Applying Ajzen's Theory of Planned Behaviour: Changing Physical Activity Health Behaviour with Activity-Tracking Technology

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Submitted in partial fulfilment of the requirements of the BA Hons in Psychology at Dublin Business School, School of Arts, Dublin

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March 2016

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Acknowledgements

A huge thanks and expression of gratitude to my supervisor Dr. Patricia Frazer for her guidance and professional expertise, as well as her generosity of time and patience.

A special thank you to my fiancé Rachel for her tower of strength, outstanding support, unending patience and delicious home-cooked comfort food.

I would like to thank my great friend Peter Halpin whose encouragement, support and motivational talks have carried me on this journey and through its challenges.

Lastly, I would like to thank my greatest supporter of all. A lady who gifted me with the courage to face any challenge and instilled a “go do it” attitude into my psyche. To my late loving mother Margaret (Peggy), forever missed, never forgotten.

Abstract

The objectives were to i) determine whether a mobile connected activity-tracking device could change physical activity (PA) health behaviour, ii) test whether the theory of planned behaviour could predict participation in physical activity, measured by mobile technology, iii) determine if PA engagement was correlated with mobile communication usage and vehicle journey time. Participants consisted of 41 males and 28 females (N=69), each completing standard TPB measures at baseline. Intervention included a health warning/advice sheet and activity-tracking wearable device. ANOVA results found a significant interaction effect of 37% when wearing device versus not. Findings did not the support the TPB as a predictor of PA engagement in a technology intervention context. Multiple regression results found no relationship between PA participation and mobile communication usage or vehicle journey time. A basis for developing interventions to include mobile connected devices for improved behavioural health is discussed.

Keywords: health, physical activity, mobile devices, theory of planned behaviour.

“Regular physical activity reduces your risk of high blood pressure, heart attack and stroke, as well as many other diseases. Over 20% of coronary heart disease and 10% of stroke is due to physical inactivity” (Irish Heart Foundation, 2015, p2-3).

In an age where technology and mobile phone usage dominate the daily lives of many and whilst the rates of mortality related to health are staggering, there is a globally recognised urgency to encourage fundamental lifestyle health changes and a rationale for the adoption of advanced technological methods in supporting change. The prevalence of overweight and obesity in children and adults in developing countries has been described as a global epidemic with rates estimated to have doubled between 1980 and 2013 (Ng et al. 2014). Furthermore, this health issue has been identified as one of the leading worldwide causes of death and found to increase risks of diabetes, cancers and cardiovascular diseases. According to the World Health Organisation, more than 2.8 million people die in the world per year as a result of being overweight and obese (WHO, 2015b). Currently, Ireland is ranked second highest in Europe for obesity rates (The Food Safety Authority of Ireland, 2012), but worryingly, Ireland is on course to become the most obese country in Europe by 2030 (WHO, 2015c). A forecast report in 2015 by the World Health Organisation (as cited by SafeFood, 2015) predicted that 91% of men in Ireland are likely to be overweight by 2030, including 27% of these likely to be obese. For women, 83% are predicted to be overweight with 57% obese. In 2014, there were more than 1.9 billion adults overweight (39% of world population), with 600 million of these obese (13% of world population) and 42 million children under the age of 5 were either overweight or obese in 2013 (WHO, 2015b). Clearly, the potential consequences of not acting in some shape or form could be viewed as catastrophic. In 2013, each member state of the World Health Organisation agreed to action a global plan with the aim of preventing and controlling non-communicable diseases, including a specific goal to reduce insufficient levels of physical activity by 10% by 2025 (Who, 2015a, p5).

Importantly, a study by Ekelund et al. (2015), consisting of over three hundred thousand European men and women, found significant supportive evidence to conclude that a lack of physical activity and being highly sedentary leads to the highest risks of death. In addition, a study by Biswas et al. (2015) found evidence to suggest that physical activity alone may not be effective enough to avoid health risks. If for example, an individual's daily sedentary hours greatly outweigh their time spent physically active, then the individual is still highly susceptible to the most common fatal diseases of today such as heart disease, diabetes and cancer. Furthermore, the study found that the average person spends half their day sedentary i.e. sitting at a TV, sitting at a desk and driving. The study highlighted the importance of both a reduction in daily sedentary hours as well as daily regular exercise.

Other recognised underlining factors linked to physical inactivity and obesity are heavy mobile phone usage (Lepp et al. 2013) and a heavy reliance on the use of sedentary modes of travel such as cars and buses (Kozo et al. 2012; National Heart, Lung and Blood Institute, 2016; Harvard T.H. Chan, 2016, para 10-13). According to a report by Worldometers (2015), the number of cars on roads globally, surpassed the 1 billion mark in 2010 and continues to increase. In Ireland, a national survey carried out by the Central Statistics Office into modes of travel among Irish people in 2014 found that 74.4% of journeys were by car as either passenger or driver, a further 9.2%

of journeys were made by bus, rail, or other (CSO, 2014). Of the sample audience, only 14.8% were found to make a journey by walking and 1.6% by bicycle.

In attempts to tackle the problem of obesity, overweight and sedentariness, health practitioners and governments all around the world are now actively encouraging people to become more physically active. Health warning messaging (or "shock advertising") and health advice is frequently promoted online, in print media and medical centres. However, the effectiveness of this messaging is uncertain (Manchanda, Dahl & Frankenberger, 2002; Urwin & Venter, 2014). In relation to physical activity advice, the Irish Heart Foundation recommends that an individual engage in 30 minutes of physical activity 5 days a week (Irish Heart Foundation, 2015). Similar recommendations are made by health organisations throughout the world. Both the Irish Heart Foundation and the UK's National Health Service promote a 10,000 steps challenge encouraging people to get more active by setting themselves a target of 10,000 daily steps. 10,000 steps is recognised globally as the daily step target goal and the concept is believed to have originated in Japan (BBC, 2015). It is estimated, that on average, a person walks between 3,000-4,000 steps per day (NHS, 2015). Interestingly, a study by Lordon and Pakrashi (2015) analysed all types of physical activities including housework, manual work, sports/exercise and identified 'brisk or fast pace walking' as being better than any other form of physical activity as a deterrent against overweight and obesity.

In tandem with global health warnings, there has been a surge in health and fitness mobile applications and wearable activity-tracking 'smart devices' (wireless connected electronic devices) flooding the global markets. These wearable activity-tracking devices are now readily available and marketed by brands such as Jawbone, Fitbit, Garmin, Microsoft and Sony, all ranging competing variants. Statistics reveal that there were 15 million global health and fitness tracker users in 2013, with that expected to rise to near 100 million by 2018 (Statista, 2015, para.2). Activity-tracking smart devices allow users to receive and analyse information about their daily life behaviour with the aim of helping to guide decisions for healthier lifestyles. Information tracked may include a user's daily steps, time spent walking, running, cycling, sleeping and transport travelling time. Some also monitor a user's heart rate and levels of mobile communication usage (i.e. texting, calling and social media). Other forms of tracking simply use mobile applications and are not paired with a wearable smart device to track physical activity. There are an abundance of available mobile applications such as Runtastic, MapMyFitness, Strava and Fitnet. The one necessity to operate these health and fitness applications and wearables is a smartphone mobile device. In a quarterly report by Ireland's Commission for Communications Regulatory, official data revealed that 73.7% of mobile subscriptions in Ireland are Smartphone users (Comreg, 2015). Like Ireland, the world has seen smartphone adoption skyrocket and this leads experts to believe there is vast scope of opportunity for eHealth to become a prominent and important force in the healthcare market. According to Morris and Aguilera (2012, p. 622), it is envisaged that forces such as "advances in mobile technology, constrained clinical care and consumer demand are beginning to change the face of psychological assessment and interventions". The integration of smartphone technology in behavioural healthcare brings a vast amount of possibilities and the benefits such as GPS tracking of patients suffering with dementia, audio and visual recording of therapy sessions, etc., are outlined in further detail by the team at Telehealth & Technology in Washington (Luxton, McCann, Bush, Mishkind & Reger, 2011).

Theory of Planned Behaviour (TPB)

Strong links have been identified between illness and behaviour with reports suggesting that 50% of the mortality, from 10 leading causes of death, is directly related to behaviour (Ogden, 2007, p15). Based upon the popular theory of planned behaviour (Ajzen, 1991), an individual's behavourial intentions are shaped by a combination of attitudes towards behaviour, subjective norms and perceived behavioural control. As such, the likelihood of an individual's participation in physical activity may be determined by analysing these behavioural dimensions. The predictive validity of the theory of planned behaviour has been supported in many studies through a wide spectrum of experimental applications including the prediction of behaviours related to drug usage (Ito et al., 2015), gambling (Martin et al. 2010), and sexual behaviours (Bryan, 2002). However, it is in the domain of physical activity that the model has been extensively applied. Galea and Bray (2006) applied the theory to predicting the walking and exercise intentions of individual's with intermittent claudication – a condition whereby a cramping pain in the leg is brought on by exercise. Supportive evidence was found for the theory with attitudes, subjective norms and perceived behavioural control explaining 67% of the variance in participant's intentions. However, in this case, perceived behavioural control was found to be the only significant determinant of exercise behaviour. Similarly, a study by Armitage (2005) found replicated findings when using the TPB theory model to predict the maintenance of physical activity. In this case, the three independent variables (attitudes, subjective norms, perceived behavioural control) accounted for

49% variance in behavioural intentions. Again however, perceived behavioural control was the only significant predictor of actual physical activity behaviour. In an interesting study by Farrell et al. (2016), the model was applied to test the influence that romantic relationship partners have on health behaviour determinants. Perceived behavioural control was once again highlighted as a key component in prediction of physical activity behaviour. The study's findings suggest that in order to change health-related behaviour, the influence of a partner's attitudes and intentions to the targeted behaviour should be considered.

This study seeks to investigate whether modern day health and fitness activity-tracking technology can help contribute a solution to the modern day overweight, obesity and highly sedentary problem engulfing millions of people globally. It aims to determine whether using a mobile connected activity-tracking device can significantly influence the amount of daily steps a person takes, and whether a person's behavioural intentions would be more motivated when using one.

In conducting the research, a market approved activity-tracking device from Sony Corporation's Mobile Communications division called the Sony SmartBand SWR10 was recruited. Partnered with the device, Sony's Lifelog application stores recorded data received from the Smartband. Data received is communicated from the Smartband to the Lifelog application via a Bluetooth connection. Suitable for 24/7 wear, the Smartband is built with comfortable lightweight material and is fully waterproof, allowing each hour of the participant's day to be tracked. Statistical information gathered includes measures of time walking, running, sleeping, as well as other aspects of a person's life including recorded data of the time spent in transport (i.e. car, bus) and the amount of accumulated time spent communicating via text, calls, social media and internet (Sonymobile, 2015).

Upon examination of previous studies in this area, there appears to be a scarcity of research into the physical activity behavioural influence of fitness/activity trackers, specifically applying the theory of planned behaviour. In an age where technology and mobile phones are heavily integrated in our daily lives, the means to statistically measure our actions have never been as insightful. Technologies are readily used in pro-sports to determine the levels of output (i.e. running, jumping, shooting) a sports person makes in for example a football game. These advances in technology allow exploration into the validity of theories that have been historically reliant upon participant self-reporting and manual data logging. Although the theory of planned behaviour has been applied to many physical activity studies, there has been a heavy reliance on participants to self-report by relaying honest and accurate information about their physical activity time achieved during the experiment. In the case of this experiment, a key advantage is that the activity-tracking data records cannot be manipulated, avoiding for any misleading information or error in memory by the participant.

The TPB questionnaire incorporated in the case of this study was adopted from Armitage (2005). The measures analyse the person's favourable or unfavourable attitudes toward physical activity, the person's perceived social pressure to engage or not to engage in physical activity, and the person's perceived ease or difficulty of engaging in physical activity. Azjen (1991, p188) explains "As a general rule, the more favourable the attitude and subjective norm with respect to a behaviour, and the greater the perceived behavioural control, the stronger should be an individual's intention to perform the behaviour under consideration".

Whilst previous studies have investigated the behavioural affects of mobile fitness applications only (Bolin, 2013; Brunstein, Brunstein & Mansar, 2012: Direito et al., 2014) and found supportive evidence to encourage the adoption of mobile applications in tackling obesity and inactivity, this unique study examines empirically whether a wearable device, delivering highly accurate real-time information about a participant's day, and acting as somewhat of a constant motivational reminder tool, can encourage higher levels of physical activity engagement. Furthermore, this study seeks to investigate the validity of Ajzen's Theory of Planned Behaviour with technically recorded statistical data and identify whether the theoretical construct is a viable predictor of a person's engagement in physical activity behaviour under the influence of technology. In addition, this study investigates whether physical activity engagement is significantly affected by mobile communication usage and vehicle journey time. Inclusively, this study aims to build upon previous research, which has explored means of changing health behaviours (Rutter & Quine, 2002) and essentially 'plug a gap' in the literature relevant to today's technologically advanced society.

Hypotheses

Based on the literature review, the proposed hypotheses are:

H1 - There will be a significant difference in the total number of steps taken by adults when wearing an activity-tracking smart device.

H2 - There will be a significantly positive correlation between the theory of planned behaviour variables and the number of steps taken by adults wearing an activity-tracking smart device.

H3 – There will be a significantly positive relationship between mobile communication usage, vehicle journey time and physical activity engagement.

Methodology

Participants:

Sixty-nine healthy participants were recruited from mainly the Republic of Ireland and also the United Kingdom. The sample consisted of 41 men and 28 women between the ages of 18 and 64 years of age. All participants had ownership or access to a smart mobile device, running the Google Android operating system, for the two-week duration of the experiment. Participants were sourced using college notice boards, social media channels along with recruitment of friends, family and colleagues. Furthermore, snowball sampling was used to augment recruitment. As an incentive to participate, the Smartband activity-tracking device was offered as a gift. Signature consent was required from each participant before commencing.

Design:

The study was quantitative in nature, using a randomised mixed groups experimental design. Participants were assigned to either one of two groups receiving the Smartband tracker intervention at different time periods. The within groups independent variable was 'time' (Week 1 or Week 2) and the between groups independent variable was 'group' (Group A= Smartband for first week, no Smartband for second week – Lifelog application only), (Group B = Smartband for second week, no Smartband for first week – Lifelog app. only). The dependent variable was 'steps'.

The study also had correlational design aspects. Multiple regressions were used to test casual relationships between variables. In the second hypothesis, the predictor variables were subsection scores on the TPB measures; attitudes, subjective norms, perceived behavioural control and behavioural intentions. The criterion variable was 'steps'. In testing the third hypothesis, the predictor variables were 'transport hours' and 'communication hours'. The criterion was 'steps'.

Materials:

i) Each participant received either a printed and digital copy of a produced health warning/advice sheet (one-page A4 size), listing key points and statistics related to the health risks of obesity, physical inactivity and being sedentary (Irish Heart Foundation, 2015; WHO, 2015; Ng et al. 2014; Ekelund et al. 2015).

ii) The questionnaire contained two main sections. The first section sought to establish the participant's physical activity level at baseline by using the Godin Leisure-Time Exercise Questionnaire (Godin, 1997). Participants were asked "During a typical 7-Day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?" which had then three options to choose from "often", "Sometimes", "Never/Rarely". The second section of questionnaire used an identical replication of the physical activity designed TPB Questionnaire used by Armitage (2005) measuring the following variables at baseline on 7-point scales: attitudes, subjective norm, perceived behavioural control and behavioural intention. Guidelines in Theory of Planned Behaviour construction by Ajzen (2006) were noted. In measuring attitude, participants were asked to rate the following stem on a scale of 1 to 7: "For me, participating in regular physical activity would be . . . " which was then anchored by the adjective choices of *dull–interesting, unpleasant–pleasant, boring–stimulating, unhealthy–healthy, bad–good,* and *useless–useful*. The mean of the six responses was used as a measure of attitude. In measuring Subjective norm, the following were rated on a scale of 1 to 7 and the mean of the total used: "*People close to me think I should participate in regular physical activity… disagree/agree";* "*People who are important to me would . . . disapprove of my participating in regular physical activity/approve of my participating in regular physical activity*"; and "*People close to me think I . . . should not participate in regular physical activity/should participate in regular physical activity*". The mean of the three responses was used as a measure of subjective norm. To measure perceived behavioural control, the following were rated on a scale of 1 to 7 and the mean average of the total used: "To what extent do you see yourself as being capable of participating in regular physical activity*? incapable–capable";* "How confident are you that you will be able to participate in regular physical activity*? not very confident–very confident*"; "I believe I have the ability to participate in regular physical activity*... definitely do not–definitely do*"; and "How much personal control do you feel you have over participating in regular physical activity*?... no control–complete control".* To measure Behavioral intention, the following were rated on a scale of 1 to 7 and the mean average of the total used: "How often do you intend to take part in regular physical activity? *never–frequently,*" and "I want to exercise regularly… *definitely do not–definitely do*". According to Armitage (2005), Cronbach's alpha indicated good internal reliability on each of the scale measurements. Scoring: In each category of questions, the mean of the items are taken and used as a measure.

iii) Each participant was also provided with a second information sheet – "The 10,000 steps challenge" taken from the UK's National Health Service website - detailing the recommended daily step count of 10,000 steps along with further information explaining the benefits of walking, the calories burned from 10,000 steps, the best way to start and recommendations on how to go about achieving this.

Apparatus:

i) A unit of the Sony SmartBand SWR10 with activity-tracking technology was provided to each participant. The Smartband device is essentially a rubber wristband with a removable core tech component, which is paired via Bluetooth with the participant's Android mobile device. Waterproof and comfortable in design, the SmartBand allowed participants the option of wearing for 24/7, recording accurate daily activity levels of the participants. Also included with the device, was a Smartband charger and an easy-to-use step guide.

ii) The Sony Mobile Lifelog application (includes GPS tracking technology) was downloaded onto the participant's smartphone mobile device. Working as standalone or in unison with the Smartband when paired, this mobile application automatically measured, uploaded and recorded the required experimental data. Physical activity stats were automatically measured, recorded and uploaded throughout the two-week period. Activity categories tracked include: walking, running, and cycling. Two more categories of information were collected and stored: The participant's travel time made by vehicle (i.e. car, bus) and the participant's time spent communicating by mobile (i.e. texting, calling, emailing, social media).

Procedure:

Prior to commencement, an information sheet outlined the purpose of the experiment to the participant and the right to withdraw at any time. Furthermore, ethical approval was sought and approved by both the DBS ethics committee and

Sony Mobile Communications for use of Smartband SWR10 product. The experiment began with the first intervention; participants were presented with the health warning/advice sheet and asked to read through it. Time was allowed for open discussion or questions posed to experimenter. Upon completion of the required questionnaire and TPB measures, a short tutorial and set-up was given on the Sony SmartBand SWR10 and Lifelog application. Lastly, each participant was provided with the details on how to achieve an easy-to-follow goal of 10,000 steps a day. Participants were not bound to any goal or target but simply presented with the relative information to encourage a more active lifestyle. In order to retrieve the necessary data, participants followed instructions by taking mobile phone screen-shots of the require elements and forwarded by email or WhatsApp messaging service after the two week completion period. The Smartband served as a dual purpose. Firstly, to record and store accurate activity data, even when the user had left their phone away from them, for example at a work desk when going for a coffee or at home on a kitchen table and not in their pocket. Secondly, the Smartband acted as a discreet motivational tool in that it was always on and insight acting as a visual reminder.

Instructions for week without Smartband device:

Participants were instructed to maintain their mobile phones on them at all times in order for the Lifelog application to collect the relevant data precisely.

All participants were debriefed at end of experiment and given the opportunity to ask questions and also communicate whether any issues or constraints occurred during the experiment period. Relevant feedback was noted.

Results

Descriptive Statistics

Thirty-six participants were assigned to group A and thirty-three participants to group B. Table 1 shows the sample (N=69) consisted of 41 males (59%) and 28 females (41%). The age of participants ranged from 18-24 years (7.2%), 25-34 years (44.9%), 35-44 years (37.7%), 45-54 years (7.2%) and 56-64 years (2.9%). When wearing the Smartband tracker device, males took more steps than females on average over the week. The mean for males was 50068 steps (SD=23487) and the mean for females was 41159 (SD=19262). When not wearing the Smartband tracker device, males still averaged more with a mean for males of 40352 steps (SD=21094) and mean for females of 26591 (SD=18243).

The mean score for both male and female of all age categories on steps taken while wearing the Smartband was 46453.03 steps (SD=22164.38) and while not wearing the Smartband was 34768.20 steps (SD=21025.68). The results indicated that only 9% of participants reached the 70,000 weekly steps recommendation when wearing the Smartband while only 7.3% of participants achieved the recommended amount while not wearing the Smartband. 76.8% of participants improved their steps count with the Smartband and 23.2% of the participants took more steps the week without. 39.1% of participants in this study surpassed 50,000 steps within the week while wearing the Smartband.

Figure 1 show the results of when asked how often in a typical 7-day period would the participant engage in activity long enough to work up a sweat, 42% (N=29) chose ‘often’, 43.5% (N=30) chose ‘sometimes’, and 14.5% chose ‘never/rarely’.

Table 1 Demographic Variable Descriptives

Variable	N	%	Mean	SD
Gender				
Male	41	59	-	-
Female	28	41	-	-
Age				
18-24	5	7.2	-	-
25-34	29	44.9	-	-
35-44	27	37.7	-	-
45-54	5	7.2	-	-
55-64	2	2.9	-	-
Steps per Sex				
Males with Smartband	41	59	50068.44	23487.48
Males without Smartband	41	59	40352.17	21094.40
Females with Smartband	28	41	41159.68	19262.85
Females without Smartband	28	41	26591.68	18243.75
Total Steps of Participants				
_with Smartband	69	100	46453.03	22164.38
_without Smartband	69	100	34768.20	21025.68

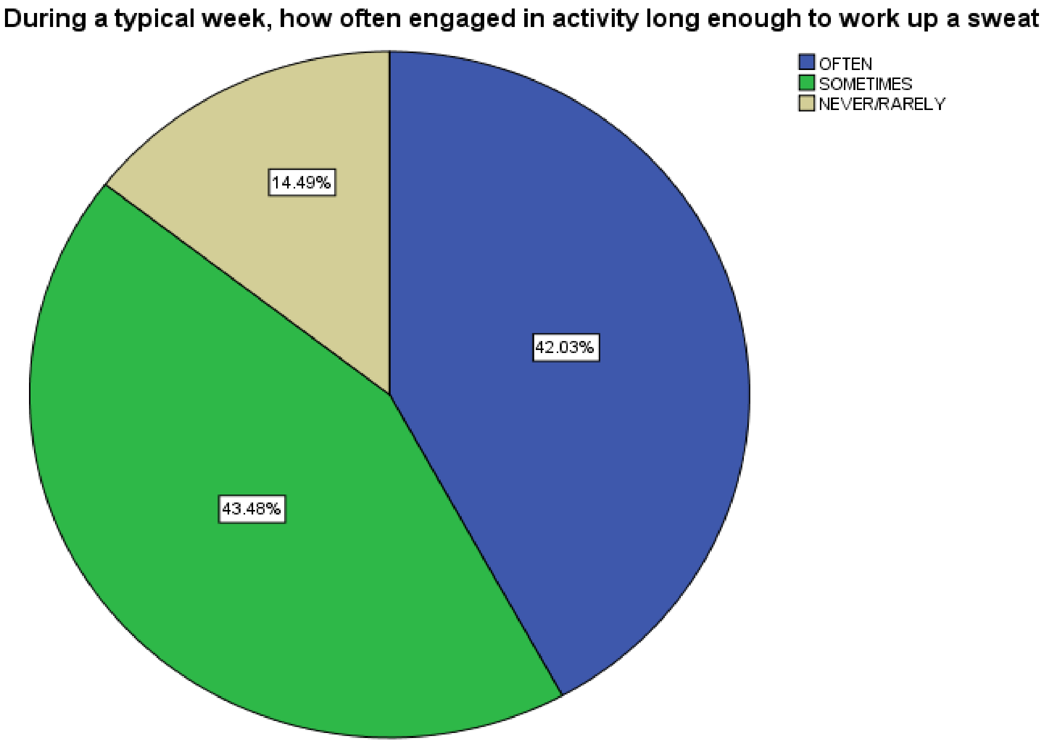

Figure 1. Pie chart with split of participant physical activity levels.

Inferential Statistics

H1: Screening of data was carried out to ensure all variables met the criteria for assumptions of a two-way mixed analysis of variance. Table 2 shows the summary of results from the analysis that found there to be a significant interaction effect between the time wearing the Smartband activity-tracking device and the time not wearing the Smartband (F (1, 67) = 39.82, p < .001) with an effect size of 37%. In relation to main effects, there was no significant difference of steps if allocated to Group A versus steps if allocated to Group B (F (1, 67) = .61, p = .439), indicating that the health guide sheet as an intervention had not a significant impact. There was also no significant difference in steps between groups (F (1, 67) = .48, p = .491) with an effect size of .7%.

Table 2 Analysis of Variance Summary

Variables	Groups	Means	SD	df	F	Sig.	Eta^2
Time (Wk1)	A	47375.67	23737.03	1, 67	.61	.439	.009
	B	32250.24	22919.15				
Time (Wk2)	A	37076.33	19161.86	1, 67	.48	.491	.007
	B	45446.46	20631.12				
Time * Group	A, B			1, 67	39.82	.000**	.373

** $p < .001$.

Figure 2 is a bar chart representing the mean scores for the number of steps taken by participants over the two-week period in their designated groups. During week1, participants of Group A (N=36) who wore the Smartband, had a mean score of 47375.67 steps (SD=23737.03) and Group B (N=33) who didn't wear the Smartband, had a mean score of 32250.24 steps (SD=22919.15). During week2, when Smartband usage was reversed, participants of Group A averaged 37076.33 steps (SD=19161.86) while Group B averaged 45446.46 (SD=20631.12).

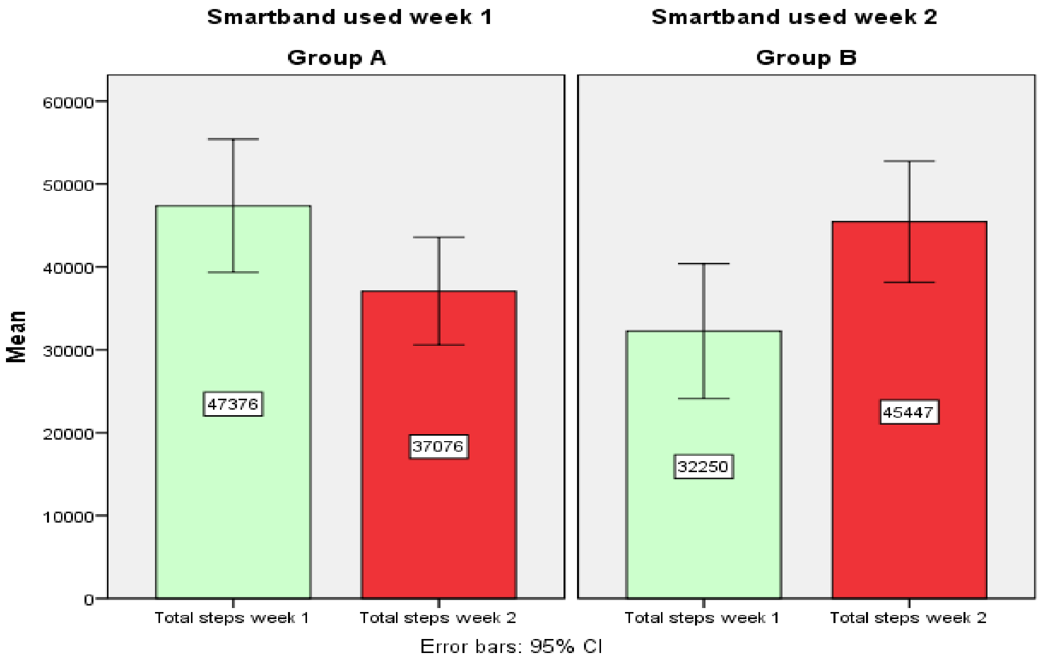

Figure 2. Bar chart showing mean number of steps per group over two weeks

H2: A preliminary screening of data was carried out to ensure all variables met the criteria for assumptions of multiple regressions (i.e. Pearson correlation, multicollinearity, multivariate outliers). The scores on all of the theory of planned behaviour variables were very positive indicating strong intentions and positive attitudes towards engaging in physical activity. Mean scores for each of the theory of planned behaviour constructs fell above each of the midpoint of scale responses. Table 3 presents the descriptive statistics and the bivariate correlations between the theory of planned behaviour variables and steps measured while wearing and while not wearing Smartband activity-tracking device. The zero-order correlations revealed attitudes, subjective norm and perceived behavioural control were significantly correlated with behavioural intentions. None of the variables were significantly correlated with steps taken with the Smartband or steps taken without the Smartband.

Table 3 Zero-Order Correlations, Means and Standard Deviations of Variables

Variable	1	2	3	4	5	6	M	SD
1. Attitude	—	.18	.45**	.52**	-.08	-.01	6.19	.70
2. Subjective norm		—	.32**	.25*	-.05	.04	6.10	1.06
3. Perceived behav. cont.			—	.56**	.06	.22	6.08	.95
4. Intention				—	-.01	.06	5.98	.94
5. Steps with Smartband					—		46453.03	22164.38
6. Steps without Smartband						—	34768.20	21025.69

* $p < .05$. ** $p < .01$.

In testing the hypothesis, a number of multiple regression analyses were computed. The first tested the validity of the theory of planned behaviour with behavioural intention regressed on attitude, subjective norm and perceived behavioural control. The results of the regression indicated that three variables accounted for 38% of the variance in participant's behavioural intentions to engage in physical activity (R^2 = .38, F (3, 65) = 14.94, p < .001). Participants' attitudes towards physical activity (β = .335, p = .003, 95% CI = .164-.738), subjective norms (β = .057, p = .574, 95% CI = -.128-.229), and perceived behavioural control (β = .393, p = .001, 95% CI = .169-.607), were positively correlated with intentions.

In the second multiple regression analysis, behavioural intention and perceived behavioural control were tested to determine if they were predictors of physical activity (steps) when wearing the Smartband. The results of the regression indicated that the two predictors explained 2% of the variance (R^2 = .024, F (2, 66) = .19, p = .829). It was found that perceived behavioural control did not predict steps (β = .090, p = .544, 95% CI = -4790.683-9009.847) and behavioural intention did not either (β = -.059, p = .693, 95% CI = -8363.480-5595.075).

In the third multiple regression analysis, behavioural intention and perceived behavioural control were tested to determine if they were predictors of physical activity (steps) when *not* wearing the Smartband. The results of the regression indicated that the two predictors explained 3% of the variance (R^2 = .03, F (2, 66) = 1.87, p = .163). It was found that perceived behavioural control did not predict steps (*β* = .268, p = .068, 95% CI = -448.660-12324.269) and behavioural intention did not either (*β* = -.087, p = .551, 95% CI = -8398.867-4520.0321). Table 4 shows a summary of each of the multiple regression results.

Table 4 Multiple Regression Analysis Predicting Intention and Physical Activity Steps

Criterion and Predictor	R^2adj	F	*df*	*β*
Predicting Intention	.38	14.94**	3, 65	
Attitude				.34**
Subjective norm				.06
Perceived behavioural control				.39**
Predicting Steps with Smartband	.02	.19	2, 66	
Intention				-.06
Perceived behavioural control				.09
Predicting Steps without Smartband	.03	1.87	2, 66	
Intention				-.09
Perceived behavioural control				.27

** $p < .01$.

H3 the hypothesis was tested using multiple regressions to analyse any significant relationship between total time spent travelling by vehicle transport, total time spent communicating by mobile and the total number of steps taken. Neither transport (*β* = -.014, p = .915) nor communication (*β* = .053, p = .684) were significant predictors of engagement in physical activity (steps taken) for participants of week 1. Both variables explained 3% of the variance (R^2 = .030, F (2, 60) = .09, p

= .914). For participants of week 2, transport (β = .004, p = .978) was not a predictor and nor was communication (β = .061, p = .647). Both variables explained 3% of the variance (R^2 = .030, F (2, 59) = .11, p = .892). Table 5 shows the summary of analysis.

Table 5 Multiple Regression Predicting Physical Activity Steps Regressed with Time Spent Communicating by Mobile and Time Spent Travelling by Vehicle

Criterion and Predictor	R^2adj	F	*df*	β
Predicting Steps with Smartband	.03	.09	2, 60	
Communication				.05
Transport				-.01
Predicting Steps without Smartband	.03	.11	2, 59	
Communication				.06
Transport				.00

Discussion

The present study had a number of objectives. The first was to determine whether mobile connected activity-tracking smart devices could positively change physical activity health behaviour. The second objective of the present study was to investigate the predictive utility of the Theory of Planned Behaviour (TPB) across a wide age range sample of adults who participated by wearing an activity-tracking technological intervention. The third objective was to explore any relationship between the amount of time spent travelling by vehicle (i.e. car or bus) and the amount of time spent communicating by mobile (i.e. texting, calling, emailing, social media) on a person's levels of physical activity (measured in steps) engagement.

The results of both Smartband weeks and non-Smartband weeks show that males were significantly more active that females. These findings were consistent with findings from previous physical activity research (Azevedo 2007; Davis et al. 2009; Bardus 2012). According to the National Health Service (2015), a person takes on average 3,000-4,000 steps per day. The findings of this study held some support for this with average daily steps count of participants without the Smartband being 4966 steps. However, with an average of 6636 steps per day taken when wearing the Smartband, this indicates a strong increase (approx. 25%). Interestingly, many health organisations also advocate a 5-day a week physical activity target and although while wearing the Smartband, less than ten percent of participants reached the 70,000 weekly steps marker recommended by health organisations (Irish Heart Foundation, 2015; NHS, 2015), of interest is that 39.1% of participants in this study surpassed 50,000 steps within the week while wearing the Smartband. This is encouraging as it suggests that the integration of smartphone technology in changing physical activity behaviour has positive immediate effects and supports related discussions outlined by Luxton et al. (2011).

The preceding analysis supported the first hypothesis with results indicating a strong uplift in the number of steps taken while wearing the Smartband activity-tracking device. In addition, the findings suggest that receiving health warnings/advice messages are not a significantly influential factor in changing physical activity health behaviour. Importantly, these findings support the inclusion of self-monitoring technology as an effective tool in positively changing physical activity health behaviour. Furthermore, findings suggest that worldwide health organisations such as World Health Organisation, Irish Health Organisation and the UK's National Health Service may need to review and adapt their approach somewhat, insofar as physical activity health warnings and advice alone, are perhaps not as greatly affective as other potential alternatives or additions. Recommendations for stronger health warning messages through practical visual examples are advised. One commonly used method is the use of advertisement called "shock advertising" where messaging and imagery are used to disturb the target audience. Research by Manchanda, Dahl and Frankenberger (2002) found support for its use, however, the effectiveness of shock advertising in the modern era has been questioned, with suggestions that an alternative method is required in order to capture the attention of audiences (Urwin & Venter, 2014).

In testing the second hypothesis, findings indicated that the Theory of Planned Behaviour was not a strong predictor of physical activity engagement whether wearing or not wearing the activity-tracking Smartband. Although, the TPB model has had substantial support for predicting physical activity behaviour (Galea & Bray, 2006; Armitage, 2005), there was no supportive evidence found in this present study and the null cannot be rejected. The findings raise questions to the validity of TPB's model in terms of its application in a modern day setting where technology and the development of smart connected devices that allow real-time precise activity-tracking capabilities have become very relevant. The evidence indicates an unpredictably of the level of physical activity a person may engage in and be spurred on if wearing an activity tracking-device.

In testing the third hypothesis, findings indicate that neither the time a person spends travelling by means of transport such as car or bus, nor the time a person spends communicating by mobile device, have any significant determination on the level of physical activity that person engages in. These findings counter those found by Lepp et al. (2013) linking physical inactivity with heavy mobile phone usage. The findings also counter suggestions and claims made linking the usage of sedentary modes of travel to causes of obesity and inactivity (Kozo et al. 2012; National Heart, Lung and Blood Institute, 2016; Harvard T.H. Chan, 2016, para 10-13). As such, the null cannot be rejected.

Upon completion of experiment, feedback was gathered from the participant's available to comment, which included the majority of sample. Some important observations were noted. Firstly, a very high number of the participants explained that they felt propelled to engage in more physical activity more so when wearing the Smartband and that this was purely due to the Smartband being constantly strapped to their wrist, acting as somewhat of a constant all-day reminder. This is interesting, as bearing in mind, the Lifelog mobile application remained operational also during the week-off (no Smartband) period, still collecting data and allowing participants to easily check their daily activity recorded levels. Secondly, participant's explained that the real-time data that was collected and observational through the Lifelog application presented them with never seen before insights about their actions and these new "learnings" impacted their decisions more. For example: individuals were able to observe and compare calculations of their time spent physically active versus long hours travelling by car or public transport. These insights influenced decisions, for example, parking the car in a space further from the door or climbing the stairs instead of taking the elevator. Thirdly, some participants revealed a positive knock on affect on friends, family and work colleagues. For example, a participant sharing the same office environment as work colleagues, with similar daily hours spent stationed at a computer desk, explained how a behavioural change to physical activity had spread to the colleagues who had recognised similar patterns. Lastly, participants admitted that when paired with experimental partners, they felt a natural competitive driver. These last two points provide support for the findings by Farrell et al. (2016) suggesting relationship partners are influential to changing health-related behaviour in one another.

Limitations and suggestions for future research

In this study, the theory of planned behaviour components did not prove to be valid predictors of the physical activity a person might engage in whilst wearing a tracking device that allows the user to self-monitor their recorded activity statistics in real-time. However, a number of suggestions are made in order to investigate further the validity of the theory in a technology lead contextual setting. Inclusively, the experiment strengths, limitations and suggestions for future research are discussed.

Future research that gives closer examination to the theory of planned behaviour variables and their predictive measures within a setting open to influences by advanced technology is required. Although the theory of planned behaviour model has been applied profusely to social behaviours, the validity of the theory of planned behaviour measures appears to have never been tested in the context whereby an individual's behaviour is influenced and monitored by a mobile connected tracking device.

One key advantage had in this experiment is that the activity-tracking data records cannot be manipulated, avoiding for any misleading information or error in memory by the participant. However, a limitation is identified in the time spent not wearing the Smartband and relying solely on the Lifelog application to record accurate activity. Although participants were instructed to carry their mobile device with them as much as possible, some participants later admitted this wasn't always feasible. As such, the data captured from the participant's time without the Smartband may not be completely accurate.

Another limitation to the study was the short timeframe afforded to conduct the experiment. Although the experiment ran for a two-week period, the recruitment of participants and data collection occupied a number of months. Furthermore, there were a number of participants who had experienced set-up issues in the initial stages, which delayed the process. Retrieving data capture from participants was at times laborious. However, for the most part, participants were very efficient with delivery of data. A suggestion for future research would be to explore the development of habits and behavioural changes over a longitudinal experimental design. This would allow observation of genuine changes and the stability of behavioural characteristics. Additionally, both an increase in the experiment sample size as well as segmenting the sample to target individuals identified as physically underactive are suggested. Although the sample in this study was representative of the population, greater external validity would be achieved with a larger one. Due to material costs and availability, there was a further limitation to recruiting a larger sample. To offset costs and manage available device inventory effectively, relationship partners were recruited. In this instance, both participants would begin experiment in opposing weeks and rotate Smartband between week 1 and week 2. In summary, future research in this area of should aim to obtain larger funding support, greater freedom of time and a target a sample population identified as physically underactive.

Another suggestion for future research is to include a relationship partner element. According to Farrell et al. (2016), relationship partners play an influential role in the health related behaviour of one another. Feedback received from participants in this study would suggest this is an avenue worth pursuing.

It was observed that some participants felt inclined to achieve a certain number of daily steps in order to impress, avoid embarrassment or not “let down” the experimenter. Future research needs to address this issue by reducing the familiarity between experimenter and participants. A longitudinal design experiment may help reduce this and allow patterns to be identified.

Conclusion

In conclusion, this unique study differs from many previous studies analysing health behaviour in that it involved the use of relevant modern day technology in the investigation. The findings support the endorsement and use of self-monitoring activity-tracking devices in the domain of health. However, the sustainability of targeted health behaviour is yet to be explored and a number of shortcomings still exist in the research with future research options plentiful. Furthermore, it would be valuable to closely examine the theory of planned variables in relation to a technologically influenced context.

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Appendices

Theory of Planned Behaviour measures (Armitage, 2005):

Participant Instructions

Please answer each of the following questions by circling the answer that best describes your opinion.

Some of the questions may appear to be similar, but they do address somewhat different issues. Please read each question carefully.

In making your ratings, please remember the following points:

* Be sure to answer all items – do not omit any.

* Never circle more than one number on a single scale.

1. For me, participating in regular physical activity would be:
   dull*:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:interesting*

2. For me, participating in regular physical activity would be:
   unpleasant*:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:pleasant*

3. For me, participating in regular physical activity would be:
   boring*:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:stimulating*

4. For me, participating in regular physical activity would be:
   unhealthy*:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:healthy*

5. For me, participating in regular physical activity would be:
   bad*:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:good*

6. For me, participating in regular physical activity would be:
   useless*:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:useful*

7. People close to me think I should participate in regular physical activity.
   disagree: 1 : 2 : 3 : 4 : 5 : 6 : 7 *:agree*

8. People who are important to me would . . . *disapprove of my participating in regular physical activity:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:approve of my participating in regular physical activity*"

9. People close to me think I . . . . *should not participate in regular physical activity:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:should participate in regular physical activity.*"

10. To what extent do you see yourself as being capable of participating in regular physical activity? *incapable:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:capable*

11. How confident are you that you will be able to participate in regular physical activity? *not very confident:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:very confident*

12. I believe I have the ability to participate in regular physical activity. *definitely do not :* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:definitely do*

13. How much personal control do you feel you have over participating in regular physical activity? *no control :* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:complete control.*

14. How often do you intend to take part in regular physical activity? *never:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:frequently*

15. I want to exercise regularly. *definitely do not:* 1 : 2 : 3 : 4 : 5 : 6 : 7 *:definitely do*

Leisure-Time Exercise Questionnaire

Godin, G., & Shephard, R. J. (1997).

INSTRUCTIONS

Please answer the following question as honestly as possible.

Participant Question:

1. During a typical **7-Day period** (a week), in your leisure time, how often do you engage in any regular activity **long enough to work up a sweat** (heart beats rapidly)?

OFTEN	SOMETIMES	NEVER/RARELY
1. ☐	2. ☐	3. ☐

Please circle you relative age group:

18-24 years old	25-34 years old
35-44 years old	45-54 years old
55-64 years old	65 or older years old

Research Topic: Health Behaviour with Activity Tracking Technology

You are invited to participate in a research study that will form the basis for an undergraduate thesis. Please read the following information before deciding whether or not to participate.

What are the objectives of the study? The full nature of this study requires participants to be naive to the exact research question, as information about the research may influence your behaviour and responses. For this reason we can only inform you that we are conducting research on the physical activity behavioural intentions of adults. A complete debriefing will be offered after participation, where any questions will be answered.

Why have I been asked to participate? I would like to collect information from different people. The research requires participants to take part that meet the following criteria. Each participant should:

- be 18 years of age or more
- be of considerable good health (free from illness or injury)
- Have ownership or access to an Android mobile device for duration of the experiment

What does participation involve?
Firstly, participants are asked to complete a short set of questions related to their levels of physical activity and health behaviour.
Participants are asked to allow the Sony Mobile Lifelog GPS tracking application downloaded on their mobile phone device to allow accurate records of the participant's daily physical activity levels.
Participants are asked to wear an activity-tracking device for the duration of 1 full week.
Finally, the researcher will meet with the participant after the completed 2 weeks to collect equipment, collect the statistical data from the Lifelog application and collect participant feedback. Photographic screen-shots of the data may be taken and temporarily saved. This will help speed the process.

Right to withdraw Participants have the right to withdraw from the research at any time for whatever reason. Participants can also request at any time to have their response data removed from record.

Confidentiality All individual information collected, as part of the study will be used solely for presentation purposes. Should this study be published, only pooled results will be documented. At no point will any participant be identifiable. All data will be stored safely and destroyed within a reasonable time frame.

Contact Details
If you have any further questions about the research you can contact:
Researcher Colin O'Shea: xxx@gmail.com
Supervisor Dr. Patricia Frazer: xxx or xxx@dbs.ie

13-14 Aungier Street,
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Website: www.dbs.ie

Researcher: Colin O'Shea
Supervisor: Dr. Patricia Frazer

Consent Form

A Study related to health behaviour and Activity Tracking Technology

I have read and understood the attached Information Leaflet regarding this study. I have had the opportunity to ask questions and discuss the study with the researcher and I have received satisfactory answers to all my questions.

I understand that I am free to withdraw from the study at any time without giving a reason and without this affecting my training.

I agree to take part in the study.

Participant's Signature: ______________________________ Date: _________

Participant's Name in print: _________________________

Participant Instructions

1) Please read through the included forms.
2) Sign consent form, take a picture and return via email or post forms back
3) Complete questionnaire, take a picture return via email or post forms back

Email: xxx@gmail.com

Address: XXX Dublin

Smatband Set-up instructions

- Your android mobile must have android software 4.4 or later – to check, go to: settings, scroll to "about phone" and then scroll to "android version".
- Charge your smartband for 30 minutes – this will give you approximately 5 days battery. You can use your mobile charger or the included data cable by plugging into a laptop.

Go to Google Play Store – download the following two apps:

- App1) Sony Lifelog – please enter app, login with Google+, then select "allow", then log into Lifelog with your age, weight, height, etc. I don't need any of this data. It is just to help the Smartband measure your activity better.
- App2) Sony Smartband SWR10 – this app will not appear on your apps box so don't worry if you don't see it. Just make sure it downloads correctly. There will be an automatic firmware update to update the software to the latest.
- Turn **Bluetooth** and **NFC** on, on your mobile. Put the smartband into pairing mode and pair with your mobile. Wait until it connects. You may need to try a couple of times.

  The best way to connect is through NFC (you may not have used this before but it's on your phones). Once you turn NFC on touch, the **white core** part of the smartband at the back of your phone. You may need to move it around the back of your phone until you find where the NFC magnet is. It's usually at the TOP - BACK part of your phone. If you connect via NFC, it will bring you to your Google Play store to download the Smartband SWR10 app AND also upgrade the firmware available for the smartband.

- You can check whether the smartband is connected to your mobile by scrolling down from the top of your mobile screen. It should say whether smartband is connected and how much battery you have remaining. It will also say if Lifelog is running.

If you go through to settings on the Smartband SWR app, you can choose some cool notifications like “smart wake-up, out-of-range alert, etc”.

Note the following:

- Please ensure your Bluetooth & NFC are on for the 2 weeks. Your Google GPS should also be on (unless you’ve turned it off already, it will be set to on).

- Please ensure the following sections are in your Lifelog applicaton: 1) Steps, 2) Transport (picture of a bus), 3) Communication (symbol of two people). If any of these are missing, please select “edit” and add them.

- Please wear the Smartband for 1 complete week. Please retain mobile phone on you 1 complete week **without** wearing it. Ensure that **Lifelog** app is installed and logged in for the complete 2 weeks.

The data required after two weeks is the following: total week **steps** count, total week **communication** hours (two people symbol), total week **transport**. If you could mail or whatsapp me screen shots, that would be perfect.

If you start the experiment midweek, for example on a Tuesday or Wednesday, you will need to send me 3 screen shots of each section (**steps, communications, transport**). This will cover the complete two weeks. 1 week with the smartband. 1 week without. I can help with this later so don’t worry.

Any questions or queries please mail me or message me on xxx

Each participant received print-out of following webpage re. 10,000 steps:

http://www.nhs.uk/Livewell/loseweight/Pages/10000stepschallenge.aspx