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Another Step towards the Understanding of Self-Tracking: A Research Model and Pilot Test

Full Paper

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Abstract

Regular physical activity prevents the development of numerous diseases. Despite this knowledge, approximately 80% of the world's adolescent population leads a sedentary lifestyle. Insurances are trying to facilitate physical activity through supporting the use of self-tracking applications. Although the usefulness of self-tracking is widely presumed, only a few studies investigate the influence of self-tracking on behavior and those few studies have published contradictory results. To provide an explanation for the different reactions, we propose a research model and measurements based on the cognitive dissonance theory. The research model proposes that self-tracking leads to a higher awareness of two inconsistent cognitions. This awareness induces cognitive dissonance. Since cognitive dissonance is experienced as a psychological tension, people try to reduce it by changing their behavior, finding new information or ignoring the situation. We tested our measurements with a pilot test and found good first indicators for construct validity.

Keywords

Quantified Self, self-tracking, cognitive dissonance theory, pilot test.

Introduction

Regular physical activity such as walking prevents the development of coronary artery diseases (Thompson et al. 2003), diabetes, osteoporosis (Vuori 2001), obesity (Wing and Hill 2001) and depression (Pollock 2001). Despite these benefits, approximately 80% of the world's adolescent population is insufficiently physically active (WHO 2017). Insurances and other companies are trying to facilitate physical activity through supporting the use of self-tracking applications (AOK 2015; Bravata et al. 2007; Nikayin et al. 2014). Self-tracking is hereby defined as the regular collection of data about the self, such as biological, physical, behavioral or environmental information (Swan 2009).

Although the usefulness of self-tracking is widely presumed and the theoretical importance of computing in everyday life is highly acknowledged (Yoo 2010), few studies investigate the influence of self-tracking on behavior and those few studies have come up with contradictory results (Bravata et al. 2007; Jakicic et al. 2016; Sanchez-Valdes and Trivino 2015; Sjöklint et al. 2015). Therefore, the goal of this investigation is to find out how and why self-tracking influences behavior, emotions and cognition to find a potential explanation for the different responses. This understanding can assist the development of effective self-tracking applications, which help people to change their behavior in a desired way (Wendel 2013).

Our investigation is based on the cognitive dissonance theory, which is one of the grandest theories in social psychology (Aronson 1992) and combines emotion, cognition and motivation. The theory suggests that an inconsistency of attitude and behavior induces cognitive dissonance, which is a psychological tension (Festinger 1962). People who suffer from it try to reduce the dissonance by using three main strategies: (1) changing the behavior, (2) adding new cognitive elements through finding new information or (3) changing cognitive elements of the environment by, e.g. ignoring or denying the situation. These

strategies lead to a reduction as regards the inconsistency of attitude and behavior and thus reduce the psychological tension and unpleasant feelings.
To investigate how self-tracking influences behavior and cognition, we intend to explore the interrelationship between self-tracking and cognitive dissonance mechanisms.
This leads to the central research questions:
1. How and why does self-tracking interact with cognition, behavior and emotion?
This investigation presents the results of a pilot study. A confirmatory factor analysis based on 28 returned questionnaires has been done to gain first indications of construct validity. We have only investigated the measurement model not the structural model because of the small sample size. This paper is an important first step toward answering the research question by providing validated measurement instruments.
The remainder of this paper is structured as follows. In the next section, we present the theoretical background and the related work on self-tracking and cognitive dissonance theory. Next, the research model and the research methods are presented. After that, we discuss the results followed by a short conclusion.

Theoretical Background and Related Work

Self-Tracking

Self-tracking is defined as the use of technology to record and observe personal information for the purpose of self-reflection and self-knowledge (Choe et al. 2014). Self-tracking takes place in different areas, e.g. internal states (mood or galvanic skin response), performance values (pace or number of steps), habits (food intake or sleep) and actions (visited places) (Rapp and Cena 2014).

There are only a few investigations in the area of self-tracking and those few studies found different reactions to self-tracking usage. Bravata et al. (2007) found out that the use of classical mechanical pedometers in a clinical context leads to a desired change in behavior. Sanchez-Vales and Trivino (2015) conducted a single-subject experimental design and found different behavioral reactions to self-tracking usage. Some participants changed their behavior in a desired way while others did not. Jakicic's (2016) results suggest that the addition of wearable technology to a standard diet behavioral intervention program does not lead to more weight loss. Furthermore, Sjöklint (2015) discovered different reactions to the usage of self-tracking applications. In the case of not reaching the goal, participants use different coping tactics. The coping strategy disregard describes the tactic of formulating excuses as an explanation as to why the goal was not reached. Procrastination as a strategy invests in plans to reach the goal in the future. The strategy to focus only on goals that are easy to reach is called selective attention and neglect means that users only focus on self-tracking data when they are certain to reach their goal.

In a qualitative investigation, Baumgart (2016) suggests that the cognitive dissonance theory is a possible explanation for the diverse reactions to self-tracking. While this is a first indicator that the cognitive dissonance theory is applicable in a self-tracking context, there are no adequately tested measurement scales for a quantitative examination of the influence of self-tracking on behavior, emotions and cognition. We therefore conducted a pilot test, which is an important step towards the development of appropriate measurement scales and an initial indicator of validity and reliability (Recker 2012).

Cognitive Dissonance Theory

Cognitive dissonance is defined as a psychological discomfort arising in the presence of two inconsistent cognitions (Festinger 1962). Cognitive dissonance may result when the attitude and the behavior of one person are not in line with each other and little justification for that behavior is available. For example, cognitive dissonance can arise if a person is aware of the benefits of physical activity (attitude) but follows a sedentary lifestyle (behavior). The existence of cognitive dissonance, which is a psychologically uncomfortable state, motivates a person to reduce the dissonance with three different strategies: (1) changing behavioral cognitive elements, (2) adding new cognitive elements and (3) changing an environmental cognitive element. Changing behavioral cognitive elements means that a person changes the behavior (e.g. walks more steps) so that behavior and attitude match. Adding new cognitive elements means that a person searches for new information, which aligns behavior and attitude. If a person ignores

or denies the dissonance inducing situation, the dissonance reduction strategy changing an environmental cognitive element is utilized.

In psychological and marketing investigations, cognitive dissonance has been measured with various indirect measures by using experimental designs (Sweeney et al. 2010). These settings have been widely criticized because other explanations for the observed reactions of the participants are also available (Murray et al. 2012; Oshikawa 1969). The present study wants to address this problem by developing more direct measurements. While Sweeney et al. (2010) have operationalized the cognitive dissonance and Bhattacherjee and Premkumar (2004) have developed the expectation disconfirmation model, which is a modification of the cognitive dissonance theory in an Information Systems context (Bhattacherjee and Premkumar 2004), there is no operationalization of the three dissonance reduction strategies. We want to address this gap by developing and testing the three dissonance reduction strategy constructs.

Theoretical Framework

Based on the cognitive dissonance theory and Baumgart (2016), we derive the following research model and the respective measurement scales. The model shows the interaction between self-tracking and the cognitive dissonance theory. Figure 1 summarizes the constructs and the respective hypotheses.

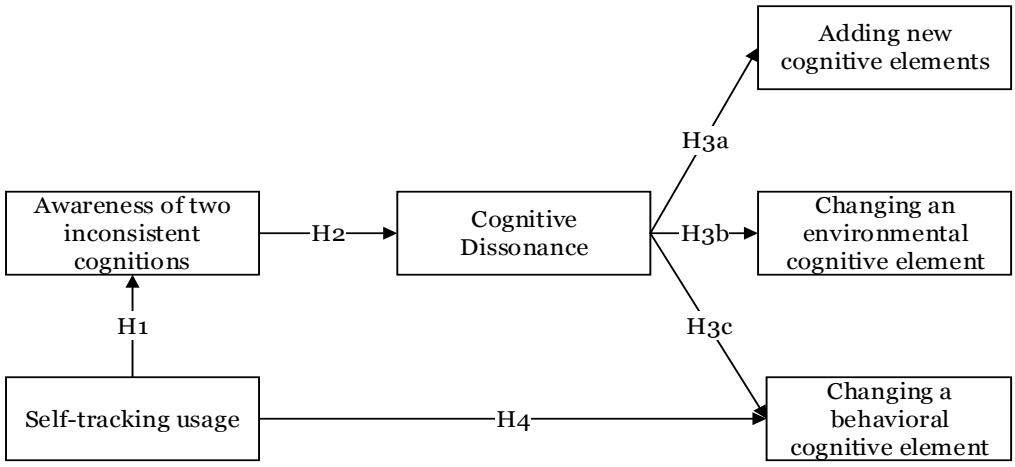

Figure 1. Research Model

We assume that the use of self-tracking software leads to a higher awareness of two inconsistent cognitions when the person has not walked much because a quantification of the number of steps is difficult to achieve without the appropriate tools.

H1: The higher the use of self-tracking software, the higher the awareness of two inconsistent cognitions, if a person has not walked much.

The awareness of two inconsistent cognitions leads to cognitive dissonance because people try to reach cognitive consistency and have negative emotions (cognitive dissonance) in the presence of inconsistency (Festinger 1962). We therefore assume that higher awareness of two inconsistent cognitions leads to a higher degree of cognitive dissonance.

H2: An increase in the awareness of two inconsistent cognitions leads to an increase in the degree of cognitive dissonance.

The presence of cognitive dissonance, which is a psychologically uncomfortable feeling, leads to pressure to reduce dissonance (Festinger 1962). One method to reduce dissonance is to search for new information, which reduces the inconsistency between the two dissonant cognitions. In the situation of step counter usage, we assume that people try to find information that justifies their low number of steps.

H3a: The higher the cognitive dissonance, the higher the dissonance reduction strategy adding new cognitive elements.

Another dissonance reduction strategy is to ignore the situation which induces dissonance (Festinger 1962). In the case of self-tracking, we assume that people who use the strategy of changing an environmental cognitive element ignore the step counter results to reduce cognitive dissonance.

H3b: The higher the cognitive dissonance, the higher the dissonance reduction strategy changing an environmental cognitive element.

A further strategy for reducing dissonance is to change the behavior to align attitude and behavior (Festinger 1962). In the context of self-tracking, a person can reduce dissonance through increased walking. We therefore assume that a higher degree of dissonance leads to increased walking.

H3c: The higher the degree of cognitive dissonance, the higher the dissonance reduction strategy changing a behavioral cognitive element.

A multitude of research in the area of behavioral psychology found a relationship between increased self-awareness and change in behavior (Burke et al. 2009; Wilde and Garvin 2007). We therefore assume that greater self-awareness through the use of self-tracking software leads to a higher tendency towards behavior change.

H4: The higher the use of self-tracking, the greater the change in behavior.

Construct	Definition and description	Key references
Awareness of two inconsistent cognitions	Awareness of two inconsistent cognitions refers to the awareness that two cognitions of a person, e.g. subject's attitude (e.g. walking is healthy) and behavior (e.g. sedentary lifestyle), are inconsistent.	(Baumgart 2016; Bhattacherjee and Premkumar 2004; Festinger 1962)
Cognitive dissonance	Cognitive dissonance is defined as a psychological tension, which arises if two cognitions of a person are inconsistent.	(Carlsmith and Aronson 1963; Elliot and Devine 1994; Festinger 1962; Sweeney et al. 2000)
Changing a behavioral cognitive element	Changing a behavioral cognitive element refers to the modification of an action resulting in the alignment of two inconsistent cognitions. For example, a person walks more to bring attitude and behavior in line.	(Festinger 1962)
Adding new cognitive elements	Adding new cognitive elements refers to the addition of information, so that the inconsistency between behavior and attitude is reduced.	(Festinger 1962)
Changing an environmental cognitive element	Changing an environmental cognitive element refers to the ignorance or denial of a dissonance-inducing situation.	(Festinger 1962)
Usage	Usage is defined as the extent and frequency of self-tracking usage.	(Davis 1989)

Table 1. Summary of Key Constructs

Research Method

We conducted a pilot test with 28 participants. A pilot test is useful for obtaining initial indications of validity and reliability of the measurements (Recker 2012) before testing the survey in a larger context. Only adequate measurements are valuable for the identification of significant relationships between the constructs (O'Leary-Kelly and Vokurka 1998). To ensure content validity, we used existing scales when possible and developed new ones based on well-established guidelines and our construct definitions (Moore and Benbasat 1991). Only the construct cognitive dissonance can be measured based on established prior literature. We reworded this scale in order to adapt it to the present context. The remaining constructs are developed according to well-established guidelines and the construct definitions (Moore and Benbasat 1991). Table 2 presents the items and the relevant literature.

Construct	**Items**		**References**
	Last time when I did not walk much…		
Awareness of two inconsistent cognitions	AC1	… my number of steps was much worse than I had intended.	Adapted from Bhattacherjee and Premkumar (2004)
	AC2	… my step level, compared to my goal, was much worse than I had planned.	
	AC3	… I walked less than I had intended.	
Cognitive dissonance	CD1	… I was in despair.	Adapted from Sweeney et al. (2000)
	CD2	… I resented it.	
	CD3	… I felt disappointed with myself.	
	CD4	… I felt scared.	
	CD5	… I felt hollow.	
	CD6	… I felt angry.	
	CD7	… I felt uneasy.	
	CD8	… I felt I'd let myself down.	
	CD9	… I felt annoyed.	
	CD10	… I felt frustrated.	
	CD11	… I was in pain.	
	CD12	… I felt depressed.	
	CD13	… I felt furious with myself.	
	CD14	… I felt sick.	
	CD15	… I was in agony.	
Adding new cognitive elements	NC1	… I searched for an explanation for this performance.	Newly developed
	NC2	… I asked myself which reasons could explain this.	
	NC3	… I considered why I have not walked more.	
Changing an environmental cognitive element	EC1	… after that I did not think any longer about how good or bad my walking performance is.	Newly developed
	EC2	… after that I ignored my walking performance.	
	EC3	… I planned not to concern myself with my walking performance any longer.	
	EC4	… I decided to pay less attention to my step performance.	

Changing a behavioural cognitive element	BC1	… my subsequent step performance corresponded to my set target.	Newly developed
	BC2	… I subsequently tried to walk more.	
	BC3	… I went out again to walk more.	
Usage	U1	How often do you look at your step quantity per day?	Newly developed
	U2	How often do you use your step-counter during a week?	
	U3	How frequently do you carry a step counter with you?	

Table 2. Overview of Items

Results

To assess internal consistency and convergent validity, we measured composite reliability and average variance extracted (AVE) (Fornell and Larcker 1981) by conducting a confirmatory factor analysis using PLS. Table 3 shows that the composite reliability of each construct is satisfactory (>0.7) and the AVE of each construct exceeds the critical threshold of 0.5 (Hair Jr et al. 2016). In the next step, we examined discriminant validity by using the criteria established by Fornell and Larcker (1981). Therefore, we compared the square root of AVE with the correlations between each pair of latent variables. Each square root exceeds the correlation of the latent variables and therefore complies with the criteria for discriminant validity.

Construct	**Cronbach's Alpha**	**Composite Reliability**	**Average Variance Extracted**	**AC**	**CD**	**CB**	**NC**	**EC**	**U**
Awareness of two inconsistent cognition (AC)	0.889	0.931	0.819	**0.905**					
Cognitive dissonance (CD)	0.934	0.943	0.562	0.586	**0.727**				
Changing a behavioral cognitive element (CB)	0.782	0.872	0.694	0.704	0.627	**0.833**			
Adding new cognitive elements (NC)	0.939	0.961	0.892	0.316	0.488	0.591	**0.944**		
Changing an environmental cognitive element (EC)	0.910	0.928	0.764	0.019	0.237	-0.017	-0.095	**0.876**	
Usage (U)	0.741	0.855	0.666	0.470	0.120	0.588	0.189	-0.297	**0.816**

Table 3. Reliabilities and Correlation Matrix

In the next step, we evaluated the construct validity. Table 4 shows that only four items fall below the recommended threshold of 0.708. A removal of indicators with outer loadings between 0.40 and 0.70 should only be considered when deleting the indicators increases the composite reliability or the average

variance extracted over the suggested threshold (Hair Jr et al. 2016). Since we already meet both criteria, we retain the reflective indicators.

Construct	**Item**	**1**	**2**	**3**	**4**	**5**	**6**
Awareness of two inconsistent cognitions	AC1	**0.934**	0.558	0.654	0.279	0.074	0.401
	AC2	**0.912**	0.506	0.677	0.272	0.005	0.382
	AC3	**0.867**	0.525	0.580	0.306	-0.028	0.492
Cognitive dissonance	CD1	0.192	**0.427**	0.111	0.208	0.130	-0.202
	CD2	0.348	**0.678**	0.230	0.223	0.351	-0.143
	CD3	0.426	**0.832**	0.526	0.364	0.251	0.153
	CD4	0.365	**0.796**	0.440	0.297	0.257	0.059
	CD5	0.335	**0.749**	0.601	0.446	-0.027	0.170
	CD6	0.379	**0.726**	0.468	0.467	-0.025	0.347
	CD7	0.161	**0.533**	-0.013	0.129	0.524	-0.391
	CD8	0.555	**0.766**	0.437	0.266	0.351	-0.016
	CD9	0.387	**0.678**	0.275	0.297	0.287	-0.199
	CD10	0.473	**0.814**	0.639	0.492	-0.124	0.201
	CD11	0.723	**0.755**	0.678	0.396	0.295	0.098
	CD12	0.247	**0.597**	0.126	0.178	0.496	-0.166
	CD13	0.553	**0.849**	0.648	0.593	0.102	0.125
	CD14	0.325	**0.743**	0.425	0.383	0.082	0.281
	CD15	0.476	**0.825**	0.482	0.251	0.123	0.321
Changing an behavioral cognitive element	CB1	0.579	0.528	**0.809**	0.529	-0.090	0.631
	CB2	0.659	0.531	**0.844**	0.411	0.083	0.485
	CB3	0.500	0.498	**0.847**	0.542	-0.036	0.299
Adding new cognitive elements	NC1	0.334	0.507	0.530	**0.952**	-0.071	0.105
	NC2	0.283	0.439	0.576	**0.926**	-0.045	0.277
	NC3	0.273	0.430	0.573	**0.955**	-0.154	0.164
Changing an environmental cognitive element	EC1	0.042	0.141	-0.003	-0.036	**0.866**	-0.265
	EC2	-0.071	0.050	-0.054	-0.143	**0.822**	-0.106
	EC3	0.006	0.191	0.048	-0.153	**0.867**	-0.154
	EC4	0.028	0.290	-0.056	-0.052	**0.946**	-0.368
Usage	U1	0.427	0.165	0.563	0.149	-0.418	**0.892**
	U2	0.336	0.190	0.459	0.252	0.115	**0.684**
	U3	0.376	-0.085	0.394	0.059	-0.386	**0.856**

Table 4. Loadings and Cross-Loadings of Reflective Items

In the next step, we examine the loadings and cross-loadings of the items. Established guidelines suggest that the item load should be considerably higher than any cross loading (Hair Jr et al. 2016). As can be seen in table 4, our items meet this criterion.

Discussion and Conclusion

The goal of this investigation was the development and validation of appropriate measurement scales that are applicable to our research model, which suggest an explanation for the different responses to self-tracking. We used the cognitive dissonance theory as a foundation because this theory combines emotion, behavior and motivations. The research model suggests that the usage of self-tracking software leads to a higher awareness of two inconsistent cognitions and this awareness triggers cognitive dissonance. Since cognitive dissonance is a psychological tension, people try to reduce it through a change of behavior, by adding new information or ignoring the situation.

So far, the cognitive dissonance theory has been tested with manifold indirect measurements through the use of experimental designs. This approach was often criticized as a built-in artifact and as being biased because other explanations for the same results are available. The present study wants to address this problem through the development and validation of more direct measurement scales as a prerequisite for a more detailed analysis of the different steps of cognitive dissonance.

Only the dissonance scale was based on existing measurement scales. To the best of our knowledge, the dissonance reduction strategies have to date not been operationalized. We therefore developed these constructs based on established guidelines.

Before testing the model in a broader context, we undertook a pilot test with 28 participants. The results of our confirmatory factor analysis suggest that our constructs and items have good internal consistency, convergent validity, discriminant validity and construct validity. This is a good first indicator of validity and reliability of measurements, which increases trust in the results of a final survey.

Concerning practical relevance, our research model gives important insights into how and why self-tracking influences behavior, emotions and cognitions. This psychological understanding is important for designing effective self-tracking applications.

This research has several limitations. First, due to the small sample size, we did not conduct a regression analysis of the relationship between the constructs. Therefore, we are not able to answer the research question in this pilot study. The main contribution of this investigation is the analysis of the measurement scales. In our future research, we will conduct an in-depth literature search to refine the measurement scales and find additional mediators for our research model. Furthermore, due to a very small sample size, our results are only indications of construct validity. To fully establish construct validity as well as nomological validity, we need a larger sample size and control variables.

This investigation is an important step toward the development and validation of new measurement scales, which are important for finding interrelationships between self-tracking and emotions, behavior and cognitions on the basis of the cognitive dissonance theory. This theory was tested with indirect measurements by using experimental designs. This approach earned a lot of criticism because other explanations for the observed reactions are possible. Our research model wants to address this gap by using a structural equation model that further supports the cognitive dissonance theory and provides an explanation for different reactions to self-tracking usage.

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