Technostressed Out By Your Tracker?

The effects of wearing an activity tracker and use of the app on performance, enjoyment and technostress.

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Abstract

Activity trackers – wearable devices that track daily physical activity – have been growing in popularity over the last years. Prior research investigated the quality and reliability of activity trackers, but not much is known about possible detrimental effects on subjective well-being. While self-quantification has been found to increase performance on an activity, it decreased enjoyment of the activity. This study tried to replicate these effects with an activity tracker and the corresponding app and investigated the mediating role of technostress for both effects. The study consisted of a 7-day field experiment with three conditions (i.e. control, tracker only and tracker and app). None of the hypotheses were supported by the data, but significant negative effects of condition on technostress were found. Use of the app in addition to wearing the activity tracker yielded mixed results. The study yielded surprising but interesting findings that gave insight in the effects of activity trackers and the apps on performance, enjoyment and technostress, which led to several suggestions for future research.

Introduction

Healthy lifestyle software applications ("health apps") have been growing in popularity and number over the last few years (Carroll et al., 2017). These apps intend to improve health outcomes, deliver health services and in some cases to enable health research (Powell, Landman & Bates, 2014; Mollee, Middelweerd, Kurvers, & Klein, 2017). Their great advantage over regular health programs is that smartphone applications are easily accessible and facilitate more available, shared and tailored information (Moorhead et al., 2013). One branch of these apps focuses on stimulating physical activity. There are currently 98.424 apps whose primary focus is to stimulate health and fitness and more are being developed every day (Steel Media Ltd, 2018). Whether one goes jogging, cycling, skiing, rowing or prefers to exercise at the gym, there is always a health app enabling the user to closely monitor their physical behaviour. Many apps draw their information from the smartphones themselves, but another popular instrument to track physical activity is the activity tracker.

An activity tracker is a wearable device which tracks its user's behaviour by counting steps, calculating distance and/or estimating the number of burned calories per day. More advanced trackers are able to recognise different sports (e.g. running, various ball sports, elliptical, rowing, cycling). Through behavioural change techniques activity trackers stimulate users to increase their physical activity (Lyons, Lewis, Mayrsohn, & Rowland, 2014). The devices are combined with corresponding apps for smartphones through which they give insight into behavioural patterns, sleep quality and goal achievement. They also provide tailored health advice based on the user's behaviour. Activity trackers have been growing in popularity over the last years (Wang, 2014) and are deemed "more than tools" to change behaviour as they evoke self-esteem boosts and help people to come closer to their ideal selves (Karapanos, Goueiva, Hassenzahl, & Forlizzi, 2016). In 2014 3.3 million trackers were sold in the US (Danova, 2015), this number has grown to 40 million in 2017 (Lamkin, 2018).

Prior research has investigated the quality of activity trackers and found that trackers are fairly accurate and reliable devices (for a review see Evenson, Goto & Furberg, 2015). Especially step-count is found to be quite reliable, whereas moderate-to-vigorous physical activity is often overestimated. Even though the validity and reliability of activity trackers could be better still, these devices seem to be successful in facilitating more physical activity (e.g. Karapanos et al., 2016; Brakenridge et al., 2016; Glance, Ooi, Berman, Glance, & Barrett, 2016). This is good news, but self-quantification (i.e. quantifying one's own behaviour into data) can have negative effects as well.

Etkin (2016) found that while self-quantification increases performance on an activity, it decreases enjoyment during the activity. This study used pedometers measurement instruments, which are similar to activity trackers, but activity trackers have additional characteristics that will be explained later in this paper. As activity trackers are currently so popular, there is a growing necessity to investigate whether the effects of self-quantification hold for these devices as well, because they can affect subjective well-being. Enjoyable activities performed in leisure time help to recover from stress and strain from work and other obligatory tasks (e.g. Cherniss, 2016). Therefore, a decrease in enjoyment of enjoyable activities leads to a decrease in subjective wellbeing (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004; Mogilner, 2010; Etkin, 2016), making investigation of the effects of self-quantification incredibly relevant. In addition, the experiments conducted by Etkin (2016) lasted only one day. An activity tracker is a gadget which might be subject to novelty effects (e.g. Chen, 2016; Stubbe, 2017). This means that initial effects wear off quickly and be replaced by new, more long-term effects. Therefore, it is interesting to examine the effect of self-quantification with an activity tracker over a longer period of time than one day.

In her paper, Etkin (2016) provides several possible explanations for the self-quantification effects that were found. One of these explanations is that that drawing attention to output makes enjoyable activities feel more like work and that spending time on work activities reduces subjective well-being and overall satisfaction (Kahneman et al., 2004; Mogilner, 2010). Another explanation is the “crowding out” effect (Deci, 1971; Kruglanski, Alon & Lewis, 1972; Higgins, Lee, Kwon, & Trope, 1995; Ryan & Deci, 2000), which occurs when people start to pursue an activity because of the rewards rather than because it is fun to do. Another possible explanation, which has not been tested before, is that activity trackers might lead to technostress and that stress in general makes an activity less enjoyable (e.g. Scanlan & Lewthwaite, 1986). This explanation will be tested in the current study.

Technostress was initially defined by Brod (1984) as “a modern disease of adaptation caused by an inability to cope with new computer technologies in a healthy manner”. Most research that has been conducted involving technostress has focused on work (e.g. Arnetz & Wilholm, 1997; Tarafdar, Ragu-Nathan & Ragu-Nathan, 2007; Ragu-Nathan, Tarafdar, Ragu-Nathan, & Tu, 2008; Wang, Shu & Tu, 2008; Gaudioso, Turel & Galimbert, 2017). However, since the first line of research on this topic technologies have changed and technostress became a relevant topic outside of work as well. Maier, Laumer, Weinert and Weitzel (2015) recently defined technostress more generally as “a psychological state of stress caused by information and communication technologies and their demands”. This is the definition that will be used in the current paper.

The most commonly used information and communication technology is the mobile phone (Lee, Chang, Lin, & Cheng, 2014). Users on average pick up their phones 34 times a day, not because they really have to, but because it has become habit (Oulasvirta, Rattenbury & Raita, 2012). Such compulsive usage leads to mental health problems (Thomée et al., 2007; Thomée, Härenstam & Hagberg, 2011; Chesley, 2005), such as technostress (Lee et al., 2014; Boonjing & Chanvarasuth, 2017; Hsiao, Shu & Huang, 2017). Quite some studies have been conducted to investigate the causes and effects of technostress, but not much attention has been given to technological devices other than mobile phones, including activity trackers. Therefore, this will be investigated in the current study.

Prior research did show that activity trackers increase work-related stress (Hunt, 2016), but the connection with technostress specifically has not yet been made. If frequent checking is the key to technostress (Lee et al., 2014; Boonjing & Chanvarasuth, 2017; Hsiao et al., 2017) then activity trackers could also be risk devices for evoking technostress. It is not only tempting to regularly check your progress when you are working towards a goal, it is also a crucial process in setting and attaining a goal (Harkin et al., 2016). This means that users will regularly check their activity trackers and could be at risk of experiencing technostress. In addition, an activity tracker is often combined with a corresponding app for smartphones and thus increases mobile phone usage, which is found to increase the risk of experiencing technostress (e.g. Thomée et al., 2011; Lee et al., 2014).

The current study will focus on the effects of wearing an activity tracker on performance, enjoyment and technostress. It will be examined whether the findings of Etkin (2016) can be replicated with activity trackers when tested over a longer period of time than one day. It will also be investigated whether the effects on performance and enjoyment are mediated by experiencing technostress. This leads to the first research question of this study.

RQ1: What are the effects of using an activity tracker on performance and enjoyment of walking and can these effects be explained by technostress?

Use of an activity tracker includes two aspects of behaviour: wearing the activity tracker and use of the corresponding app on smartphone. In practice these devices will be used interchangeably, but when examining them together as one there will be no certainty that the activity tracker causes the expected effects, independent from the smartphone. It is for example possible that the activity tracker increases performance through behavioural change techniques (Lyons et al., 2014), but that the increased mobile phone usage evokes technostress (e.g.

Thomée et al., 2011; Lee et al., 2014). Therefore the distinction between the activity tracker and use of the app in addition to the activity tracker will be made in the current study. This part of the study is mainly exploring, but might yield important nuances in conclusions about the influence of activity trackers on users' performance, enjoyment and technostress. This leads to the second research question.

RQ2: Does usage of the corresponding app for smartphone in addition to wearing an activity tracker make a difference in the effects on performance, enjoyment and technostress?

Theoretical framework

Activity Trackers and Performance

Activity trackers are becoming more and more popular (Wang, 2014; Danova, 2015), which raises the question whether they have the desired positive effect on physical activity or not. Tracking steps with pedometers has been found to increase performance (Bratava et al., 2007; Spence, Burgess, Rodgers, & Murray, 2009). Etkin (2016) also found that self-quantification with pedometers increases performance. This suggests that people do more of an activity when they are quantifying their behaviour than when they are not quantifying their behaviour. Other studies specifically examined the effects of activity trackers and reported positive results on performance as well (e.g. Poirier et al., 2016; Glance et al., 2016; Brakenridge et al., 2016). One of these studies found that an activity tracker based workplace activity program helped employees to walk 10.000 steps a day for a period of sixteen weeks (Glance et al., 2016). Another study showed that adding a tracker to a health intervention increased the overall effect of the intervention (Brakenridge et al., 2016). The intervention alone decreased sitting time at work, but with a tracker this effect was enhanced with an increase in steps.

This positive effect of wearing an activity tracker on performance is driven by behavioural change techniques (BCTs) implemented in activity trackers (Lyons et al., 2014). BCTs that are used in almost all activity trackers are goal-setting, review of behavioural goals (i.e. encouragement to update the goal over time), feedback of behaviour, self-monitoring of behaviour and rewards. These BCTs have proven effectiveness in interventions, where they help to increase physical activity (for reviews see Hartmann-Boyce, Johns, Jebb, & Aveyard, 2015; Bird et al., 2013) and are therefore used by developers of activity trackers to increase performance (Lyons et al., 2014). Based on this, a positive effect of wearing an activity tracker on walking performance is expected.

H1a: People who wear an activity tracker have a higher walking performance (minutes) than people who do not wear an activity tracker.

As mentioned in the introduction, not much is known about the distinction between the activity tracker and the app for smartphone. This makes the following part of the study mainly explorative. Health apps for smartphones have positive effects on physical activity (e.g. Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014; Case, Burwick, Volpp, & Patel, 2015), however these effects are small. Nevertheless, this gives some reason to expect a positive effect of use of the app in addition to the activity tracker on performance.

In addition, the BCTs weaved into activity trackers (Lyons et al., 2014), are mainly present in the app. The activity tracker enables users to self-monitor their behaviour through the step-count and notifies the user when goals are met, but the app provides feedback of behaviour and asks the user to set and frequently review goals in addition to counts and rewards. Research has shown that interventions with more BCTs tend to have larger effects than interventions with fewer BCTs (Webb, Joseph, Yardley, & Michie, 2012), which gives more reason to expect a positive effect of use of the app in addition to wearing an activity tracker on performance, leading to the following hypothesis.

H1b: People who wear an activity tracker and use the app have a higher performance (minutes and steps) than people who wear an activity tracker but do not use the app.

Activity Trackers and Enjoyment

Enjoyable activities are usually pursued simply because they are enjoyable (Kruglanski et al., 1972; Ryan & Deci, 2000). In this case people do not think too much about how much of an activity they do (Kruglanski, Friedman & Zeevi, 1971). When quantifying behaviour – like when using an activity tracker – attention shifts from the enjoyment of an activity to quantitative output, which makes the activity feel more like work and undermines enjoyment (Etkin, 2016). Another reason why wearing an activity tracker might have an effect on enjoyment is because adding external rewards to an activity can "crowd out" enjoyment (Deci, 1971; Kruglanski et al., 1972; Higgins et al., 1995; Ryan & Deci, 2000). Instead of pursuing the activity because it is fun, people start to pursue the activity for the rewards. This shift in attribution subsequently reduces enjoyment of the activity (Deci, Koestner & Ryan, 1999; Etkin, 2016). Activity trackers use the BCT of rewards and show reward notifications whenever a goal is met (Mercer, Giangregorio, Burns, & Grindrod, 2016; Lyons et al., 2014). The corresponding app supplements the information of the activity tracker. When a step goal is met, the activity tracker gives a notification. Other goals (e.g. distance, burned calories, challenges) are often only visible in the app. Therefore, use of the app increases the number of rewards. Moreover, walking in itself offers external benefits as well, like being fit and healthy (Choi & Fishbach, 2011; Fishbach & Choi, 2012). These external benefits can also be seen as rewards, which can undermine enjoyment of an activity (Kruglanski et al., 1975; Werle, Wansink & Payne, 2015). Based on this, walking with an activity tracker and use of the app are expected to decrease enjoyment of walking.

H2a: People who wear an activity tracker have a lower enjoyment than people who do not wear an activity tracker.

H2b: People who wear an activity tracker and use the app have a lower enjoyment than people who wear an activity tracker but do not use the app.

Activity Trackers and Technostress

Prior research defined five dimensions of technostress (Tarafdar, Ragu-Nathan & Ragu-Nathan, 2007; 2011; Ragu-Nathan, Tarafdar, Ragu-Nathan, & Tu, 2008): techno-overload (i.e. having too much technology), techno-invasion (i.e. personal life is being invaded by technology), techno-complexity (i.e. difficulty performing one's tasks because of complex technology), techno-insecurity (i.e. insecurity about holding a job with co-workers who know more about technology) and techno-uncertainty (i.e. feeling unsettled by continuous upgrades from technology). Two dimensions – techno-overload and techno-invasion – are considered most relevant for this study on the effects of activity trackers. This relevance will be explained in the following paragraphs. The other dimensions are considerably less relevant for this study as activity trackers are simple devices which are not subjected to frequent updates and because this study does not investigate technostress at work.

Techno-overload is a feeling of being pressured to change one's ways to deal with the great amount of information available through technologies (Wang, Shu & Tu, 2008; Tarafdar et al., 2007; Gaudioso, Turel & Galimbert, 2017). An activity tracker adds to the constant stream of information that tries to reach people every day (e.g. Potter, 2012). Not only does the device itself display quite some information, but the app supplements this information. Therefore an activity tracker and use of the app are expected to increase the feeling of having too much information coming from technologies and thus to have a positive effect on techno-overload.

Techno-invasion is a feeling of never being "free" from technology (Wang et al., 2008; Tarafdar et al., 2007; Gaudioso et al., 2017). An activity tracker is worn at one's wrist, 24 hours a day. This means that users are able to connect with the technology 24 hours a day as well. This constant connection and the feeling one has to be connected at all times are two stressors which cause techno-invasion (Tarafdar et al., 2011). In addition, activity trackers send notifications whenever the user has been sitting still for longer than one hour. It has been proven that disruption of other activities causes technostress (Tacy, 2016). These notifications are a typical example of such a disruption. This makes it plausible that users of activity trackers might feel like their life is being invaded by the tracker and the app and therefore positive effects are expected of wearing an activity tracker and use of the app on techno-invasion.

Recent research explored another facet of demands of technology, namely vigilance (Johannes, Veling, Verwijmeren, & Buijzen, 2018). This concept does not appear in the classification of Tarafdar and colleagues (2007; 2011), but holds relevance in the context of activity trackers as well. Until now, vigilance has only been examined in the context of smartphones. Smartphone vigilance has been defined as "a state of being aware that one can always get connected with others or access information, accompanied by a permanent readiness to respond to incoming smartphone stimuli" (Bayer, Campbell & Ling, 2015). Johannes and colleagues (2018) found that the mere presence of a smartphone increased self-reported vigilance. Participants in the study who had their phone on their table felt the urge to pick up the phone and were preoccupied with their phone, even more so when they received notifications that they were not allowed to check. From smartphone vigilance a bridge can be built to a concept called techno-vigilance. The definition would be a paraphrase of the definition of Bayer and colleagues (2015) where "incoming smartphone stimuli" is replaced by "incoming stimuli from technological devices".

Techno-vigilance is a permanent state of alertness to respond to technological devices, which is more and more reported by users (Pew Research Center, 2015). Even though most activity trackers do not enable users to connect with others, they do grant access to information and urge people to respond to this information by adjusting their current pursuits and start walking. This access to information and suitable response correspond to the definition of vigilance (Bayer et al., 2015) and are therefore expected to facilitate techno-vigilance. Use of the app increases the chance of notifications from technological devices and is thus expected to further increase the alertness. This means that positive effects are expected of wearing an activity tracker and use of the app on techno-vigilance.

H3a: *People who wear an activity tracker experience higher levels of technostress (techno-overload, techno-invasion and techno-vigilance) than people who do not wear an activity tracker.*

H3b: *People who wear an activity tracker and use the app experience higher levels of technostress (techno-overload, techno-invasion and techno-vigilance) than people who wear an activity tracker but do not use the app.*

The Mediating Role of Technostress For Performance

The main interest of this study is technostress as a mediator of the presumed effects of wearing an activity tracker and use of the app on performance and enjoyment. This part of the study is mainly exploratory because the connection between activity trackers and technostress has not yet been made and because there are mixed results reported in the literature regarding stress an performance.

As set out earlier in this chapter there is reason to believe that wearing an activity tracker and use of the app have a positive influence on techno-overload, techno-invasion and techno-vigilance, which are all forms of psychological stress (Maier et al., 2015). In the literature there are mixed results considering the influence of stress on performance. It has been found that stress in general can have a negative influence on performance in sports (Otter, Brink, van der Does, & Lemmink, 2016; Szalma & Hancock, 2017; Jones & Hardy, 1990). However, it is also said that stress can build resilience and enhance performance (Fluckey, 2017). It seems to depend on the form and amount of stress that is experienced whether stress is detrimental to performance or not (Jones & Hardy, 1990). For example, Freedman and Edwards (1988) found that stress created by time pressure increased performance on a simple task, while other studies showed that emotional stress decreased performance on simple tasks (e.g. Slaski & Cartwright, 2003). It is also found that people expect stress to decrease when their goal is met and that people who are confident they will achieve their goal, because they are close to reaching their goal, experience less stress than people who are less confident they will achieve their goal (Lazarus, 1990). This means that stress enhances performance as long as the performance is congruent with reaching the goal. When wearing an activity tracker and using the app the goal is to walk a certain amount of steps. Even though the literature reports mixed results, based on the findings of Lazarus (1990) it is plausible that people who experience technostress because of an activity tracker might be inclined to increase their walking as they expect the stress to wear off when their goal is met. This gives reason to expect mediation effects of wearing an activity tracker and use of the app on performance through technostress.

H4a: The positive effect of wearing an activity tracker on performance (minutes) is mediated by technostress (techno-overload, techno-invasion and techno-vigilance).

H4b: The positive effect of using the app on performance (minutes and steps) is mediated by technostress (techno-overload, techno-invasion and techno-vigilance).

The Mediating Role of Technostress For Enjoyment

Mediation effects of wearing an activity tracker and use of the app on enjoyment through technostress are expected as well. As outlined before there is reason to expect that wearing an activity tracker and use of the app increase techno-overload, techno-invasion and techno-vigilance. Technostress in general is one of many forms of stress (Maier et al., 2015) and stress in general decreases enjoyment of physical activity (Scanlan & Lewthwaite, 1986). Therefore it is expected that the increase in techno-overload, techno-invasion and techno-vigilance caused by wearing an activity tracker and use of the app has a negative effect on enjoyment and thus that there are mediation effects of wearing an activity tracker and use of the app on enjoyment through technostress. This leads to the last hypotheses of the current study.

H5a: The negative effect of wearing an activity tracker on enjoyment is mediated by technostress (techno-overload, techno-invasion and techno-vigilance).

H5b: The negative effect of using the app on enjoyment is mediated by technostress (techno-overload, techno-invasion and techno-vigilance).

Method

Design

A between subjects field experiment with three conditions was conducted. The first experimental condition was the tracker only condition (n = 37). Participants in this condition wore an activity tracker for seven days. They were not allowed to download the corresponding application for smartphone. The second experimental condition was the tracker and app condition (n = 43). Participants in this condition wore an activity tracker for seven days and used the corresponding application on their smartphones. The third and last condition was the control condition (n = 42). Participants in the control condition neither wore an activity tracker, nor were they asked to download the app. Participants were assigned to conditions at random.

The other variables included in the study were mediator variable technostress, outcome variables performance in minutes, performance in steps and enjoyment and several control variables (see Materials and Measures). Mediator variable technostress and outcome variables performance in minutes and enjoyment were measured with questionnaires. Performance in steps was measured with the activity trackers. Both measures of performance were taken into the analyses separately. The control variables were measured with questionnaires as well. The model of this study is visualized in Figure 1. Note that there were separate analyses for each outcome variable.

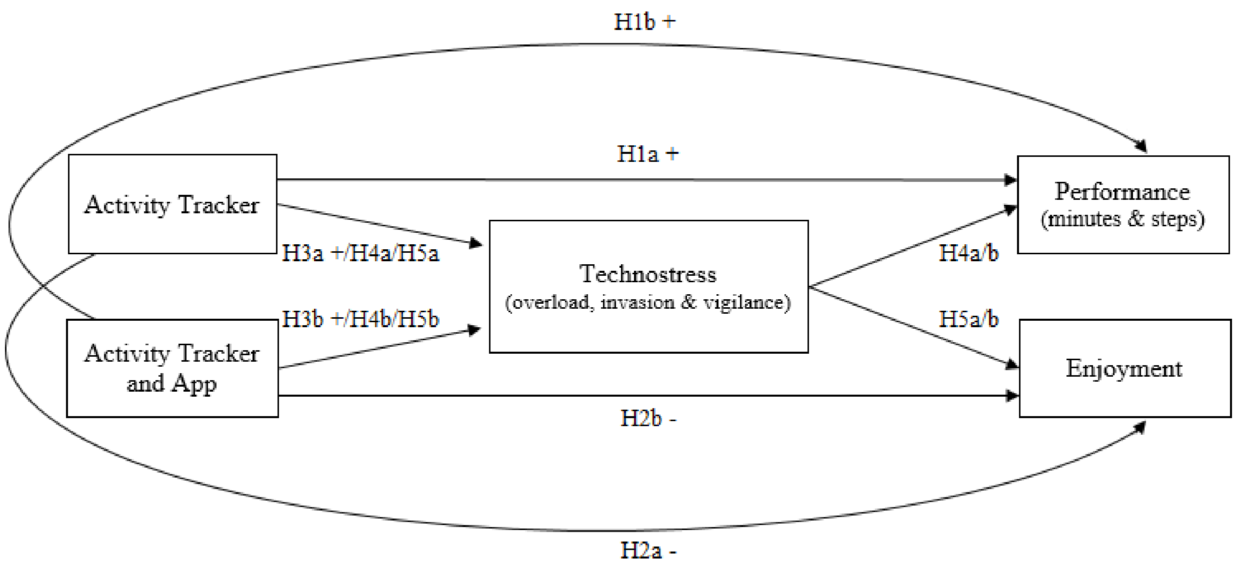

Figure 1. Model of the study.

Participants

In total 128 people participated in the study. Severe outliers on the outcome variables (n = 6) were excluded from the analyses. Therefore the final sample existed of 122 participants (66.4% female). Participants were Dutch-speaking adults (M_{age}= 36.21, SD_{age}= 14.20) who were not using an activity tracker prior to the experiment and who were, by own saying, interested in adopting a healthy and active lifestyle. The educational level of the participants was normally distributed over lower (34%), middle (38%) and high education (28%). On average participants had a healthy BMI (M = 24.67, SD = 3.81). A healthy BMI ranges between 18.5 and 24.9 (Voedingscentrum, 2018), this means that quite a few of participants in the final sample were moderately (25%) to severely (11%) overweight.

Procedure

Participants were recruited via social media and sports facilities to participate in a study about exercise and health. Prior to the study it was explained that participants were going to set a personal daily step-goal and that they were going to try to achieve that goal for seven days. Participants were free to choose their own goal, however the goal had to be challenging. The standard goal (i.e. ten thousand steps per day) and an estimation of how long it takes to achieve that goal (i.e. approximately an hour and a half non-stop walking) were given as guidance. For the two experimental groups information followed about the activity tracker. Participants in these groups were asked to wear the activity tracker constantly during the next seven days and nights and to check it regularly during the day. Exceptions were made for charging and showering or other activities in water, as the trackers were not waterproof. Participants in the tracker and app group were asked to download the HPlus Watch application on their smartphones and were instructed to check the information in this app regularly during the day as well. Lastly, participants were told that they could terminate their participation at any moment without specification of reason, that their data would be stored anonymously and that the coded data could be shared with other researchers for scientific or publication purposes. After reading this information participants gave their consent and filled in the first questionnaire, which contained demographic questions (i.e. age, gender, educational level), some control questions (i.e. height, weight, motivation to be active, sports per week, activity in general and at work) and setting the daily goal.

The next day the experiment began and participants started monitoring their walking behaviour. Every night around eight o'clock the participants received an e-mail with the link to the daily questionnaire, which they had to fill in before they went to bed. Here participants filled in the date, what day of the experiment it was, when applicable how many steps they had taken that day, how many minutes they had walked that day and whether they had reached their goal. This went on for seven consecutive days. On the eighth day of the experiment participants received the last e-mail with the link to the final questionnaire and when applicable an invitation to hand in the activity tracker. The final questionnaire contained the measures of outcome variable enjoyment, mediation variable technostress, the last control variables (i.e. openness to technology, mental occupation with the experiment and when applicable wearing and checking of the tracker and app) and the manipulation check variables. At the end of the questionnaire participants were thanked for their time and effort, debriefed about the true purpose of the study and given the opportunity to sign up for the e-mail containing the final results and conclusions of the study. At the end of the experiment four tourist vouchers of €25,- were rallied among the participants as reimbursement.

Materials and Measures

Activity Tracker and HPlus Watch App

The DFit Smart Health Rate Bracelet was used for the study. This activity tracker displayed the date and time, heartrate, number of steps, walked distance and burned calories. The corresponding application for smartphone (i.e. the HPlus Watch app) displayed the same measures and graphs of activity during the day, heartrate during the day, sleep reports and sports reports. Additionally, the app made several comparison graphs which showed patterns in the user’s activity over several days.

Dependent Variables

Performance was measured with self-report (*Minutes*) and a behavioural measurement (*Steps*). All participants estimated how many minutes they had walked each day for seven consecutive days. The two experimental groups also filled in how many steps their activity tracker showed they had walked each day for the same seven days. Mean scores were computed for performance in minutes and steps. Both measures were used in the analyses, however the steps measurement only corresponded to a subsample (n = 80), namely the experimental groups. Pearson’s correlations showed a moderate to high correlation between the two measures ($r(78) = .51$, $p < .001$), which indicated a strong overlap between the measures even though they did not measure the exact same concept.

Enjoyment was measured with the Physical Activity Enjoyment Scale (Motl et al., 2001). This scale existed of sixteen items, which reflected one's enjoyment during walking (e.g. "When I walk I enjoy it"; "When I walk my body feels good"). Participants responded to these items using a 5-point Likert scale (from 1 = "Strongly disagree" to 5 = "Strongly agree"). Eight items (e.g. "When I walk I am bored") were recoded to match all answer categories.

Several criteria were used to examine the factorability of the sixteen items. Fifteen of the sixteen items correlated at least .3 with at least one other item. All diagonals of the anti-image correlation matrix were over .5 and the communalities were all above .3. The Kaiser-Meyer-Olkin measure of sampling adequacy was .87, well above the commonly recommended value of .6, and Bartlett's test of sphericity was significant (χ^2 (120) = 878.53, $p < .001$). Given these indicators, factor analysis was regarded suitable for all sixteen items.

Principal component analysis using oblimin rotation revealed that the sixteen items contained three factors with eigenvalues greater than 1. Two items had cross-loadings above .3. The scree-plot on the other hand, indicated only one factor and because this was an existing, validated scale it was decided not to make any moderations and thus extract only one component. This single component had an eigenvalue of 6.01 and explained 37.5% of the variance (see Appendix A for the factor loadings). The sixteen items had a high reliability (α = .78) and were all used to compute composite scores.

Mediator

Technostress was measured with eighteen items using a 5-point Likert scale (from 1 = "Strongly disagree" to 5 = "Strongly agree"). Twelve items were derived from the technostress questionnaire from Tarafdar and colleagues (Ragu-Nathan et al., 2008; Tarafdar et al., 2007; 2011). The original questionnaire contained five dimensions of technostress. However, the questionnaire focused specifically on technostress at work, while the current study focused on technostress in a broader context. Two of the five dimensions – techno-overload and techno-invasion – were adaptable for general technostress[1]. Therefore, six items corresponding to techno-overload, reflecting whether one feels like they have too much technology and information from technology in their life (e.g. “I feel forced to change my work habits to adapt to new technologies”; “I feel forced by technologies to do more work than I can handle”), and six items corresponding to techno-invasion, reflecting whether one feels like their life is being invaded by technology (e.g. “I spend less time with family due to technologies I use at work”; “I feel my personal life is being invaded by technology I use at work”), were used and slightly adapted to make them applicable to general technostress instead of workplace related technostress (e.g. “I feel forced by technology to do more than I can handle”, “I feel my personal life is being invaded by technology”). Six items were added to the questionnaire to measure techno-vigilance. These items measured whether one feels distracted by and alert to technology (e.g. “I often feel distracted by technology”; “I am always at some level waiting for notifications from technology”).

The factorability of the eighteen items was examined. All items correlated at least .3 with at least one other item. All diagonals of the anti-image correlation matrix were over .5 and the communalities were all above .3. The Kaiser-Meyer-Olkin measure of sampling adequacy was .89, above the commonly recommended value of .6, and Bartlett’s test of sphericity was significant (χ^2 (153) = 1294.48, $p < .001$). Given these indicators, factor analysis was regarded suitable for all eighteen items.

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[1] Activity tracker induced technostress was measured as well. This variable consisted of the same eighteen items as for general technostress, but slightly adapted to make them applicable to activity tracker use specifically (e.g. “I feel forced by my activity tracker (and the app) to do more than I can handle”; “I feel like my personal life is being invaded by my activity tracker (and the app)”). Composite scores were computed for these eighteen items as well ($\alpha = .89$) and tracker induced technostress was taken into the analyses as mediator variable. As this yielded no significant results, the analyses have been excluded from the paper.

Principal component analysis using oblimin rotation, revealed that the eighteen items contained four components with eigenvalues greater than 1. Four items had cross-loadings above .3. The scree-plot on the other hand, indicated only one component. Both solutions have been tested in the analyses, but the separate dimensions did not yield diverging or more insightful results than the single component solution. Therefore the composite scores of all eighteen items of general technostress were used in the analyses. This component had an eigenvalue of 8.25 and explained 45.9% of the variance (see Appendix B for factor loadings). The items had a high internal reliability ($\alpha = .93$).

Control Variables

Body Mass Index (BMI) was computed from participants' height and weight. BMI was included in the study as control variable because people with lower BMI scores are physically more active and have a healthier diet than people with higher BMI scores (e.g. Voedingscentrum, 2018). This could explain differences in daily activity that were not due to the manipulation.

Motivation to be active was measured with one item ("Are you in general motivated to have an active and healthy lifestyle?") using a 5-point Likert scale (from 1 = "Not at all" to 5 = "Very much"). This variable was included in the study as control variable because intrinsic motivation resembles enjoyment and is a strong predictor of behaviour (Ryan & Deci, 2000) and could thus explain differences in daily activity and enjoyment of walking that were not due to the influence of the activity tracker and/or the app. When one is not intrinsically motivated to be active, there is a smaller chance that an activity tracker will have an effect on behaviour (Kruglanski et al., 1971).

Sports per week indicated how often participants generally exercised per week. With three items participants were asked whether they exercised sports other than walking or cycling for commuting (y/n) and if yes, which sports and how often they performed these sports per week. This variable ranged from 0 to 7 with 0 meaning that the participant never exercised and 7 meaning that the participant exercised every day of the week. This control variable was included because this has a direct link with daily activity that is not due to walking and therefore not due to the manipulation.

Active life was measured with one item ("Are you active in your daily life?") using a 5-point Likert scale (from 1 = "Not at all" to 5 = "Very much") and indicated whether a person was active in general. This variable is included as control variable because it has a direct link with performance that is not due to the manipulation, which aimed to increase performance relatively and not solely absolutely. There might also be a link to enjoyment as someone who is voluntarily very active in life, might enjoy physical activity more than someone who is not very active.

Active job was measured with one item as well ("Do you have a job where you need to walk a lot?"), again using a 5-point Likert scale (from 1 = "Not at all" to 5 = "Very much"). This variable also has a direct link to performance that is not due to the influence of the activity tracker and/or the app.

Goal achievement was measured with self-report. Participants were asked every day whether they had reached their goal that day. The score was computed by adding the number of days when the participants achieved their goal. This score ranged from 0 to 7, with 0 meaning that the participant never achieved his or her goal and 7 meaning that the participant achieved his or her goal every day of the experiment. This variable was included as it could have an influence on enjoyment and technostress. Working with a goal increases enjoyment of an activity (Lee, Sheldon & Turban, 2003), especially when the goal is met. When a goal is too difficult to achieve, this works demotivating and decreases enjoyment (Shalley, Oldham & Porac, 1987). It is plausible that the activity tracker evokes more technostress when the goal is very challenging and thus harder to achieve. This way the demands of the technology increase, which leads to higher technostress (Maier et al., 2015).

Openness to technology was measured with three items (e.g. "I think the use of technology adds value to my life"; α = .68) using a 5-point Likert scale (from 1 = "Strongly disagree" to 5 = "Strongly agree"). This variable reflected to what extend one was comfortable with technology in their life. Openness to technology is a strong predictor for perceived ease of use and perceived usefulness of technology (Nov & Ye, 2008), which correspond to the subjective demands of technology (Tarafdar et al., 2011). Therefore openness to technology might have an influence on technostress, that was not due to the manipulation and was included in the analyses as control variable.

Mental occupation with the experiment was measured with one item ("How much did the study mentally occupy you?"), using a 5-point Likert scale (from 1 = "Not at all" to 5 = "Very much"). This variable was included as control variable because it could have an influence on all outcome variables that was not due to the manipulation. When participants did not pay attention to the experiment and therefore to their goal and when applicable the activity tracker and app, it is unlikely that there would be changes in performance, enjoyment and technostress due to the manipulation.

Manipulation Check Variables

Wearing of the activity tracker was measured with three items. The first item measured whether participants had worn the activity tracker during the entire experiment accept during charging and showering or other activities in water (y/n). If not, participants were asked why not and for how long they did not wear it.

Checking of the activity tracker was measured with two items, asking whether participants checked the activity tracker every day (y/n) and if yes, how often participants checked it during the day, using a 5-point Likert scale (from 1 = “Rarely” to 5 = “Very often”).

Checking of the app was measured with two items, asking whether participants checked the app every day (y/n) and if yes, how often participants checked it during the day, using a 5-point Likert scale (from 1 = “Rarely” to 5 = “Very often”).

Analyses

The data were analysed in statistical analyses programs R (R-Core Team, 2017) and SPSS (IBM Corp, 2017). First descriptive statistics were analysed to explore the dataset. Second, several manipulation and randomization checks were conducted. These checks included frequency analyses of wearing and checking of the tracker and the app as manipulation checks and analyses of variance as randomization checks. Third, Pearson’s correlation analyses were used to determine covariates. Fourth, for the mediation analyses the PROCESS macro of Andrew Hayes was used (Hayes, 2013; Hayes & Preacher, 2014). The model was analysed separately for each outcome variable (i.e. minutes, steps, enjoyment), using model 4 of the PROCESS macro. This way the direct and indirect effects of condition on the outcome variables with technostress as mediator were calculated. Contrasts were set to Helmert coding (contrast 1: control vs. two experimental groups; contrast 2: tracker only group vs. tracker and app group) and percentile bootstrap confidence intervals based on 5.000 bootstrap samples were computed for the indirect effects.

Results

Descriptive Statistics

A set of analyses was conducted to describe the sample. Table 1 provides means and standard deviations of the dependent, mediator and control variables for the entire sample and split per condition. On average participants exercised twice a week (*M* = 1.95, *SD* = 1.94). However, there was a large variance of participants who did not exercise at all (35%), exercised once or twice a week (32%), exercised three or four times a week (21%) and exercised five or more times a week (12%). Almost half of the participants (49%) indicated that they were not at all to moderately active in general. On average the participants were moderately active (*M* = 3.46, *SD* = .84), which is opportune because this leaves room for the manipulation to improve physical activity. Only a small portion of the participants (7%) were not motivated to adopt a healthy lifestyle. This is apt, as external incentives like activity trackers are more influential when the user is intrinsically motivated as well (Ryan & Deci, 2000). Almost a third of the participants (30%) had a job requiring them to walk a lot. This variable has been taken into account as control variable as this could influence the results of the main analyses. On average participants reached their goal on half the days of the experiment (*M* = 3.84, *SD* = 1.74). This can either mean that they chose goals that were too challenging or that their behaviour was not changed by the activity tracker. All variables have been scaled and standardized and the z-scores were used in the analyses.

Table 1

Means and standard deviations of the outcome, mediation and control variables, split by condition.

Variables	*Total*	Condition		
		Control	Tracker only	Tracker&App
Minutes (n = 119)	113.88 (63.29)	108.20 (61.93)	122.90 (64.23)	111.55 (64.44)
Steps (n = 80)	10913.39 (3853.72)		11109.25 (4029.77)	10745.52 (3737.12)
Enjoyment (n = 119)	3.97 (.40)	3.92 (.37)	3.95 (.46)	4.05 (.38)
Technostress (n = 120)	2.36 (.65)	2.58 (.65)	2.20 (.76)	2.29 (.74)
BMI (n = 115)	24.67 (3.89)	25.66 (3.68)	24.37 (3.59)	23.90 (4.23)
Motivation (n = 115)	3.69 (.79)	3.59 (.81)	3.78 (.64)	3.71 (.90)
Active life (n = 115)	3.46 (.84)	3.37 (.80)	3.56 (.73)	3.47 (.98)
Active job (n = 115)	2.64 (1.34)	2.71 (1.38)	2.58 (1.44)	2.63 (1.22)
Goal achievement (n = 122)	3.84 (1.74)	3.74 (1.70)	4.06 (1.79)	3.73 (1.76)
Openness to technology (n = 120)	3.04 (.82)	2.98 (.78)	3.14 (.83)	3.02 (.85)
Mental occupation (n = 122)	2.81 (1.13)	2.53 (1.08)	2.69 (1.02)	3.20 (1.02)

Checks

Manipulation Checks

Participants with activity trackers (n = 80) were asked to wear the activity tracker constantly and to check the information it provided regularly during the day. Most participants in this group (74%) indicated to have worn the activity tracker during the entire week. Participants who failed to wear the tracker during the entire week mainly indicated that they took it off at night (88%). Other reasons were jobs where people were not allowed to wear jewellery or other wearables, certain sports where the tracker could have been damaged and in one case a participant forgot to wear the tracker after charging. Only one participant indicated failure to check the activity tracker every day and eight participants (11%) checked it only once or twice during the day. All other participants (88%) were above scale centre and thus checked their tracker regularly. In conclusion, the manipulation of the activity tracker was fairly successful. Almost all participants wore the tracker the entire week, at least during the day, and only a small group failed to regularly check the data which the tracker quantified.

Participants in the tracker and app condition (n = 43) were asked to check the corresponding application for smartphone regularly during the day as well. About half of the participants in this group (47%) checked the app daily, albeit only a few times a day (24%). Ten participants (23%) checked the app regularly. In conclusion, the manipulation of the HPlus Watch app was moderately successful.

Randomization Checks

There were no differences between the conditions in age, gender, educational level, BMI, motivation to be active, sports per week, active life, active job or openness to technology. Therefore it was concluded that the randomization was successful.

Determining Covariates

Pearson's correlations were computed between the outcome and control variables. All significantly correlating control variables were taken into the analyses as covariates for the corresponding outcome variables.

Possible covariates for performance in minutes were age, gender, educational level, BMI, motivation to be active, active life and active job. Significant correlations with minutes were found for educational level ($r(111) = -.26$, $p = .006$), motivation to be active ($r(111) = .19$, $p = .046$), active life ($r(111) = .19$, $p = .048$) and active job ($r(111) = .38$, $p < .001$).

The same possible covariates as for performance in minutes were checked for performance in steps. Significant correlations with steps were found for motivation to be active ($r(72) = .30$, $p = .010$) and active life ($r(72) = .34$, $p = .004$).

Age, gender, educational level, BMI, motivation to be active, active life, active job and goal achievement were considered as possible covariates for enjoyment. Significant correlations with enjoyment were found for age ($r(108) = .29$, $p = .002$), motivation to be active ($r(108) = .26$, $p = .007$) and active life ($r(108) = .21$, $p = .030$).

For technostress age, gender, educational level, goal achievement, openness to technology and mental occupation were checked as possible covariates. Significant correlations were found between technostress and age ($r(108) = -.37$, $p < .001$), gender ($r(108) = .19$, $p = .045$), openness to technology ($r(114) = .23$, $p = .012$) and mental occupation ($r(114) = .25$, $p = .007$).

Main Analyses

Model 4 from the PROCESS macro was used to analyse the mediation models, separately for each dependent variable. The results are discussed following the structure of the hypotheses. The standardized regression coefficients, their standard errors and significance can be found in Tables 2 to 4 at the end of the results chapter (p. 29). See Appendix C for the exact regression coefficients of the mediation models.

From the omnibus test of direct effects, wearing an activity tracker – with or without using the app – did not influence performance in minutes ($F(2, 96) = .69$, $p = .504$). Use of the app in addition to wearing an activity tracker did not influence performance in minutes ($t = .36$, $p = .720$), nor in steps ($t = -.45$, $p = .651$). As can be seen in Tables 2 and 3 participants who wore an activity tracker – with or without using the app – did not walk longer than participants who did not wear an activity tracker (H1a) and participants who used the app in addition to wearing an activity tracker did not walk longer, nor did they take more steps than participants who only wore the activity tracker (H1b). Hypothesis 1a and 1b are therefore rejected.

According to the omnibus test of direct effects, there was no influence of wearing an activity tracker or use of the app on the enjoyment of walking ($F(2, 98) = .65$, $p = .626$). Table 4 shows that participants who wore an activity tracker – with or without using the app – did not enjoy walking less than participants who did not wear an activity tracker (H2a) and participants who used the app in addition to wearing an activity tracker did not enjoy walking less than participants who only wore the activity tracker (H2b). Hypothesis 2a and 2b are also rejected.

Tables 2, 3 and 4 show differing results concerning the effects of wearing an activity tracker and use of the app on technostress. Tables 2 and 4 show, opposite to the hypotheses, that participants who wore an activity tracker – with or without using the app – experienced less technostress than participants who did not wear an activity tracker (H3a) and participants who used the app in addition to wearing an activity tracker experienced less technostress than participants who only wore the activity tracker (H3b). However, Table 3 shows that there were no differences between participants who used the app in addition to wearing the activity tracker and participants who only wore the activity tracker (H3b). The hypotheses were rejected, but the opposite was supported by the data for hypothesis 3a and partly for hypothesis 3b.

There was no evidence for a mediation effect of wearing an activity tracker – with or without use of the app – on performance in minutes through technostress, according to a percentile bootstrap confidence interval based on 5.000 bootstrap samples which included zero (*effect* = .06, *se* = .08, *95%CI*[-.093, .235]). Based on the same analysis there was no evidence for a mediation effect through technostress of use of the app in addition to wearing an activity tracker on performance in minutes (*effect* = .06, *se* = .07, *95%CI* [-.096, .206]) or steps (*effect* = .02, *se* = .08, *95%CI* [-.137, .189]). In other words, hypotheses 4a and 4b are not supported by the data.

According to the total effects analyses, there was no effect of wearing an activity tracker – with or without use of the app – on performance in minutes (*t* = 1.42, *p* = .158), nor was there an effect of use of the app in addition to wearing an activity tracker on performance in minutes (*effect* = .14, *se* = .23, *t* = .61, *p* = .541) or steps (*t* = -.35, *p* = .729), all considering technostress.

No evidence was found for a mediation effect wearing an activity tracker – with or without using the app – on enjoyment through technostress either, according to a percentile bootstrap confidence interval based on 5.000 bootstrap samples including zero (*effect* = .06, *se* = .06, *95%CI*[-.045, .214]). This also applied to the mediation effect of use of the app in addition to wearing the activity tracker on enjoyment through technostress (*effect* = .06, *se* = .05, *95%CI* [-.046, .194]). Hypotheses 5a and 5b are not supported by the data.

According to the total effects analyses, there was – while considering technostress – no effect of wearing an activity tracker – with or without use of the app – on enjoyment (*t* = -.57, *p* = .569), nor was there an effect of use of the app in addition to wearing an activity tracker on enjoyment (*t* = .48, *p* = .632).

Table 2

Regression model of the mediation analysis of condition on performance in minutes through technostress.

	Technostress				Minutes			
	β	*se*	*T*	*p*	*B*	*se*	*T*	*P*
Constant	.33	.14	2.25	.027*	-.11	.16	-.66	.508
Condition contrast 1	-.45	.21	-2.14	.035*	.26	.23	1.14	.259
Condition contrast 2	-.43	.21	-2.00	.048*	.08	.23	.36	.720
Technostress					-.13	.11	-1.22	.226
Age	-.23	.09	-2.48	.015*	-.15	.10	-1.49	.140
Gender	.03	.09	.37	.709	.01	.10	.07	.943
Educational level	.04	.10	.44	.659	-.25	.10	-2.41	.018*
Motivation	.14	.11	1.24	.217	.26	.12	2.17	.033*
Active life	-.34	.12	-2.85	.005*	-.08	.14	-.62	.537
Active job	.04	.10	.43	.665	.28	.11	2.53	.013*
Openness to technology	.21	.09	2.35	.021*	.03	.10	.28	.780
Mental occupation	.15	.09	1.64	.104	-.03	.10	-.29	.774

Note: * p < .05. The model explained 33% of the variance in technostress and 25% of the variance in minutes.

Table 3

Regression model of the mediation analysis of condition on performance in steps through technostress.

	Technostress				Steps			
	β	*se*	*T*	*p*	*B*	*se*	*T*	*P*
Constant	-.10	.15	-.72	.475	-.02	.17	-.10	.919
Condition (contrast 2)	-.07	.21	-.34	.736	-.11	.24	-.45	.651
Technostress					-.32	.14	-2.22	.030*
Age	-.26	.11	-2.37	.021*	.00	.13	.01	.992
Gender	-.03	.11	-.31	.754	-.07	.12	-.53	.596
Motivation	.16	.14	1.16	.251	.25	.16	-.45	.121
Active life	-.35	.13	3.09	.011*	.12	.16	2.80	.448
Openness to technology	.12	.11	1.16	.252	-.05	.12	1.57	.656
Mental occupation	.34	.11	-2.61	.003*	.38	.14	.76	.007*

Note: * p < .05. The model explained 37% of the variance in technostress and 24% of the variance in steps.

Table 4

Regression model of the mediation analysis of condition on enjoyment through technostress.

	Technostress				Enjoyment			
	β	*se*	*T*	*p*	*B*	*Se*	*T*	*P*
Constant	.32	.14	2.25	.027*	.06	.16	.35	.723
Condition contrast 1	-.44	.20	-2.14	.035*	-.19	.23	-.84	.401
Condition contrast 2	-.42	.21	-2.02	.046*	.05	.23	.21	.838
Technostress					-.15	.11	-1.35	.181
Age	-.24	.09	-2.77	.007*	.30	.10	3.03	.003*
Gender	.04	.09	.41	.683	-.11	.10	-1.09	.278
Motivation	.14	.10	1.31	.192	.32	.12	2.75	.007*
Active life	-.33	.11	-2.99	.004*	-.03	.13	-.27	.791
Openness to technology	.21	.09	2.39	.019*	-.08	.10	-.83	.408
Mental occupation	.16	.09	1.78	.079	.26	.10	2.65	.010*

Note: * p < .05. The model explained 32% of the variance in technostress and 25% of the variance in enjoyment.

Discussion

Even though none of the hypothesis were supported by the data, there were interesting findings in the current study. There was a significant effect of condition on technostress, albeit opposite to the expectations. Participants who wore an activity tracker – either with or without using the app – reported lower levels of technostress compared to participants in the control group who did not wear an activity tracker and did not use the app. When looking more closely into the effect of use of the app in addition to the activity tracker on technostress some mixed results were found. In the models of performance in minutes and enjoyment use of the app in addition to wearing the activity tracker decreased reported levels of technostress compared to only wearing the activity tracker. This effect did not occur in the model of performance in steps. Last, there was a significant, negative effect of technostress on performance in steps, but no effects on the other two outcome variables.

This means that the answer to the first research question (i.e. "*What is the effect of wearing an activity tracker on performance and enjoyment of the activity and can these effects be explained by technostress?*") is that there were no effects of the activity tracker on performance and enjoyment and technostress did not mediate these effects. The answer to the second research question (i.e. "*Does usage of the corresponding app for smartphone in addition to wearing an activity tracker make a difference in effects on technostress, performance and enjoyment?*") is that use of the app in addition to the activity tracker did not make a difference for performance and enjoyment, but it did for technostress. Use of the app decreased technostress in two out of the three models. In this chapter the results will be discussed, followed by limitations of the current study and suggestions for future research will be made across the chapter.

Activity Trackers and Performance

In spite of positive results in the literature on self-quantification (Bratava et al., 2007; Spences et al., 2009; Karapanos et al., 2016; Glance et al., 2016; Etkin, 2016), the current study was unable to replicate the positive effect of wearing an activity tracker on performance. Neither was there an effect of use of the app in addition to wearing the activity tracker. One possible explanation for this is that behavioural change techniques (BCTs), which were expected to drive the effects of both the activity tracker and the app, are not as effective in activity trackers as they are in interventions. Studies have proven the effectiveness of BCTs in interventions (Hartmann-Boyce et al., 2015; Bird et al., 2013) and developers of activity trackers have used this information to develop their products (Lyons et al., 2014). However, there has been no scientific follow-up research to the effects of specific BCTs in activity trackers. BCTs that are used in almost all activity trackers, including the activity tracker used in this study, are goal-setting, review of behavioural goals, feedback of behaviour, self-monitoring of behaviour and rewards (Lyons et al., 2014). It could, for example, be that goals set with activity trackers are not challenging enough or too challenging or that users are not committed enough to the goal, which are some conditions for effective goal-setting (e.g. Locke & Latham, 1994). It could also be that the feedback given by the tracker and the app is not personal enough or not provided in the right amount or at the right time, which are conditions for effective feedback (e.g. Butler, 1987; Ackerman & Gross, 2010; Ackerman, Dommeyer, & Gross, 2017). These are just some suggestions which need empirical investigation. Future research should go further into investigating specific effects of isolated and combined BCTs in activity trackers and the corresponding apps.

Another explanation might be that the external incentives of the activity tracker and the app are not solely responsible for the positive effect on performance (Patel, Ash & Volpp, 2015; Patel et al., 2017). Patel and colleagues suggest that behaviour change should be ascribed to personal engagement strategies rather than to external incentives like activity trackers. These engagement strategies are a combination of individual encouragement, social competition, social collaboration and effective feedback loops (Patel et al., 2015). The current study did not measure specific engagement strategies, but somewhat similar variables like motivation to be active and mental occupation were measured. Motivation to be active was on average quite high, while mental occupation with the experiment was on average quite low. Even though this was controlled for where appropriate, this and/or more specific personal engagement strategies could have an influence on the effect of activity trackers and their apps on performance and could be further looked into in future research.

Activity Trackers and Enjoyment

It was expected that wearing an activity tracker and use of the app would have negative effects on enjoyment because shifting attention from the enjoyment of an activity to quantitative output makes the activity feel more like work, which undermines enjoyment (Etkin, 2016) and because of the "crowding out" effect (Deci, 1971; Kruglanski et al., 1972; Higgins et al., 1995; Ryan & Deci, 2000). As explained in the theoretical framework the crowding out effect occurs when people start to pursue an activity because of the rewards rather than because it is fun to do (Deci, 1971; Kruglanski et al., 1972; Higgins et al., 1995; Ryan & Deci, 2000). Even though activity trackers and their apps send reward notifications when goals are met, the enjoyment of the activity of walking was not crowded out. In fact, there was no effect on enjoyment at all. One explanation for this is that these notifications might not have been rewarding enough for the crowding out effect to occur. When a reward is not considered rewarding by the receiver, the activity will continue to be pursued because it is fun and the shift in attribution from intrinsic motivation and enjoyment to external incentives will not occur (Deci et al., 1999). In other words, the fun will not be crowded out of an activity when the rewards are not desirable enough to pursue.

Another reason might be that it takes more time before enjoyment is influenced by activity trackers and their apps. An activity tracker is a gadget and gadgets are often subdue to novelty effects (e.g. Chen, 2016; Stubbe, 2017). This means that their short-term effects are radically different from their long-term effects. Not much is known about this effect from the perspective of the user, however for activity trackers and their apps this might mean that when people start wearing a tracker the device is considered fun and stimulating, but after a certain period of time the novelty has worn off and the activity tracker becomes a pressuring device. This might be the moment when the shift in attribution of the crowding out effect appears, meaning that people walk to achieve their goal and receive the reward and not anymore because walking is fun to do (Deci et al., 1999). Or it could be that the pressure makes that walking starts to feel like an obligatory task, which might even feel like work, undermining enjoyment (Etkin, 2016). For both explanations, it is possible that a week was too short for the novelty of the activity tracker to wear off and the long-term effect to occur. Future research could investigate the effects of activity trackers and the corresponding apps on enjoyment over a longer period of time to rule out novelty effects.

Activity Trackers and Technostress

Positive effects were expected of wearing an activity tracker and use of the app on technostress. These expectations were not met by the data. Interestingly, the opposite was found to be true. As mentioned before, the experiment lasted one week and it is possible that the novelty of the activity tracker interferes with these expected effects as well and that they might occur later in time (e,g, Cheng, 2016; Stubbe, 2017). At the beginning the device might be regarded as a fun gadget which stimulates healthy behaviour and does not lead to stress (e.g. Karapanos et al., 2016). In fact, it decreases stress, possibly because of the initial boost of motivation and self-esteem people experience when wearing a tracker (Karapanos et al., 2016), which masks the pressuring and invading characteristics of the device. Later the novelty has worn off and the pressure, invasion and vigilance become clear. This suggestion should be further investigated in future research.

Another reason might be the possibility that an activity tracker is not the kind of device that evokes technostress. There is plenty evidence that mobile phone usage leads to technostress (e.g. Lee et al., 2014; Boonjing & Chanvarasuth, 2017; Hsiao et al., 2017, Thomée et al., 2011), but no evidence has been found for such an effect of activity trackers, including in the current study which found the opposite effect. One obvious difference between smartphones and the activity tracker used in the current study is the social aspect. It could be that the social demands weigh more heavily than other kinds of demands in driving the psychological state of stress caused by technological devices (i.e. technostress; Maier et al., 2015). It might even be that using a technological device that does not urge you to connect with others feels like a relief in comparison to other devices, as this urge has been found to have a negative effect on subjective well-being (e.g. Brooks, 2015; Choi & Lim, 2016). This could explain the decrease in technostress which was found in the current study. This suggestion should be investigated by future research. Perhaps activity trackers that do have a social aspect could be compared to activity trackers that do not have such an aspect in their effects on technostress.

Mixed results were found for the effect of use of the app in addition to wearing an activity tracker on technostress. In the models of performance in minutes and enjoyment there was a significant negative effect, meaning that use of the app in addition to wearing the tracker decreased technostress. In the model of performance in steps such an effect was not apparent. This leaves the matter whether it is the activity tracker or the app which evokes effects inconclusive. As set out in the theoretical chapter, use of mobile phones increases technostress (Lee et al., 2014; Boonjing & Chanvarasuth, 2017; Hsiao et al., 2017) and it remains plausible because of the large amount of prior research that an increase in mobile phone usage leads to an increase in technostress. Yet, this was not supported by the data. Here too it could be due to novelty that the effect did not appear as expected (Cheng, 2016; Stubbe, 2017), but more research should be conducted to rule out this and other explanations.

Mediation Role of Technostress For Performance and Enjoyment

Since no direct effects of wearing an activity tracker and use of the app on performance and enjoyment were found in the current study, it was not surprising that there was no concrete evidence of mediation effects through technostress either. As mentioned in the theoretical framework, these expectations were mainly explorative, however, as set out multiple times earlier in this chapter, activity trackers might be subdue to novelty effects (Cheng, 2016; Stubbe, 2017), which means that the short-term effects might be different than long-term effects. Therefore the mediation should perhaps not be written off immediately, but further research should be conducted over a longer period of time.

The current study did find some indication of an effect of technostress on performance (i.e. a significant negative effect of technostress on performance in steps). This effect however, was opposite to the expectations as well. Still, combined with the significant negative effect of condition on technostress, this finding gives reason to believe there might still be a mediating role of technostress on the effect of using an activity tracker on performance, albeit opposite to what was expected. The current study indicates that a positive effect of wearing an activity tracker and use of the app could be mediated by technostress as wearing an activity tracker decreases technostress and decreased technostress leads to higher performance. This should be further investigated in future research. There was no such indication for enjoyment as technostress did not influence enjoyment in any of the models.

Limitations

The current study contained some limitations. First of all, the duration of the experiment. It was argued at the beginning of the paper that effects of activity trackers should be measured over a longer period than one day. The experiment lasted for a week for each participant, but as mentioned various times before this may still have been too short for several effects to occur. Therefore future research should replicate the current study over a longer period of time. This way novelty effects can be ruled out as confounding factors and the long-term effects can be revealed. Besides, a novelty-like effect of motivation might occur as well. People might be strongly motivated to increase their daily activity when they buy an activity tracker, but after a certain period of time this motivation might have worn off and the tracker becomes pressuring and irritating. This and other novelty effects should be investigated in future research. Repeated measures can give insight into when exactly effects appear and for how long they last. A second limitation was the relatively small sample. The final sample contained 122 participants, while at least 129 participants were needed for sufficient power (f = .30, 1-β = .80; Faul, Erdfelder, Lang, & Buchner, 2007). Due to participants who did enrol, but never started with the experiment and outliers the final sample was smaller than initially planned, however the difference is very small. A third limitation was the moderate correlation between performance in minutes and steps, which interferes with the study's reliability. Future research should try to creatively solve this problem. The fourth and last limitation was the measurement of technostress. As set out before technostress is becoming more and more important in general life (Maier et al., 2015) in addition to its relevance at work (e.g. Tarafdar et al., 2011). However, there is no validated scale to measure technostress in this broader context. It is possible that the measurement of technostress as used in the current study did not contain all relevant elements for technological devices like activity trackers, which may have interfered with the results. Future research should construct a valid scale for technostress.

Conclusion

In conclusion, the study yielded different results than expected, but nevertheless brought interesting insights in the effects of wearing an activity tracker and use of the app on performance, enjoyment and technostress. It was said in the introduction of this paper that the growing popularity of activity trackers evoked a growing relevance of research on these devices as they might have detrimental effects on subjective well-being. As far as the results of this study go, activity trackers do not have detrimental effects on subjective well-being. In fact, technostress was decreased by wearing an activity tracker and use of the app and there was no effect on the enjoyment of walking. However, the activity tracker was unable to increase performance, which makes the tracker inefficient as its purpose is to increase physical activity. As this was the first study investigating the connection between activity trackers and the corresponding apps on technostress and as there are reasons to belief the effects might be different when measured over a longer period of time, it cannot be concluded that activity trackers are harmless devices which have no negative influence on well-being at all. Future research should continue this line of research and further investigate what was initiated by the current study.

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Appendix

Appendix A.

Factor loadings single component solution enjoyment.

Item	Loading
1	.810
2r	.476
3r	.344
4	.825
5r	.407
6	.819
7r	.148
8	.852
9	.730
10r	-.729
11	.576
12r	.374
13r	.545
14	.482
15	.761
16r	.308

Appendix B.

Factor loadings single component solution technostress

Item	Loading
1	.585
2	.600
3	.642
4	.609
5	.643
6	.516
7	.603
8	.602
9	.671
10	.716
11	.671
12	.716
13	.759
14	.842
15	.844
16	.703
17	.626
18	.744

Appendix C.

Regression coefficients of mediation analyses.

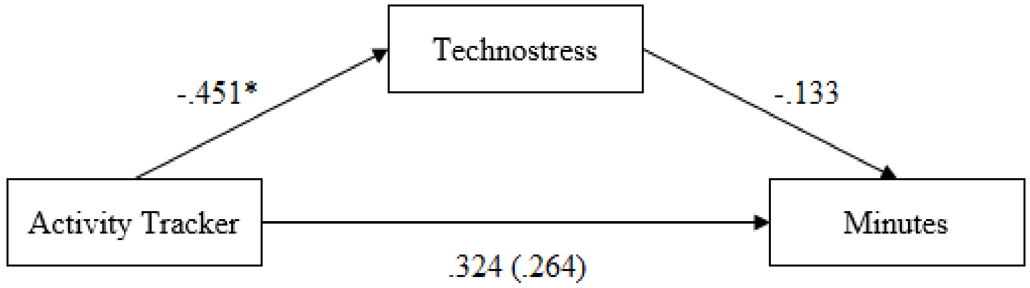

Figure 2. Regression coefficients mediation analysis of wearing an activity tracker – with or without use of the app – on performance in minutes through technostress. The direct effect independent of technostress is in parentheses. Significant regression coefficients are marked with an *.

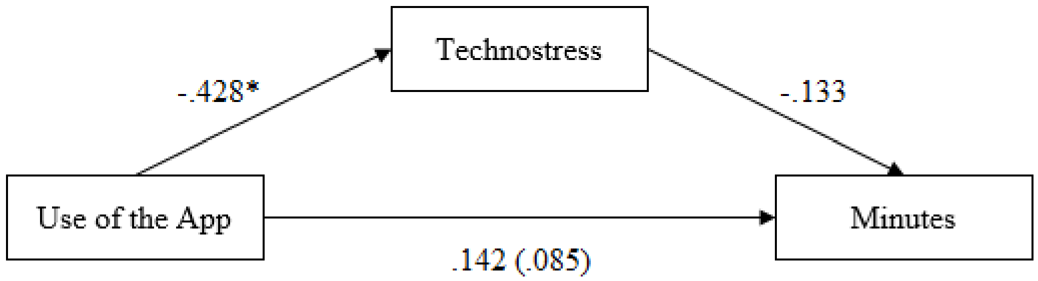

Figure 3. Regression coefficients mediation analysis of use of the app in addition to wearing the activity tracker on performance in minutes through technostress. The direct effect independent of technostress is in parentheses. Significant regression coefficients are marked with an *.

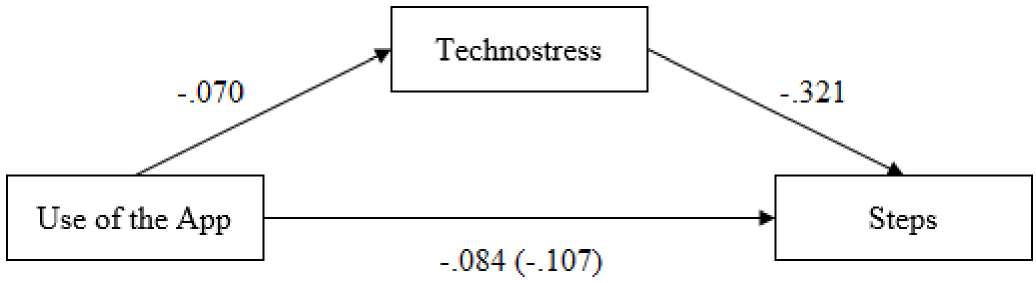

Figure 4. Regression coefficients mediation analysis of use of the app in addition to wearing the activity tracker on performance in steps through technostress. The direct effect independent of technostress is in parentheses. Significant regression coefficients are marked with an *.

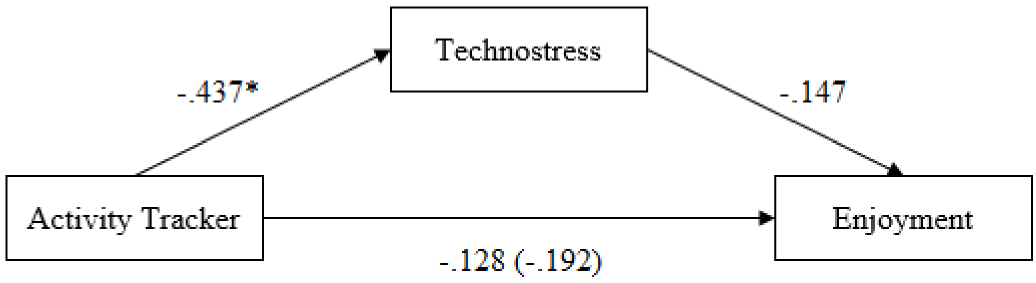

Figure 5. Regression coefficients mediation analysis of wearing an activity tracker – with or without use of the app – on enjoyment through technostress. The direct effect independent of technostress is in parentheses. Significant regression coefficients are marked with an *.

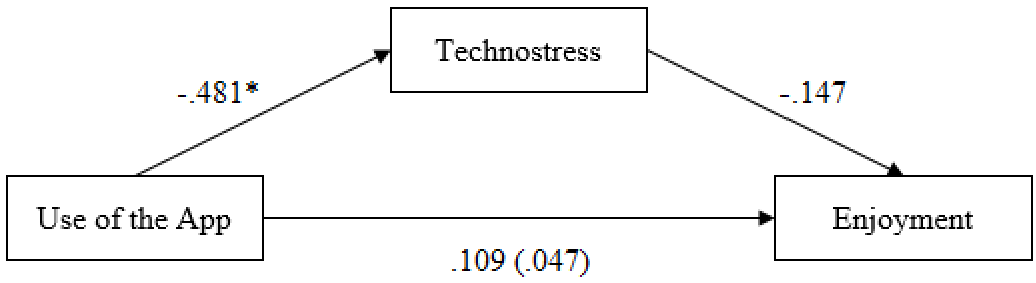

Figure 6. Regression coefficients mediation analysis of use of the app in addition to wearing the activity tracker on enjoyment through technostress. The direct effect independent of technostress is in parentheses. Significant regression coefficients are marked with an *.