli could be something that someone else told you, something that you think about or something that has happened. The second step is where emotional self regulation takes place, someone perceives the stimuli and generates a mental representation and feelings about it. The third step is how the person chooses to handle responses about the stimuli, such as what someone will do to affect his mental or emotional representation. The fourth step is where the behaviour self regulation takes place, how the person chooses to behave or respond to the stimuli. The fifth and last step of the loop is the evaluation of the person regarding the results of the behavior or response from the fourth step, this step could affect the previous steps depending on the result. In other words, this evaluation of the result gives to himself a feedback, positive or negative, about the action or thought regarding the stimuli.

2.4 Self-regualtion in practice

Having in mind how the model of self regulation works, we could build an example of the model in action so we can understand how self regulation theory is applied to someone that has health problems because of physical inactivity. Firstly, we're gonna name the imaginary person John so it will be easier to address him. John was diagnosed with obesity and now confronts a new reality: he must change his diet, he has to increase physical activity and break sedentarism. The diagnosis would be John`s stimulus, in other words, the trigger of the model. To better understand the diagnosis, John talks to his doctor, asks friends that have or had obesity about what they did and he tries to remember everything he knows about obesity. All these informations gathered is feeding the mental representation of the diagnosis. He starts to be worried about his health status and also be scared about what will occur if he keeps with his actual lifestyle. These feelings shape his emotional representation about the diagnosis. Once John starts to comprehend his feelings and thoughts about the diagnosis, he must make some decisions about what he should do next. After he talks again with the doctor he decides to: start a diet, break as much as he can sedentarism and increase his physical activity. These decisions are to handle responses about the stimuli, in other words, how he decides to act regarding his diagnosis and feelings. John started a healthy diet and used a physical activity tracker to monitor his physical activity and set weekly goals to accomplish his general goal, that is to lose weight and have a healthier lifestyle. Those are the actions he will use to face the stimuli. After one month John decided to compare his actual physical activity and health status to how he was when he started, John`s average steps per day have increased by 200% and he lost more than 6 kg. This is an example of a positive feedback of doing physical activity and as mentioned before by Notthoff (2014) this will increase John's re-engagement with physical activity. The objective of the research question is if, in this kind of situation by giving feedback to people, that they were gathering by themselves (e.g. thinking about how much times they have to stand up and walk) will reduce their ability to track how much physical activity they did and will make them dependent on the tracker to tell them what to do (e.g. Stand up and take a walk!) and when to do (e.g. Every time someone didn't stand up in the last hour).

3 Literature review

The goal of the literature review is to present two studies that are related to the use of notification prompting systems, to the dependence effect of activity trackers and the motivation to do physical activity by using them. This will help us further on the creation of the watch face, in finding the gaps that it will be filled by the results of the present thesis and it will give the possibility to compare the results of the below studies with the results of the present study.

The first study to be presented is the one made by Luo Et Al. (2018), where they found that participants increased the amount of times they were taking a break through the day because of notifications. In more detail the goal of the study was to investigate different ways to break prolonged sedentary behavior among workers while they maintained a productive work. To gather the data they made a program for desk computers named “Time for Break”, which is a system that gives users notifications when they have more than an hour working continuously to take a break. After receiving the notification, the participants had the option to respond with “Yes, great idea!”, “No, I can't right now” or just ignore the notification. They used “Time for Break” during a three week field study at a state university in the U.S. with 26 participants. The study procedure consisted of five stages: pre-study questionnaire, pre-study tutorial to learn how to use the system, three-week data collection using the system, post-study questionnaire, and optional post-study interview. They found that participants with stronger self regulation responded faster to the notification and more positively in contrast with participants with weaker self regulation. Furthermore, there was a decrease of the self regulation from pre study to post study in participants with stronger pre study self regulation because of daily use of the notification system. Moreover, they found that participants increased the amount of times they were taking a break through the day because of notifications. Summarizing the findings, by using this notification system participants were developing a dependence effect on the system to notify them whenever they have to stand up and take a walk.

This first study is important for the present thesis because it gives a clear image of the dependence effect to a notification system. However, in the present thesis there will be developed a watch face for Smart Watches that will have a similar way to work regarding notifications. The watch face will send a notification to participants whenever they didn't stand up the last hour and tell them to take a two minute walk. The gap that the present study wants to fill is to examine what happens when the notifications are stopped. The question that appears is: They will keep monitoring their physical activity and stand up by themselves when notifications are stopped or will they keep waiting for the notification to show up?

The second study to be presented is the one made by Attig (2019) where they find that participants with high extrinsic motivation to do physical activity are more likely to be more dependent on activity trackers. Furthermore, participants with high intrinsic motivations seem to act like a shield against dependency effects on activity trackers. In more detail, the goal of the research was to advance knowledge on how personal quantification and motivation of participants for physical activity are relationed. Moreover, they wanted to investigate the dependence effect of activity trackers in everyday usage and wanted to observe what the motivations are for tracker usage and physical activity.

To measure the dependence effect on activity trackers, they developed two approaches. In the first approach, they created fictional scenarios. For example: “Imagine you have just arrived at work/university. The first thing you need to do is to go to the fourth floor to take care of something. You notice that you forgot your tracker at home. Thus, no steps or other activities will be counted on this day. You now have the choice to take the staircase or the elevator to get to the fourth floor”. After the presentation of the fictional scenario, two statements were presented to them: “To reach the fourth floor, I will very likely take the staircase instead of the elevator” and “To reach the fourth floor, I will very likely take the elevator instead of the staircase”. After the presentation of the statements, participants had to disagree or agree with the statements on a scale ranging from 1, completely disagree to 6, completely agree. In the second approach they created and added to the previously mentioned questionnaire 13 statements to measure the dependence effect on five dimensions: shift to external attribution (e.g., “Sometimes I have the feeling that I collect steps or carry out activities for the tracker instead of myself”), behavioral outcomes of not wearing the tracker (e.g., “When I do not wear my tracker, I nevertheless collect as many steps as possible, resp. carry out my usual physical activities”), activity evaluation (e.g., “When I do not wear the tracker, I have the feeling that steps or activities are 'less valuable"), affective outcomes of intrinsic motivation loss (e.g., "I am only proud of myself when my tracker makes me sure that I met my activity goals" and cognitive occupancy "When I take some exercise, I virtually automatically think about the collected steps or burned calories that my tracker is going to display". To answer the previously statements, participants had to disagree or agree on a scale ranging from 1, completely disagree to 6, completely agree.

To measure the motivation for tracker usage, they developed six items to add to the questionnaire Three items evaluate intrinsic (e.g. "I use my activity tracker because it is fun to deal with my activity data") and three items evaluate extrinsic motivation (e.g. "I use my activity tracker because it assists me in taking care of my physical fitness"). Answers were provided on 6 point Likert scales ranging from 1, completely disagree to 6, completely agree. Regarding the measurement of the motivation for physical activity, they developed eight items to measure the intrinsic and extrinsic motivations to be physically active. Four items evaluate intrinsic motivation (e.g. "I am physically active or exercise because this activity is fun") and four items evaluate external regulation (e.g. "I am physically active or exercise because I am supposed to do it"). Answers were provided on 6 point Likert scales ranging from 1, completely disagree to 6, completely agree.

Summarizing the results of the experiment, users who use activity trackers to achieve specific goals (e.g. Lose weight) tend to agree with statements where lower physical activity (e.g. To reach the fourth floor, I will very likely take the elevator instead of the staircase) is required. That means that they experience a stronger dependency effect on the activity trackers. In contrast, the participants who were physically active because it was a fun experience, tend to agree with statements where higher physical activity (e.g. To reach the fourth floor, I will very likely take the staircase instead of the elevator) is required. In other words, participants with higher intrinsic motivation for physical activity had weaker dependency effects and vice versa. Furthermore, activity tracker feedback (e.g. notifications) can be perceived as externally rewarding and can create a stronger dependency on them. Moreover, it can impair users' motivation for physical activity when the feedback is not available anymore.

This second study is important for the present thesis because it gives a clear image on how important it is to know what is the motivation of participants for physical activity because it may drastically affect the dependency effect. Furthermore, it gives some results that may be compared with the presented study to see if they match. However, the results of the second study are subjectively because they are based on the perception and thoughts of the participants. This is the gap that the present study is ready to fill by giving results that are objectively because they are not influenced by any personal feelings or opinions. The question that appears is: The results of the second study will match with the results of the present study?

4 Methodology

The main method in this study is the experiment. In the following paragraphs, the three main compartments that comprise the methodology will be mentioned. The research tool that will be used to collect all the required data that is needed to resolve the research question, the sample that this study will address and the research process.

4.1 Research Tools

The present thesis will develop a watch face for smartwatch that will allow us to measure physical activity over the past hour, and release a notification to participants that they have to stand up and take a walk for 2 minutes. The notification will appear if he or she has been inactive over the past hour. The prototype will work similar to the Apple watch activity tracker. The Apple watch displays on the screen three circles that are related to Move, Exercise and Stand. The outside circle is Move and it is about how many calories a person has burned throughout the day and works nonstop. The middle circle is Exercise, which is used to track a specific kind of activity that raises your heart rate consistently. The inside circle is Stand, this is the circle that measures if you have stood up for at least one minute in 12 different hours of the day. In our prototype, the Exercise and Stand circles will be used. After 1 hour without any physical activity, the app will prompt a message to move for 2 minutes. Furthermore, we will use a standardized questionnaire (Richard et Al., 1997) to measure the degree of intrinsic and extrinsic motivation that individuals have for physical activity.

4.2 Sample

Participants will be recruited from Reddit that according to Duggan (2013), reddit is a network of communities based on people's interests. We will use Reddit for the recruitment of participants because we can find big communities of people that are currently using a specific model of Smart watch, so it will be not necessary to debug the App for a large scale of Smart watches.

4.3 Procedure

After it will gather more than 50 participants from the different threads of reddit, the next step would be to give to participants the questionnaire about the motivation to do physical activity. After they complete the questionnaire, they will proceed to download the app and start using it for the next month. It’s remarkable to say that the research design will be within-subject, that means that all the participants will be submitted to both conditions. The first condition(A) is that they will receive a notification message every time an hour passes from the last time they didn't stand up and tell them to take a walk for 2 minutes. The second condition(B) is that the participants won't get any notification prompt message. These two conditions are the independent variables. The dependent variable is if the participants will do physical activity after they get the notification.

The interventions will be the following: In the first week, the participants will be submitted to the A condition, that means that they will get every day of the week a notification to stand up and take a walk if they didn't do it in the past hour. In the second and third week the participants will be submitted to both conditions, Tuesday and Thursday they will be submitted to the B condition, that means that they won't get any notification through the day about when they should stand up and take a walk, and in the rest of the days of the weeks they will normally get the notifications. In the fourth and last week the participants will be submitted only to the A condition.

The goal by doing this is: First, it will be given the opportunity to compare the first week and the fourth week to see if by stopping the notifications in two weeks will affect somehow the participants behavior regarding physical activity. The second opportunity is to compare the days that they didn’t get any notification with the days that they did receive notification and see if there are differences between how many times they stood up. The analysis that will be used to analyze all the data that we will get from the app and the questionnaires will be: Correlation analysis, Pearson r and Linear Regression.

4.4 Hypothesis

Taking into consideration the studies mentioned above, we can end up with four hypotheses about the results of the research. The first one based on the results of Shih et. Al. (2015) is that we expect notifications will lead to an increase in their physical activity, but the removal of notifications will also lead to a decrease in physical activity. The second one is that, according to the results of Kurti (2013) study, by adding reward messages (e.g. Well done for taking a short walk!) will increase the participants motivation to re-engage with physical activity and the amount of steps walked. The third expected result is that by using physical activity trackers will lead to a dependency effect on the notifications according to the results of Ledger (2014) study because they will rely on them to do physical activity. Taking into consideration the four hypotheses and previously mentioned information, we can reach the research question of the thesis: Using activity trackers to measure physical activity can lead to a dependency effect?

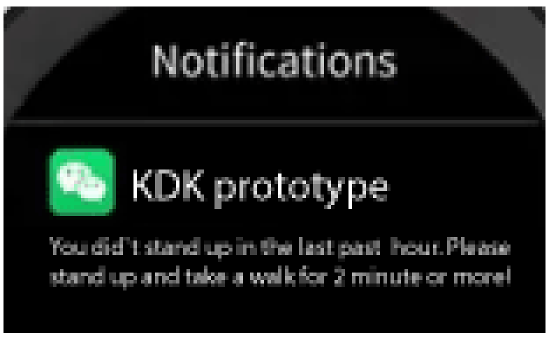
4.5 Contribution of this thesis

Having in mind previous mentioned studies, it can be observed the gap of those studies that researches the dependence effect on activity trackers. Those studies collect data based on participants' beliefs and that can't be considered objectively. The present thesis, by using the above-mentioned watch face for smart watches that we will design and develop, gives us the option to collect objectively data enabling precise interventions and monitoring users' physical activity. In other words it gives the possibility to research objectively the dependence effect on participants in contrast with Attig' (2019) study. We will employ a within-subject experimental study where it will give and remove notifications to participants about when they have to stand up and observe in which degree they sustain their walking behaviors.

5 Design and development of the KDK prototype

The app` watch face gives to users the option to set a daily step goal and count how many times the users have stood up in 12 different hours. Also the watch face will use notifications to get in touch with users, so will tell them whenever a goal has been reached or when they didn't stand up the last hour. Furthermore, users will get a reward message when the users got the notification to stand up and they did it.

Image 1: Notifications



5.1 Description of User interfaces

Main interface

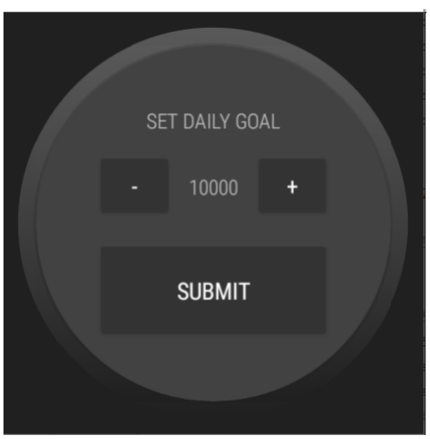
As we can observe, the Main interface displays three items: In the center is displayed the local hour of the smartwatch. Around the screen there will be two circles, the green and bigger one represents the amount of steps that users have walked and the red and smaller one represents how many times users have stood up in 12 different hours in a day. When the circle reaches the top it means that the goal has been completed, in the green circle the top is the default or setted by the user amount of steps and the red one is 12 because that is the amount used by the Apple watch.

Image 2: Main interface

Goal setting interface

As we can observe in the Set daily goal interface below it displays 5 items: At the top is displayed the title of the interface. In the middle row at the left and right are displayed two buttons, in the left the button used to decrease the goal by 1.000 each time is pressed and in the right is the button used to increase the goal by 1.000 each time is pressed. In the middle of the middle row is displayed the amount of the goal that was setted previously or is desired to set. At the bottom is displayed the Submit button and when it is pressed it will save the amount of steps that are shown in the middle of the screen.

Image 3: Set daily goal interface



5.2 Intervention logic

There will be only one intervention in all the process, in the second and third week the notification that prompt to users whenever they didt stood up the last hour will get disabled on Tuesday and Thursday. The goal by doing this intervention is to observe if by giving them notification when they have to stand up they will do it and by taking them the notifications they will monitor and decide by themselves when they have to stand up and take a walk.

5.3 Main classes used

It's important to explain how the most important classes of the watch face work so it will be clear how all the classes are related one to each other. Below the classes are explained in detail.

Stance_Database

One of the most important parts of the developed watch face are the local databases on the watch (which are created as soon as the watch face is installed for the first time on a smartwatch). These databases are for saving and retrieving users' data and use it for various reasons (update the graphs, alert users with notifications, etc.). The class Stance_Database is responsible for storing users' detected activities. This database has seven columns: The TIME column that saves the current hour when an activity is detected. The DATE column that saves the current date when an activity is detected. The CONFIDENCE column which saves the confidence level of the activity when an activity is detected (eg, the user walks with 30% confidence or the user is immobile with 100% confidence). The SENSOR column that saves the detected activity. The STOOD column which saves true statements if users are in motion or false statements if they are stationary. The NOTIFICATION column that saves if the participant will receive notifications or not. Last, the TIME MODIFIED column which saves a number that helps us identify data more easily from the database. One of its most important methods is the insert Data method, which is called whenever new activities are detected and saves all the aforementioned data into the local database of the smartwatch. Moreover, the methods get Activities Stood, get Activities Stood Hour and get Walking 2 are used to see how many times the participant was active during the day and to get the number of steps that the participant made in the given date and hour. The rest of the code is used to connect to the external database and get the data and save it into the external database.

Inserted Data

The class Inserted Data is used to create and update the database where the steps and the goal are saved. This process occurs in the methods on Create and on Upgrade. Such as the class Stance_Database, the Inserted Data will save some variables into the database of the smartwatch. This database has four columns: Like the Stance_Database, Inserted Data saves the TIME column which is the current hour when an activity is detected and the DATE column that saves the current date when an activity is detected. The third saved variable is the VALUE and refers to the goal of the steps or the steps the participant has walked. So we can know when the VALUE variable refers to the goal or to the amount of steps the participant has walked, it has been created the fourth and last variable that is saved into the database and that is the STATE variable. This variable has an option for every saved line, or it will be "goal" or "Start of Walk". Using this variable it's easier to refer to a specific type of VALUE. Lastly, the methods getAllData1 and getAllData2 are used to get the latest goal that was set by default or by the participant and to get the amount of the latest steps recorded into the database respectively. The rest of the code is used to connect to the external database and get the data and save it into the external database.

Set Goal

The next class to be analysed is the Set Goal class. This is the second display of the watch face which enables when the participant will tap the principal screen. Basically, the objective of this class is to give the participant the option to change the default goal of the steps per day, that initially is 5000 steps to the desired amount. The interface created is simple: On the top is the title of the display screen "SET DAILY GOAL". In the middle row are the 2 buttons to add or remove steps from the daily goal in the sides, increase at the left and decrease at the right. In the middle of the middle row is the amount of steps that it's gonna be saved as the daily goal after the SUBMIT button is pressed. Last, in the last row is the SUBMIT button. When the watch face is used for the first time the default goal will be 5000, after that the goal shown in the center will be the goal that has been set by the participant. The increase and decrease buttons were created with the set On Click Listener and the amount of the addition or subtraction is 500 steps on every tap. After the button SUBMIT is tapped, the data will be saved into the database created into the Inserted Data class with its respective hour, date, value and state. The rest of the code from the submission set On Click Listener is used to connect to the external database and get the data and save it into the external database.

Detected Activities Intent Service

The goal of the class Detected Activities Intent Service is to detect based on the sensors of the smartwatch which from the eight possible activities the participant is doing right now. Because some of them are about running or going on a bicycle it was added the variable Boolean Check so you get a True when the activity implicates some physical activity and False when the activity is sitting down or tilting. There are two more things that the class is doing and are important, the first one is to check if the Confidence level mentioned previously is enough to be sure that the activity given by the class is the right one. After some testing of the confidence level, it was selected 70% as confidence level. That's because with a minor level from 70% the class was giving inaccurate the activity, and with a bigger confidence level from 70% sometimes the app wasn't giving at all the activity because wasn't sure if that's the accualy activity. In other words, 70% confidence level was the perfect balance between error and precision. Furthermore, the method call Notification was added so it will give the watch face the possibility to push a notification to the participants with a desired message. This method was used to push notification when the goal of the steps was meet, when the participant did physical activity in 12 separate hours and when the participant didt do any physical activity in the last 55 minutes and when the participant did physical activity and stood again so it will motivate the participant to engage the activity once more in the future.

Constants

The Constants class is in charge of controlling two things. The first one is how often it will gather the data from the Background Detected Activities Service process. The time between the collections is 45 seconds. Is not less than 45 seconds because of the high battery consumption of the process. With less than 45 seconds the battery life of the smartwatch is highly affected and lasts for less. Is not more than 45 seconds because it needs time between collections to be as fast as possible so the gathered data will be processed and shown to the participant as soon as possible. The second one is to control the confidence level that will be used to evaluate the different activities.

My Watch Face

The class My Watch Face is in charge of controlling and combining the already mentioned classes and some other classes that weren't mentioned so everything will work as is desired. Firstly, My Watch Face takes into account how many steps users have walked in a day, the daily steps goal as set by the users and creates a circular bar which is updated as soon as new steps are detected by the sensors. If the steps covered by the users meet the set goal, then the circular bar is fully complete. For detecting the steps covered, the method on Sensor Changed() is implemented. This method is responsible for listening to all the changes registered by the sensor named step counter. Each time a new walk is initiated, this method begins as well and counts the steps covered by the users. These steps are saved in the local database Inserted Data with the parameter "Start of Walk" where they will be retrieved and used as input for the circular progress bar. It is important to point out that when the date changes (i.e. there's a new day), the sensor starts counting from zero steps. The daily set goal is also retrieved from the Inserted Data database by using the parameter "Goal".

Secondly, the My Watch Face class is also responsible for drawing a second circular bar (of a smaller size) on the screen which displays the number of times users broke sedentary behaviour throughout the day. However, it is important to highlight that this number doesn't depict how many times users were active in a day but how many hours users were active throughout the day. As an illustration, if a user broke a sedentary behaviour (e.g. took a mini-walk) five times between 2pm and 3pm, this is displayed as one on the second circular bar and not five. This is because we want to check if the user was active for the time 14:00 and not how many times the user broke sedentary behaviour for the time 14:00. Likewise, if the user didn't do anything and was inactive between 2pm and 3pm, the system counts it as inactivity. The maximum number of breaking sedentary behaviour throughout the day is 12 times, meaning that users need to break sedentary behaviour at least one time every hour. If they successfully do that, then the second circular bar will also be complete. The method get Activities Stood (String date Input) from the local database Stance_Database, is used in this case to measure if users broke sedentarism. Specifically, this method gets all the instances/rows of the distinct hours, for the current date, that users were active (e.g. on foot, walking, running). Moreover, when the class My Watch Face detects 12 times of breaking sedentary behaviour, it fires a notification congratulating the users for doing so and being more active.

6 Conclusion

The main contribution of this thesis is the design and development of the KDK smartwatch watch face that enables a precise intervention and monitoring of its effects on people's physical activity. Having in mind previous chapters, we can observe the importance of using technologies such as the KDK prototype to study dependency effects on activity trackers because of the easiness and precision of collecting data. Moreover, it collects data based on what happens and not what the participants believe is happening. In other words it gives the possibility to research objectively the dependence effect on the participants. Furthermore, it gives the possibility to research in more depth the action of participants whenever a condition is met. For instance, it seeks to study what happens when they get notification to stand up. Will they stand up or will they keep sitting down ignoring the notification? However, at the current stage of the thesis we can't make a general conclusion because of the lack of collected data and the analysis of it. So, the results of the analysis cannot be matched with the hypothesis made based on previous studies and theories.

The idea to create the KDK prototype, that is similar to the Apple watch, started because there was observed a lack of tools to help gather data in context of physical activity and help to know how much they will develop a dependency effect based on the participants' reactions when they get or not, a notification. The expected time to create the prototype was about one month but at the end it took about four month because of different complications such don’t having advanced knowledge in programming or debugging. When someone is debugging in terms of programming refers to the process of identifying and removing errors from computer software. In terms of the final prototype it was better than expected because it could be added to, options that we were not expecting that we could add in the start. For example modifying the days that we wanted participants to get notification from the external database so it gives more flexibility.

At this point we can concur that the KDK prototype has a big potential to help researchers study dependency effects of activity trackers objectively. However, the prototype has to be tested in a real environment where some other problems that weren't taken into consideration may appear. Moreover, one of the objectives of the thesis was to test it in a real environment and gather the data needed for the analysis, but because of the lack of time it couldn't be possible to do. Although, the prototype is able to fill the gap of the tools that can be used for such research and gives the possibility to study in depth how the dependence effect is related to notifications.

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APPENDIXI

Questionnaire

Subject: Motives for Physical Activities Measure – Revised (MPAM-R)

The following is a list of reasons why people engage in physical activities, sports and exercise. Keeping in mind your primary physical activity/sport, respond to each question (using the scale given), on the basis of how true that response is for you.

Scale goes from 1 to 7 with 1: not at all true for me and 7: very true for me

1. Because I want to be physically fit.
2. Because it's fun.
3. Because I like engaging in activities which physically challenge me.
4. Because I want to obtain new skills.
5. Because I want to look or maintain weight so I look better.
6. Because I want to be with my friends.
7. Because I like to do this activity.
8. Because I want to improve existing skills.
9. Because I like the challenge.
10. Because I want to define my muscles so I look better.
11. Because it makes me happy.
12. Because I want to keep up my current skill level.
13. Because I want to have more energy
14. Because I like activities which are physically challenging.
15. Because I like to be with others who are interested in this activity.
16. Because I want to improve my cardiovascular fitness.
17. Because I want to improve my appearance.
18. Because I think it's interesting.
19. Because I want to maintain my physical strength to live a healthy life.
20. Because I want to be attractive to others.

21. Because I want to meet new people.
22. Because I enjoy this activity.
23. Because I want to maintain my physical health and well-being.
24. Because I want to improve my body shape.
25. Because I want to get better at my activity.
26. Because I find this activity stimulating.
27. Because I will feel physically unattractive if I don't.
28. Because my friends want me to.
29. Because I like the excitement of participation.
30. Because I enjoy spending time with others doing this activity

Scoring Information:

Interest/Enjoyment: 2, 7, 11, 18, 22, 26, 29

Competence: 3, 4, 8, 9, 12, 14, 25

Appearance: 5, 10, 17, 20, 24, 27

Fitness: 1, 13, 16, 19, 23

Social: 6, 15, 21, 28, 30

Code:

You can find the code written for the Wear watch face at this link:
https://github.com/Victor-Drenea/Watch_Face

Images:

Image 1: Notifications

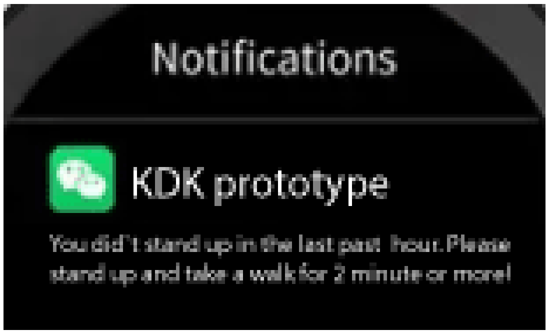

Image 2: Main interface

Image 3: Set daily goal interface