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Health empowerment through activity trackers: An empirical smart wristband study

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ABSTRACT

The increasing popularity of activity trackers has shown a remarkable shift in human computer interaction; individuals seem willing to wear a device that constantly tracks health related metrics such as movement, exercise, sleep, and calorie burn. Using the insights derived from their activity trackers, individuals are expected to be more empowered to set and stick to personal health goals. Whereas the outcome of using activity trackers is of great importance to both individuals and society at large, there are no empirical studies substantiating this presumption. This study aims to contribute to filling this research gap. Making use of self-regulation theory as theoretical framework, we developed a model that proposes six system specific elements (attractiveness, monitoring, feedback, privacy protection, readability, and gamification) as determinants of health empowerment, and thereof health commitment. Using survey data collected from individuals wearing smart wristbands ($N = 210$), the model was validated. Overall, the results provide strong support for the health empowering capabilities of smart wristbands. The paper concludes with implications for theory and practice, and some suggestions for future research.

1. Introduction

Following the increased attention toward healthier lifestyles in society, we recently have seen an increase in the adoption and use of so-called activity trackers (Martin, 2015). These activity trackers, which are usually offered to individuals as smart wristbands, watches, and clip-ons, represent a form of wearable technology that monitors and tracks activities such as movement, sleeping, and use of calories (Dontje, de Groot, Lengton, van der Schans, & Krijnen, 2015). With the collected data and presented information, users not only gain insight into their daily activities but are also supported in setting and adjusting personal health goals (cf. Quinlan, 2015). Remarkably, academic research into the use of activity trackers is scarce and has been openly demanded (Bice, Ball, & McClaran, 2015; Wiederhold, 2015). In this paper we aim to add to the underexplored field of activity tracker research by examining how and to what extent activity trackers may empower their users in setting and sticking to personal health goals. We believe the answers to these questions are of particular interest, as relationships between activity trackers and user empowerment implicitly have been suggested through related studies such as those involving mobile activity apps (e.g. Achterkamp Hermens, & Vollenbroek-Hutten, 2015; Bice et al., 2015). However, to the best of our knowledge, these relationships have never been tested.

We will focus our inquiry on smart wristbands because these constitute the largest segment of the activity tracker market (Statt, 2015), adding to the external validity of our study. Smart wristbands are devices worn on the wrist and constantly monitor an individual's activity, inactivity, light, and deep sleep, and feed back the information to an application on a mobile phone or tablet (Sullivan, 2013). The information usually is presented in a simple format, which displays the individual's current activity and compares it with their daily goals (Dominus, 2015). However, smart wristbands are not only used for utilitarian purposes, but also fulfill an aesthetic function and can give individuals an enjoyable, almost game-like experience, by having them set and achieve positive new health goals (Bice et al., 2015). It is the combination of utilitarian,

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aesthetic, and gamified elements that characterize the smart wristband as a multipurpose information appliance (Hong & Tam, 2006), which makes it of particular interest to see how and to what extent the different smart wristband characteristics may lead to feelings of health empowerment.

This paper intends to make three contributions to the existing body of literature. First, using the principles of self-observation and self-regulation as put forward in self-regulation theory as a theoretical anchor (Bandura, 1991), we propose and test a model relating system-specific characteristics of smart wristbands to perceptions of health empowerment and health commitment. As such, we intend to demonstrate the applicability of self-regulation theory as an explanatory mechanism in activity tracker settings and come up with observations regarding the overall influence of smart wristbands on user behavior in terms of setting and sticking to personal health goals. Second, by including attractiveness, monitoring, feedback, privacy protection, readability, and gamification as system-specific determinants of health empowerment (cf. Hong, Chan, Thong, Chasalow, & Dhillon, 2013) we intend to generate knowledge about the predictive validity of these individual system elements. Given the limited amount of research on actual influence of smart wristbands, this will lead to first insights into the relevance of these system-specific elements. Third, the findings of our study aim to serve various stakeholders associated with smart wristbands, as our results will show the extent to which the system-specific elements may empower their users in terms of achieving healthy behavior. Developers might use these insights to prioritize particular development efforts whereas health organizations might use the information to help their clients more effectively.

In the remainder of this paper we first provide a conceptual background by describing the concept of activity trackers and reviewing the few studies available. We then proceed with the introduction of our research model and hypotheses. Next, we present our research method and report on the outcomes of the data analysis. We conclude with a discussion of the implications of our findings for research and practice and highlight some interesting directions for future research.

2. Conceptual background

2.1. Activity tracker research

Activity trackers have been around for some time and can be used for routine daily activity as well as for monitoring more intense exercise (Dontje et al., 2015). Activity trackers have attracted the interest of the academic community at large (Bice et al., 2015; Dontje et al., 2015; Takacs et al., 2014). While such disciplines as movement science have been studying the technology for decades (Weerdesteyn, Nienhuis, Hampsink, & Duysens, 2004), information and social sciences have started to investigate rather recently what is growing to be a multi-disciplinary field (Achterkamp et al, 2015). One reason for this attention is we are seeing a widespread adoption due to the introduction of easy to wear and easy to use activity trackers, of which the smart wristband is one of the most prominent examples (Statt, 2015).

Past research has analyzed the benefits of smart wristbands from a variety of perspectives. Research on activity tracker usage in recovering patients suggests that the feedback of the health data could assist in returning to functional independence (Appelboom et al., 2014). Research in pharmaceutical literature has discussed whether health trackers such as smart wristbands should be recommended to the public in a similar manner as other health care devices (Mercer, Li, & Grindrod, 2015). The constant collection of health data has removed obstacles, which doctors and researchers have experienced, including time spent collecting data, patient/subject drop out rates, and subjective reports of health information (Appelboom et al., 2014). While past research on patients is encouraging, there is little research analyzing smart wristbands used by healthy individuals (Bice et al., 2015). Therefore, it is unknown whether utilization of a smart wristband contributes to empowering (healthy) users in setting and sticking to their health goals.

2.2. Empowerment

The concept of empowerment has its origins in the social sciences (Ward & Mullender, 1991) and has been most widely researched with organizational literature (Meyer, Allen, & Smith, 1993; Spreitzer, 1996; Thomas & Velthouse, 1990). Within this stream of research, researchers have studied quite extensively whether empowerment contributes to managerial effectiveness and work motivation (Gagné & Deci, 2005; Hochwalder & Bergsten Brucefors, 2005; Spreitzer, 1996). Health theorists have also adopted the empowerment concept, for example, in areas such as patient empowerment (Feste & Anderson, 1995) and consumer empowerment in healthcare (Lober & Flowers, 2011). Achterkamp et al. (2015) found that achievement feedback from mobile devices can increase elements related to empowerment in individuals striving towards a goal. The few studies we found mostly adopted research approaches analyzing an inter-device reliability. However, some studies focused on the impact of the technology on behavior of individuals (e.g. Dontje et al., 2015; Bice et al., 2015; Achterkamp et al., 2015), and showed significant influence on feelings such as affiliation, enjoyment, challenge, and positive health motivation (Bice et al., 2015).

In this study we consider empowerment from a self-regulation perspective. With the aid of the device's goal settings and feedback mechanisms an individual feels competent to define and impact their self-made goals. Unlike most past research the focus of this study is on individual health empowerment rather than empowerment inspired by another individual or authority. In other words, health monitoring is optional. We define empowerment as the belief that a person has a significant influence over an outcome, which includes: their ability to perform a task well or fit between the requirements of the tasks and their personal values, and feeling of control over the situation (Karasek & Theorell, 1990; Spreitzer, Kizilos, & Nason, 1997). This form of autonomy has proved to be a protective factor against ill health in the workplace (Spreitzer et al., 1997) and can be an important mechanism for reducing stress. We aim to add to past research by showing that smart wristbands positively influence feelings of health empowerment through self-made goals.

3. Research model and hypotheses

Fig. 1 displays the proposed research model. The overall structure of the model is rooted in the theory of self-regulation (Bandura, 1991), which postulates that human behavior is extensively motivated and regulated by the ongoing exercise of self-observation and self-influence (Bandura, 1991, p. 248). One of the presumptions of the theory is that people can only influence their own motivation and actions if they engage in self-observation of their activity. Such self-observation results in self-diagnostic information that is needed for setting behavioral goals and evaluating progress towards these goals. The theory further postulates that the collected self-diagnostic information has an important self-motivating function, that is, it gives people the capabilities to set goals of objective improvements and gives them the feeling that they can regulate these goals themselves (Bandura, 1991, pp. 250–251). This so-called self-regulation is, following Bandura and

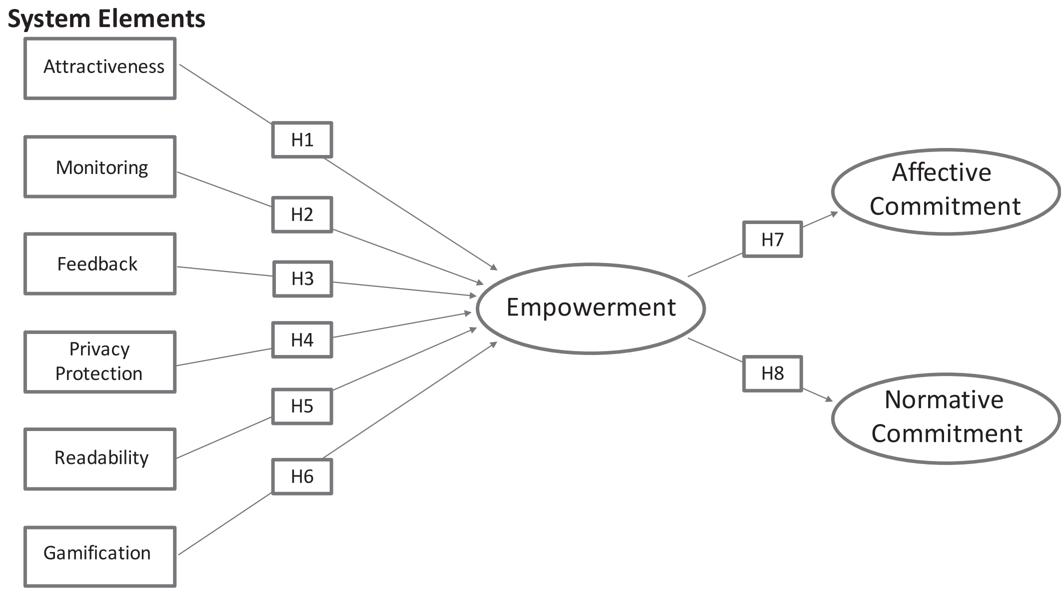

Fig. 1. Research model and hypotheses.

Schunk (1981), important because if people have the belief that they can set and regulate their own behavioral goals they will demonstrate higher levels of commitment to stick to these goals.

We position six system-specific characteristics of smart wristbands as independent constructs (cf. Hong et al, 2013) at the left side of the model; all characteristics enable smart wristband users to engage in self-observation or self diagnosis of their performances. The six characteristics were selected because they tap into the typical extrinsic values (monitoring, feedback, privacy protection and readability) and intrinsic values (attractiveness, gamification) that smart wristbands deliver to their users. To conceptualize the self-regulation stage, health empowerment is positioned in the heart of our model and, following the theory of self-regulation and the specific literature on commitment (e.g., Meyer & Allen, 1991; Meyer et al., 1993), leads to two types of commitment. In the next sections, we elaborate on all research constructs and their assumed interrelationships.

3.1. *The influence of system elements on empowerment*

3.1.1. *Perceived attractiveness*

Perceived attractiveness pertains to an individual's subjective reaction to a product's features (Badarudeen & Sabharwal, 2010) and represents the extent to which a person believes a product is aesthetically pleasing to the eye (Van der Heijden, 2003). It seems quite plausible to assume that perceived attractiveness of a smart wristband may influence empowerment because attractiveness has been found to influence all kinds of positive responses toward various forms of technology (Ben-Bassat, Meyer, & Tractinsky, 2006; Sonderegger & Sauer, 2010; Hartmann, Sutcliffe, & De Angeli, 2007; Hassenzahl, 2004). More specifically, attractiveness of a product has been related to consumer's self-confidence (see Micu, Coulter, & Price, 2009), which is a variable that is closely related to empowerment within the area of empowerment impact (Micu, 2013; Spreitzer, Dejanasz & Quinn, 1995). This constantly worn device must be a part of the personal belief state of the individual. Orth and De Marchi (2007) found that symbolic product beliefs fulfill personals needs such as approval and self-expression, and that symbolic beliefs are more important to the need for self expression or approval than experiential or functional product aspects (Orth & De Marchi, 2007). Given the above, we postulate:

H1. *Perceived attractiveness positively influences health empowerment.*

3.1.2. *Perceived monitoring*

Perceived monitoring encompasses the set of actions taken to ensure that all data transmissions are performed as determined by widely accepted agreements and rules for quality, delivery, and performance (Pavlou, 2002, p. 221). When worn, smart wristbands continuously monitor daily activities such as physical movement and sleep. There is evidence in the literature that leads us to assume that such monitoring contributes to health empowerment. It has been demonstrated, for example, that personal monitoring tools provide insight and empower individuals to achieve personal goals (Oakley, 1988; Holte-McKenzie, Forde, & Theobald, 2006). Furthermore, in a goal appraisal study, Karoly (2005) found self-monitoring to positively influence regular exercise. The logic for this finding is also reflected in studies within self-regulation theory, which has been applied to show that monitoring of self-driven goals indeed functions as an empowering process. These processes develop the analytical capacity of individuals to evaluate their own priorities and goals, make decisions, and take action (Gajendran & Harrison, 2007; Holte-McKenzie et al. 2006; Vancouver, 2008). Therefore, we hypothesize:

H2. *Perceived monitoring positively influences health empowerment.*

3.1.3. *Perceived privacy protection*

While past studies draw attention to identifying privacy concerns associated with technological innovation (e.g., Westin, 2003; Feng & Xie, 2014), the relevance of privacy protection has not been examined in the context of smart wristband usage. Still, as smart wristbands are personal devices that are supposed to be used privately, protection of privacy seems to be a priority for both individuals and corporations (Bansal, Irving, & Taylor, 2004; Baek, Kim, & Bae, 2014). Therefore, perceived privacy protection, that is, a consumer's perception of the likelihood that a smart wristband provider will protect consumer's confidential information, collected during electronic transfer, from unauthorized use or disclosure (Kim, Ferrin, & Rao, 2008, p. 551) may be a key factor in shaping user perceptions such as health empowerment. As previous research into empowerment indeed suggests that impressions of privacy protection might enhance feelings of empowerment (Conger & Kanungo 1988; Lanier & Saini, 2008), we arrive at the following hypothesis:

H3. *Perceived privacy protection positively influences health empowerment.*

3.1.4. Readability

The ease by with individuals can comprehend textual information is known as readability (Huenerfauth, Feng, & Elhadad, 2009). Readability is assumed to be of high importance in computer-mediated communication as it can avoid ambiguity of information transfer (Oquist, 2006; Sallis & Kassabova, 2000). Research into computer readability has demonstrated that, especially in situations where users make use of small screens, facets like a screen's size, design, contrast, and color, may influence the readability of the provided information (Oquist & Goldstein, 2003; Sharmin, Spakov, & Raiha, 2012; Ziefle, 2010). But also in health research there is a tradition of examining readability, where particular attention has been devoted to exploring how health information should be presented in order to assure an acceptable level of readability (e.g., Calderón, Morales, Liu, & Hays, 2006; Powers, 1988; Tarnowski, Allen, Mayhall & Kelly, 1990; Meade & Howser, 1991; Hopper, Lambe, & Shirk, 1993).

There is accumulating evidence in the literature that leads us to expect a positive influence of readability of the information provided by smart wristbands on health empowerment. Alghamdi, Yunus & Househ (2013), Alghamdi, Yunus & Househ (2014), for example, demonstrated that when readability on mobile devices is high, the individual will be able to grasp and understand health information better and thus seems to be able to make more informed health choices. A comparable observation comes from the work of Lorenz and Opperman (2009) who put forward that a better readability of the display of mobile devices contributes to a better understanding of health data and as such gives users the ability to act accordingly. Lober and Flowers (2011), in closing, state that the ease of reading health information through mobile devices leads to the so-called ‘technology-enabled patient’ or ‘e-patient’, that is, an individual who is equipped and empowered in his/her health decisions. In sum, the above leads to the following hypothesis:

H4. *Readability positively influences health empowerment.*

3.1.5. Gamification

Gamification refers to creating gameful experiences which include or make possible feelings of mastery, flow, and intrinsic motivations (Csíkszentmihályi, 1990; Deci & Ryan, 1985; Ryan, Rigby, & Przybylski, 2006) with the aim of supporting and motivating the users to perform certain tasks (Deterding, Dixon, Khaled, & Nacke, 2011; Koivisto & Hamari, 2014). In this case the individual is stimulated towards increasing activity and sleep through engaging daily goals. Gamification has emerged in the digital media industry (Paharia, 2010, 2011) where it has been labeled as “productivity games” (McDonald, Musson, & Smith, 2008), “surveillance entertainment” (Grace & Hall, 2008), “funware” (Takahashi, 2008) and “playful design” (Ferrara, 2012). Gamification also exists in the field of health applications, where it is being used to motivate and support users to perform exercises. Via the implementation of game-like components such as achievable goals, progress indicators, and encouragements, users are stimulated to increase exercise (Koivisto & Hamari, 2014). This mechanism, which predicates upon the notion that a difference between the perception of an individual's actual goals and desired states generates a tension that instigates action (Vancouver, 2008), typically applies to smart wristbands today where gamification is used to positively reinforce goal pursuit (cf. Palfai & Macdonald, 2007). Given that previous literature suggests that health goal pursuit in the format of a game could result in more investment in the process of striving toward these health goals as one perceives more empowered to do so (e.g., Kitsantas, 2000; Lippke Ziegelmann, & Schwarzer, 2004; Palfai & Macdonald, 2007), we propose the following hypothesis:

H5. *Gamification positively influences health empowerment.*

3.1.6. Perceived effectiveness of feedback

In essence, smart wristbands are biofeedback instruments that can measure physiological activity such as muscle activity, heart rate, and breathing (Chittaro & Sioni, 2014) and then “feed back” the collected data to its user. Subsequently, the user might use the biofeedback to learn about his/her physiological state and, if considered necessary, try to change his/her behavior in order to achieve a more optimal physiological balance (Chittaro & Sioni, 2014; Fairclough, 2009). Over time, these behavioral changes might even become integrated and automated without continued use of the biofeedback (Chittaro & Sioni, 2014). A key part of the feedback mechanism is the effectiveness by which the mechanism feeds back the health data to the user. Perceptions of feedback mechanisms in terms of its effectiveness have been studied in literature on a variety of technologies (e.g. see Dellarocas, 2003; Pavlou & Gefen, 2004; Abrahamse, Steg, Vlek, & Rothengatter, 2007; Nestoriuc, Rief, & Martin, 2008). Basically, a mechanism that is perceived to be highly effective is assumed to trigger an individual to involve him/herself more in the feedback process, and therefore may lead to a higher sense of empowerment (Spreitzer, 1995). This logic also is reflected in educational studies, where effective feedback has been demonstrated to empower individuals as self-regulated learners (Nicol & Macfarklane-Dick, 2006). When extrapolating this knowledge to smart wristband settings, the above makes it plausible to assume:

H6. *Perceived effectiveness of feedback positively influences health empowerment.*

3.2. The influence of health empowerment on commitment

The concept of commitment has a long history in employee research (e.g., Allen & Meyer, 1990; Mathieu & Zajac, 1990; Meyer et al., 1993) where it has been described as the psychological bond an employee has to their employing organization (Klein & Park, 2015, p.334). Also, marketing theorists have adopted the commitment concept in their research domain, mainly to study why individuals attach to particular products, brands, and service providers (e.g., Bansal et al., 2004; Dean, 2007; Gruen, Summers, & Acito, 2000). In this study, we bring the concept of commitment to health settings and define it as an individual's psychological attachment to self-made health goals (Blickem et al., 2011; Burton & Hudson, 2001).

There is relative consensus in the academic literature that commitment consists of multiple distinct dimensions (Dean, 2007; Meyer, Stanley, Herscovitch, & Topolnytsky, 2002). Here we adopt this conceptualization and focus on two of the most important types of commitment: affective commitment and normative commitment.[1] Affective commitment reflects a desire-based, positive feeling of attachment (Bansal et al., 2004; Dean, 2007), whereas normative commitment is derived from a sense of moral obligation; an individual acts in a certain way because he thinks he ought to (Bansal et al., 2004; Gruen et al., 2000).

To relate empowerment to commitment, we make use of three lines of reasoning. First, there are theoretical reasons to assume a positive influence of empowerment on commitment. Following self-regulation theory (Bandura, 1991; Bandura & Schunk, 1981), individuals who can exert an influence on their own health goals will feel more committed to stick to these goals (Bandura, 2005). Second, there is empirical evidence that higher levels of empowerment indeed lead to higher levels of commitment. In their study into the behavior of health nurses, for example, Chang, Shih, and Lin (2010) showed that empowerment does contribute to commitment. Third and finally, also at the level of the two types of commitment, there are supporting empirical results. Wasti and Can (2008), for instance, demonstrated that empowerment may have a positive influence on both affective and normative commitment. In sum, the above makes it plausible to propose the following two hypotheses:

H7. *Health empowerment positively influences affective commitment.*

H8. *Health empowerment positively influences normative commitment.*

4. Research method

To test our hypotheses, data were collected via an online questionnaire posted on online communities that were focused on smart wristbands. The goal of the posted surveys was to engage current users of smart wristbands to see if they were empowered by their smart wristbands to achieve self-made health goals.

4.1. Procedure

To collect data and assure an acceptable level of external validity, we approached eleven smart wristband communities via Facebook. The smart wristband communities provided general information on technology updates and tech comparisons, discussions, health challenges, and success stories to their online visitors. The communities, who mostly originated in the U.S., had an international reach and ranged from new to experienced users. None of the communities was sponsored by a particular wristband or company. After having asked for permission from the administrator of each community, we posted an invitation to complete an online survey on the communities' discussion boards. Visitors to the discussion boards were asked to participate and were offered the opportunity to register for the raffle of a new smart wristband device worth around 80 USD. A total of 210 respondents responded and completely filled in the online survey.

4.2. Measures

To measure the research constructs, we used five-point multi-item Likert scales (1 = totally disagree, 5 = totally agree). All selected measurement items were taken from previous empirical studies (see appendix A), where they were reported to meet the required psychometric levels of validity and reliability. The wording of some of the items was slightly adapted to make them more applicable to the context of our study. For instance, the wording of the items of the modeled determinants of health empowerment was modified to assure that all items referred to the technological artifact under study, that is, the smart wristband.

The measurement instruments for the six smart wristband-specific constructs were taken from previous studies within the fields of information systems, psychology, and advertising. The measures for perceived attractiveness were derived from Ohanian (1990), and included the following five items: attractive, classy, beautiful, elegant, and sexy. To measure the perceived monitoring construct we drew upon the studies of Chalykoff and Kochan (1989) and Kidwell and Bennett (1994), and accordingly used four items that tapped into the amount, presentation, constructiveness, and frequency of monitoring. Perceived privacy protection was measured using the measurement instrument as applied by Kim et al., (2008) and contained four items that reflected the use, sharing, access, and privacy of personal information. The measurement items for readability were borrowed from Huenerfauth et al., (2009), which resulted in a three-item scale that tapped into facets such as the length, interesting nature, and ease of understanding of the textual information provided. To measure the perceived effectiveness of the feedback provided we took the following four items from Pavlou and Gefen (2004): perceived accuracy, usefulness, effectiveness, and reliability. Gamification, in closing, was measured by adapting the measures as used by Witt, Scheiner, & Robra-Bissantz (2011), which resulted in a four-item measurement instrument that addressed the happiness, comprehension, and motivation individuals experienced when observing personal (health) progress in terms of percentages or points.

The measurement instruments for health empowerment and commitment were extracted from previous studies in the fields of organizational study and, following our research goals, adapted to make them suitable for personal health settings. As there is relative consensus in the literature that empowerment can be described best in terms of meaningfulness, competence, self-determination, and impact (Spreitzer, 1995; Thomas & Velthouse, 1990), we decided to measure the construct with a set of four beliefs that mirrored these facets (cf. Verhagen, Meents, & Tan, 2006). Affective commitment was measured using the four items: personal meaning, belonging, emotional attachment, and happiness related to goal striving (Meyer & Allen, 1991). Normative commitment was measured using the five items: guilt, loyalty, an obligation to remain, an obligation to the task, and feeling it wrong to leave, as described by Meyer and Allen (1991).

4.3. Sample/participants

Our research included 210 individuals (143 women, 67 men). All individuals owned a smart wristband which constantly measured activity, inactivity, and sleep. The smart wristbands all synced to a mobile app, which displayed the daily activity and sleep progress in comparison to the individual's pre-set goals. The majority of the sample was between the ages of 26 and 55 (n = 152, 72.4%). The majority of respondents reported wearing a Fitbit or Jawbone device (n = 129, 61.4%), which reflected the market presence at the time of the research (Pai, 2015). The majority of participants had been using their current wristband for 1 year or less (n = 135, 64.3%), (n = 39, 18.6) using their current devices for 1–2 years, and (n = 36, 17%) using their device for more than 2 years. Most (n = 156, 74.2%) of the respondents currently resided in the United States. Other respondents currently resided in Australia, Canada,

[1] A third type of commitment, continuance commitment (see Allen & Meyer, 1990; Meyer et al., 1993), was not included in this study because it concerns a calculative cost-based type of commitment (Bansal et al., 2004; Wetzels, de Ruyter, & Lemmink, 2000) and therefore was considered less applicable for a study into personal health settings.

and European locations. Table 1 shows the participant characteristics.

4.4. Pretest

The survey was developed through three stages of monitored trials. Twelve individuals in total participated in the pretest, 4 individuals in each stage. All participants were current smart wristband users with more than 6 months of use. The participants were asked to take the survey and make note during the process of any questions or uncertainty. Participants were instructed to make note of confusing or misleading wording while taking the survey and report in detail on which questions were unclear and why. Some phrasing had to be altered for better comprehension.

5. Results

Partial Least Squared modeling (PLS) was used to test the conceptual model. This decision was not only supported by the fact that the combination of the number of indicators in our research model and our sample size made PLS more suitable over covariance-based structural equation modeling (Duarte & Raposo, 2010; Reinartz, Haenlein, & Henseler, 2009), but also because PLS has proven to be effective when the research is chiefly predictive (Ringle, Wende, & Becker, 2014).

5.1. Test of measurement model

We used the software Smart PLS (Ringle et al., 2014) to test the adequacy of the measurement model. We first assessed the convergent validity and measurement reliability of the measures by computation of Cronbach's alphas, composite reliabilities and Average Variance Extracted (AVE) (see Table 2).

All results exceeded accepted criteria (factor loadings: 0.70; alphas and composite reliabilities: 0.80; AVEs: 0.50; see Hair, Black, Babin, Anderson, & Tatham, 2010). Thus, the convergent validity and reliability of the measures could be confirmed. Next, we assessed the discriminant validity of the measures by analyzing the cross-loading matrix in the PLS output. A visual inspection revealed that all items showed high loadings on the factor that they intended to measure while loading considerably lower on all other factors. As such, a first indication of discriminant validity at the item-level was obtained. We further tested the discriminant by making use of the Fornell-Larcker criterion (Fornell & Larcker, 1981) (See Table 3).

Table 1
Participant characteristics and descriptive measures (N = 210).

	n	n %		n	n %
Age			Country of residence		
<15	1	0.5%	US	156	74.2%
15–25	21	10.0%	UK	15	7.1%
26–35	64	30.5%	Canada	7	3.3%
36–45	58	27.6%	Netherlands	5	2.4%
46–55	30	14.3%	Australia	4	1.9%
56–65	18	8.6%	Sweden	4	1.9%
66–75	10	4.8%	Other	19	9.0%
>75	8	3.8%			
Brand of Wristband			How long have you been using your wristband?		
Fitbit	81	38.6%	0–5 months	93	44.3%
Jawbone	48	22.8%	6–12 months	42	20.0%
Misfit	26	12.4%	1–2 years	39	18.6%
Nike	21	10.0%	2 years	36	17.1%
Garmin	20	9.5%			
Other	14	6.7%			
Gender					
Male	67	31.9%			
Female	143	68.1%			

As all squared correlations between the constructs were lower than each of the individual AVE's of the constructs, the use of the Fornell-Larcker criterion confirmed the discriminant validity (see Table 4). Given recent debate about the possible limitations of the Fornell-Larcker criterion in variance-based structural equation modeling methods such as PLS (see Henseler, Ringle, & Sarstedt, 2015), we decided to conduct an additional discriminant validity test. Making use of the PLS output, we studied the heterotrait-monotrait ratio (HTMT), that is, the average of the correlations of indicators across constructs measuring different phenomena relative to the correlations of indicators within the same construct (Henseler et al., 2015, p. 121).

All HTMT values between the constructs were below the critical value of 0.85, which implies that discriminant validity between the constructs again was demonstrated. We concluded the assessment of our measurement model by testing for common method bias. We conducted Harman's single factor test by running an exploratory factor analysis (principle components analysis) on all measurement items (software package: IBM SPSS Statistics 23). If more than one single factor would have emerged or if the largest factor would have explained more than half of the amount of variance explained, then common method bias could have been an issue (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). As the factor solution resulted in multiple factors and given that the largest factor did only explain for 28% of the variance, evidence for common method bias was not found.

5.2. Test of structural model

We then estimated the standardized beta coefficients (b) and R^2values of the structural model (bootstrapping technique; 500 resamples) and assessed the significance of the path coefficients using a one-tailed P value estimation (cf. Kock, 2015). Fig. 2 displays the results.

Overall, the magnitude of the effects found and the amount of variances provided support for the hypothesized structure of our research model. In terms of the individual hypotheses, except for the influence of monitoring on health empowerment, all smart wristband characteristics contributed significantly to health empowerment. As such, hypothesis 2 was rejected whereas hypotheses 1, 3, 4, 5, and 6 could be accepted. As both assumed influences of health empowerment on affective commitment and normative commitment were significant as well, hypotheses 7 and 8 could also be confirmed. Table 5 summarizes the implications of the results for our hypothesis testing.

6. Discussion & conclusion

6.1. Key findings

The results of this study lead to two major findings that together answer our central research question. First, this study showed that the system-specific elements of smart wristbands do influence an individual's feelings of empowerment. Together, the six system elements explained 38% of the empowerment variance, which is quite encouraging given that an individual's health empowerment may be driven by multiple non-technological facets such as, a supportive community (Bartlett & Coulson, 2011), and additional intrinsic motivations related to improvement (Froiland, Oros, Smith, & Hirchert, 2012). When zooming in on the individual system elements, gamification and readability seemed to be the strongest empowerment determinants. Obviously, having a game-like experience and the ease of obtaining information from the smart wristband are of utmost importance when empowering one's health decisions. The provision of feedback, attractiveness

Table 2
Convergent validity: Cronbach's alphas, composite reliabilities and (AVE).

Construct	Number of items	Chronbach's alpha	Composite reliability	AVE
Attractiveness	5	0.93	0.93	0.72
Monitoring	4	0.87	0.912	0.72
Privacy protection	4	0.86	0.91	0.72
Readability	3	0.85	0.91	0.77
Feedback	4	0.84	0.89	0.68
Gamification	4	0.82	0.88	0.65
Empowerment	4	0.83	0.89	0.67
Normative commitment	5	0.88	0.91	0.68
Affective commitment	4	0.89	0.92	0.75

Table 3
Discriminant validity Fornell-Larcker criterion.

	1	2	3	4	5	6	7	8	9
1. Attractiveness	0.848								
2. Monitoring	0.101	0.850							
3. Privacy protection	−0.108	−0.210	0.848						
4. Readability	−0.112	−0.375	0.354	0.878					
5. Feedback	−0.023	−0.083	0.306	0.294	0.823				
6. Gamification	−0.039	−0.243	0.198	0.383	0.374	0.806			
7. Empowerment	0.059	−0.226	0.281	0.444	0.354	0.509	0.816		
8. Affective commitment	−0.032	−0.217	0.319	0.319	0.376	0.482	0.468	0.867	
9. Normative commitment	0.044	−0.266	0.261	0.389	0.306	0.579	0.590	0.721	0.825

Table 4
Heterotrait-monotrait ratio (HTMT).

	1	2	3	4	5	6	7	8	9
1. Attractiveness									
2. Monitoring	0.120								
3. Privacy protection	0.152	0.238							
4. Readability	0.157	0.423	0.407						
5. Feedback	0.065	0.097	0.356	0.362					
6. Gamification	0.105	0.277	0.240	0.451	0.471				
7. Empowerment	0.054	0.263	0.332	0.519	0.421	0.599			
8. Affective commitment	0.093	0.241	0.366	0.366	0.436	0.568	0.533		
9. Normative commitment	0.049	0.300	0.301	0.442	0.350	0.675	0.685	0.811	

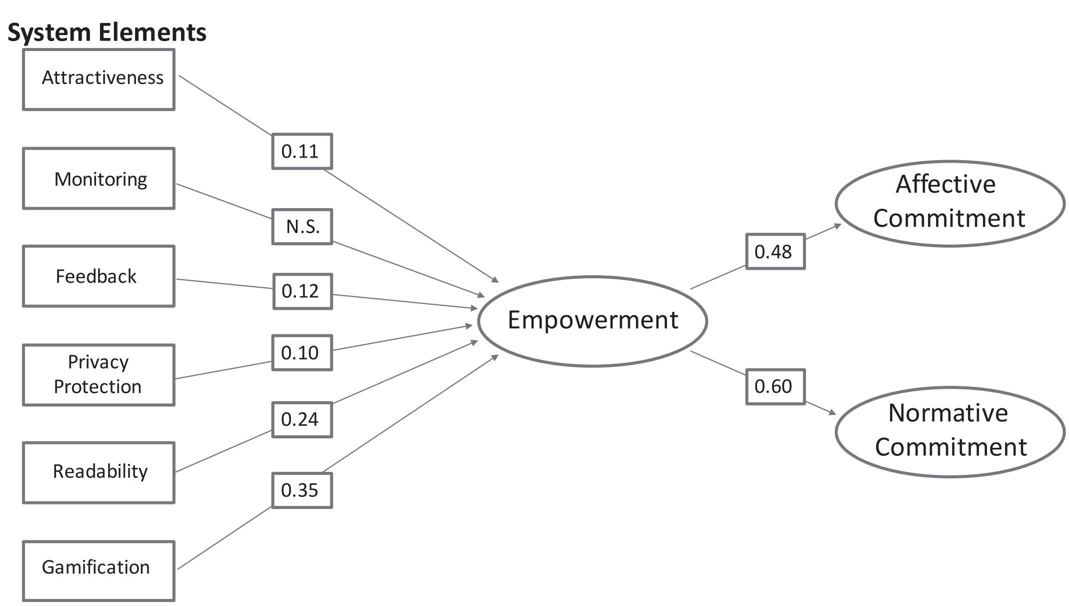

Fig. 2. PLS results of structural research model.

Table 5
Summary of the hypotheses testing results.

Hyp	Path	β	T-statistic	Sign.	Result
Hypothesis 1	Attractiveness → Empowerment	0.12	1.44	<0.05	Accepted
Hypothesis 2	Monitoring → Empowerment	- 0.03	0.55	N.S.	Rejected
Hypothesis 3	Feedback → Empowerment	0.12	1.76	<0.05	Accepted
Hypothesis 4	Privacy → Empowerment	0.09	1.50	<0.05	Accepted
Hypothesis 5	Readability → Empowerment	0.24	3.40	<0.01	Accepted
Hypothesis 6	Gamification → Empowerment	0.35	4.94	<0.01	Accepted
Hypothesis 7	Empowerment → Affective Commitment	0.47	7.41	<0.01	Accepted
Hypothesis 8	Empowerment → Normative Commitment	0.59	11.58	<0.01	Accepted

and privacy protection also mattered but their (significant) influence was rather weak in nature. So in terms of relative importance, these elements seem to be of another order. In contrast to our expectations, monitoring did not have a significant influence on empowerment. A possible explanation for this finding comes from the organizational literature where monitoring has mainly been associated with negative consequences for the individual, such as the invasion of privacy, dissatisfaction, stress, and distrust (Greengard, 1996; Lewis, 1999; Piturro, 1989). When extrapolating this logic to the context of smart wristband usage, it might well be that monitoring functions as driver of negative beliefs and attitudes rather than being a positive determinant of perceptions such as empowerment.

Second, our results confirm that health empowerment leads to normative and affective commitment. Empowerment accounted for 36% of the normative commitment variance and 23% of the affective commitment variance. In terms of relative importance, this finding slightly differs from previous research outcomes in the field of organizational science, where empowerment seemed to have stronger effects on affective commitment than on normative commitment (cf. Bansal et al., 2004). A possible explanation for this difference might be derived from the fact that our research centered on the use of smart wristbands in assisting individuals in monitoring and achieving self-made goals. As such, the moral obligation to stick to one's goals was mainly internal and no moral obligations set by external parties, such as the organization one is working for or the colleagues one is working with, exist. Thus, in an attempt to mirror reality, the influence of empowerment in our nomological structure could be centered on only one type of normative commitment, instead of being dispersed across multiple types of normative commitment that differ from each-other in terms of their target specificity (e.g., the organization; colleagues) (cf. Verhagen et al., 2006). This could have had, both in absolute as relative terms, an upward biasing effect on the influence of empowerment on normative commitment.

6.2. Theoretical implications

The findings of this study translate into three theoretical implications. First, this research cross-validated self-regulation theory (Bandura, 1991; Palfai & Macdonald, 2007; Vancouver, 2008) by extending it to smart wristband settings. We used the self-regulation principle as a theoretical anchor to examine the interaction of individuals with smart wristbands with the ultimate objective of seeing how this interaction adds to setting and sticking to personal health goals. Noticeably, the predictive validity of our model demonstrated that individuals indeed might engage in self reflective and self reactive action by using smart wristband technology as input for setting personal health goals and staying committed to these goals in both normative and affective terms. Thus, contextual extension of self-regulation theory was accomplished (Berthon, Pitt, Ewing, & Carr, 2002).

Second, at the system-specific level, we demonstrated that the system elements of smart wristbands individually contribute to health empowerment, specifically: attractiveness, feedback, privacy protection, readability, and gamification. While these elements may not be completely exclusive to smart wristband technology, they did demand renewed attention as they reflect typical characteristics of the technological artifact under study. By examining the influence of system-specific elements as determinants of empowerment and thereof commitment, we added contextual richness to the backbone of our research model and gained a deeper understanding of the influence of smart wristband technology. Such context-specific theorizing is openly called for as it helps us to understand the influence of the technology more thoroughly (Hong et al., 2013; Hong & Tam, 2006).

Third, we were amongst the first to bring the empowerment construct to the emerging domain of activity tracker research. The study inclusion of this construct helped us to generate first insights about the outcome of smart wristband use. We also obtained first insights into the predictive validity of the empowerment construct by including normative and affective commitment as behavioral outcomes. Given that the empowerment → commitment relationship was only investigated previously in the field of organizational studies (e.g., Chang et al., 2010; Wasti & Can, 2008), we generated first knowledge about the explanatory value of this nomological structure in smart wristband settings.

6.3. Implications for practice

This research has several practical implications. First, for organizations in the healthcare industry it seems of interest that our research outcomes suggest that smart wristband technology indeed might empower individuals in setting and monitoring personal health goals, and that this empowerment is to a large extent carried over to one's commitment to stick to these health goals. Keeping these findings in mind, health agencies might consider playing a more proactive role in having customers adopt activity trackers such as smart wristbands as this might effectively assist these customers in achieving a healthier lifestyle. On the longer term, this would not only be beneficial to the individual customer but also to society at large as a healthier lifestyle might translate into lower per person health costs. Costs has become a vital issue in today's society (Levey, 2015) this eventually could have important implications for all parties engaged.

Second, our research has highlighted the relevance of particular system-elements of smart wristbands. Developers and designers of smart wristband technology might use these insights to prioritize future developments. For instance, offering a game-like experience and assuring the provision of interesting and easy to read information were shown to give smart wristband users a substantially higher sense of empowerment. Designers and developers of smart wristbands might take this knowledge into account by focusing specifically on the implementation of more gamified elements and by keeping the user interfaces simple and informative. Additionally, elements such as attractiveness, provision of feedback, and privacy protection may be an area for future attention by developers. Designers of smart wristbands may continue designing wearable technology to be seen by the user and by others, for example, as being a fashion accessory (cf. Bearne, 2015). But also the accurate provision of feedback on one's progress and goal achievement and protection of privacy demand continued attention.

6.4. Limitations & future research

This research did experience a few limitations. First, participants were approached through online communities centered around brands of wristbands or wristbands in general. Therefore, it is possible that the surveyed individuals were more enthusiastic/committed to the technology than the average individual. Further research of activity trackers could be done through other channels to extend our findings to other samples. Second, while the goal of our research was to focus on some of the most important system elements, it did not intend to cover all system elements available. Given that the amount of variance explained still leaves room for further improvement, an extension of our model with other system elements could lead to additional insights. One possible extension could be to include the social aspects of activity tracker technology. As echoed in recent studies in the field of computer supported collaborative learning (e.g., Amara, Macedo, Bendella, & Santos, 2015; Järvelä et al., 2014; Järvelä & Hadwin, 2013; Ke & Hsu, 2015), individuals may not only use technology for the purpose of self-regulated learning but also benefit from the social interactions they have with others. This principle, which has been described as co-regulated learning (Järvelä et al., 2014), seems highly applicable to the context of activity tracker technology as its infrastructure enables social sharing of personal achievements as a way to motive individuals to set and stick to personal goals (cf. Munson & Consolve, 2012). Third, another interesting direction for extension could focus on what is known as embodiment, the process where the mind perceives an instrument/tool to be part of one's body (Kujundzic & Buschert 1994; Leder, 1990; Murray, 2004). While embodiment is a relatively old concept (Merleau-Ponty, 1962) it may prove greatly explanatory in measuring the interaction between individuals and smart wristbands. Future research could adopt the embodiment construct to see how it performs in relation to the system elements that were examined in this study.

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Appendix A

Item	Measures	Mean	SD
Attractiveness	ATT1: I find my wristband attractive	3.34	1.03
	ATT2: I find my wristband classy	2.99	1.05
	ATT3: I find my wristband beautiful	2.71	1.12
	ATT4: I find my wristband elegant	2.69	1.12
	ATT5: I find my wristband sexy	2.53	1.12
Monitoring	MON1: The amount of information I receive	4.01	0.72
	MON2: The way in which information is presented	4.08	0.65
	MON3: The constructiveness of the information	4.08	0.74
	MON4: The frequency you receive information	4.06	0.74
Privacy Protection	PRV1: My personal information won't be used without my authorization.	3.94	1.24
	PRV2: My personal information won't be shared with other entities without my authorization.	3.99	1.24
	PRV3: Unauthorized people don't have access to my personal information.	3.98	1.25
	PRV4: I am not concerned about the privacy of my personal information.	3.35	1.48
Readability	READ1: The length of the text is the right length	3.91	1.28
	READ2: The text is easy to understand.	3.75	1.44
	READ3: The text is interesting	3.79	1.39
Feedback	FDBK1: I feel confident that wristband's feedback mechanism gives accurate information	4.07	1.11
	FDBK2: A considerable amount of useful feedback information about my health of is available through wristband.	4.15	1.14
	FDBK3: I believe that the feedback mechanism in the wristband is effective.	4.11	1.10
	FDBK4: I believe that the feedback mechanism of the wristband is reliable and dependable	4.06	1.05
Gamification	GAME1: Gaining higher percentages of activity and sleep makes me happy.	3.91	1.35
	GAME2: The allocation of percentage points was comprehensible.	4.16	1.03
	GAME3: Gaining points increased my motivation to introduce further effort.	3.91	1.29
	GAME4: The increase of my percentage in the activity counter increases my motivation	3.93	1.33
Empowerment	EMP Competence: I am confident about my capabilities to perform my health goals.	3.87	1.38
	EMP Self Determination: I can decide on my own how to go about reaching my set health goals.	3.86	1.39
	EMP Impact: I have a great deal of influence on what happens with my health.	3.63	1.44
	EMP Meaning: I consider the activities I do for my health to be meaningful to me	3.65	1.44
Affective Commitment	AFCOM1: I would be very happy to spend the rest of my life achieving my health goals	3.89	1.37
	AFCOM2: I feel a strong sense of "belonging" to my health goals.	3.92	1.28
	AFCOM3: I do feel "emotionally attached" my health goals.	3.73	1.29
	AFCOM4: My health goals have a great deal of personal meaning for me.	4.07	1.30
Normative Commitment	NCOM1: I feel obligated to remain striving towards my health goals	3.72	1.40
	NCOM2: Even if it were to my advantage, I feel it would be wrong to leave my current progress.	3.75	1.22
	NCOM3: I would feel guilty if I left my health goals now.	3.66	134
	NCOM4: The process involved in reaching my health goals deserves my loyalty.	3.73	1.33
	NCOM5: I would not leave my current health goals right now because I have a sense of obligation to the goals set	3.61	1.30

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