Social Comparison in mHealth: The Role of Similar Others and Feelings of Envy

Completed Research Paper

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Abstract

To foster ambitious goal setting, mHealth app developers increasingly implement social comparison features such as leaderboards. However, extant research does not sufficiently look at affective consequences of such features and their impact on goal-setting behavior. We focus on two aspects of social comparison to better address this issue: (1) the similarity of comparison targets and (2) the affective consequence of envy. We distinguish between two similarity dimensions (performance and related attributes) and two distinct emotions of envy (benign and malicious). In an experimental study, we find that comparing to targets similar on related attributes (age and gender) determines the relevance of the comparison and positively impacts benign and malicious envy. We further show that comparing to targets similar in performance (step count) decreases malicious envy and increases benign envy, based on appraisals of perceived control. Moreover, benign and malicious envy differentially impact goal-setting behavior.

Keywords: Social Comparison, Envy, mHealth, Gamification, Leaderboards

Introduction

Physical inactivity is a major risk factor for global mortality (6% of deaths globally) with it being the principal cause for approximately 25% of breast and colon cancer burden, 27% of diabetes, and 30% of the ischemic heart disease burden (World Health Organization 2020). Despite evidence supporting improved health outcomes from regular physical activity (World Health Organization 2014), population levels of physical activity remain low (Guthold et al. 2018). Mobile Health (mHealth) technology has the potential to impact physical activity behavior. Yet, the extent to which individuals actively use mHealth is often limited to few initial interactions (Levy 2014) and it is unclear how mHealth use impacts behavior change (Fallon et al. 2019). For mHealth to be effective, it is not only important that people use mHealth, but also that they stay motivated over a sustained period of time and set ambitious goals for themselves.

Extant research has shown that setting ambitious goals is associated with higher levels of effort and performance in physical activity (Shilts et al. 2004). To foster ambitious goal setting, mHealth app developers increasingly implement social comparison features such as leaderboards that illustrate one's

own performance in comparison to others (Schmidt-Kraepelin, Thiebes, Schöbel, et al. 2019). Social comparison features are based on the idea that social comparison information can have an impact on people's behavior; an effect described by Festinger in his seminal work on social comparison theory (SCT) (Festinger 1954). According to SCT, the existence of a discrepancy on a comparison dimension leads to discrepancy-reducing actions. One example is goal-setting behavior, where people first set a goal for themselves (Locke and Latham 2006). Then, depending on how their present state compares to their goal (Carver and Scheier 1982; Locke and Latham 2002), maintain their original goal, lower their goal or adopt an even more challenging goal (Bandura 1991). Given the case that mHealth users are confronted with social comparison information after they have initially set a physical activity goal for themselves (e.g., through recommendations for sufficient levels of physical activity in the media), social comparison information may likely lead to the adjustment of these goals (Liu et al. 2019).

Researchers have reported inconclusive evidence for the effectiveness of social comparison features on goal setting behavior in mHealth. While some research shows that social comparison features can have both positive and negative effects on goal-setting (e.g., Consolvo et al. 2006; Liu et al. 2019), the inner workings are mostly hidden and we know only little about the underlying reasons why such features can lead to contradicting effects. Accordingly, it remains largely unclear how to leverage features that enhance the positive effects and mitigate the negative effects, which is crucial when it comes to designing mHealth apps with the goal to positively influence users' health behavior. To overcome this lack of knowledge and shine light into the black box of social comparison features in mHealth, we focus on two different aspects of social comparison: (1) the similarity of comparison targets and (2) the affective consequence of envy. It is widely presumed that individuals who are similar are the best comparison targets because they determine likelihood for success (Wheeler et al. 1997). However, the cognitive, affective and behavioral consequences of comparing to similar or dissimilar others have not yet been fully investigated. In addition, several researchers in domains other than mHealth have shown that social comparison information can evoke feelings of envy (Krasnova et al. 2015; van de Ven 2017). Traditionally, envy has been conceptualized as a unitary construct describing an unpleasant emotion in which one feels inferior, resentful or even hostile (Smith and Kim 2007). More recent research suggests that two distinct forms of envy exist (i.e., benign envy and malicious envy) that result in distinct behavioral consequences (van de Ven 2016). We follow this line of research and explore how who users compare themselves to impacts the two distinct feelings of envy and how this may influence goal-setting behavior. Specifically, we ask the following research questions:

RQ1: What is the role of similar comparison targets on feelings of benign and malicious envy?

RQ2: How do benign and malicious envy differentially impact goal increase behavior?

In order to answer our research questions, we conducted an online experiment among 285 potential users of mHealth apps for physical activity. Within our online experiment, we followed a between-subject design and provided participants with social comparison information of comparison targets with different levels of similarity. Our results indicate that comparing to similar comparison targets can increase feelings of both benign and malicious envy and that benign and malicious envy have differential impacts on goal increase behavior. The study contributes to information systems (IS) literature in three key ways. First, we contribute to the growing body of literature that explores affective factors influencing user behaviors (Stein et al. 2015). Second, we extend our knowledge concerning the circumstances that determine when social comparison features lead to positive user experiences and when they yield negative outcomes (Schmidt-Kraepelin, Thiebes, Stepanovic, et al. 2019). Third, we take a closer look at how social comparison features can impact self-regulation of behavior in mHealth (Fallon et al. 2019).

This paper proceeds as follows. In the next section, we briefly introduce the landscape of extant research on social comparison in mHealth and describe the theoretical foundations of SCT and envy. Afterwards, we develop our hypotheses and present our research model. Then, we outline the applied research method, including our experimental design. Subsequently, we present our results. We outline implications of our findings, limitations of the study, and opportunities for future research in the discussion section, before we briefly conclude our paper in the last section.

Theoretical Background

Social Comparison in mHealth

Social comparison features have been widely implemented in mHealth physical activity apps, predominantly in the form of social networking features (e.g., messages including social norms, or group competitions), leaderboards and features allowing the deliberate sharing of physical activity (e.g., sharing your daily step count with a group of friends). However, research has yielded inconclusive findings regarding the effects of social comparison features. For example, whereas social comparison features can increase engagement with mHealth (e.g., Anderson et al. 2007), they are also associated with avoidance of an app because the comparison is perceived as forced and unwanted (Jia et al. 2017; Miller and Mynatt 2014). Similar contrasts are seen regarding the effects of social comparison on physical activity motivation. Whereas social comparison can increase physical activity motivation by increasing awareness of others' physical activity levels, it can also decrease motivation if people are constrained in converting the increased awareness into actual physical activity (Anderson et al. 2007; Jia et al. 2017; Wu et al. 2015).

When investigating effects of social comparison features, extant research largely treats social comparison as a black box and focuses on measuring its direct effect on physical activity behavior (e.g., Chen et al. 2016; Lee and Lim 2015) or usability of an mHealth app (e.g., Middelweerd et al. 2015; Zuckerman and Gal-Oz 2014). To the best of our knowledge, there are only few studies that aim to open this black box by investigating cognitive or affective consequences of social comparison features. Table 1 provides a selection of these studies that help us understand the causal links between social comparison and physical activity behavior. The results indicate that there are in fact important factors that explain the effect of social comparison on physical activity, such as perceived competitive climate (Wu et al. 2015), self-efficacy (Miller and Mynatt 2014) or goal-setting (Arigo 2015; Chen et al. 2017; Liu et al. 2019). Another stream of research is concerned with investigating the impact of different characteristics of the social comparison information (e.g., with whom individuals compare themselves to or how they are placed on a leaderboard) on physical activity motivation. For example, extant research indicates that social comparison to individuals that are perceived as highly dissimilar can lead to decreased motivation (Arigo 2015) and that social comparison to foreign individuals may result in more long-term motivational benefits (Fritz et al. 2014). Furthermore, after manipulating individuals' position on a fitness leaderboard, Jia et al. (2017) found that individuals enjoyed the social comparison most when being placed at the bottom, which may translate to a heightened sense of physical activity motivation. Overall, the largely inconsistent findings show that it is crucial to consider cognitive and affective consequences of social comparison features in mHealth physical activity apps as well as the effects of different social comparison information.

Study	Social comparison features			Affective, cognitive or goal-related outcome	Overall effects of SC	Manipulation of SC elements
	Social networking	Leader-boards	Social sharing			
Anderson et al. (2007)			X	Qualitative analysis of SC outcomes	positive	No
Arigo et al. (2015)	X		X	Goal setting, negative responses to SCs	mixed	No
Chen et al. (2017)		X		Goal setting	positive	No
Fritz et al. (2014)			X	Qualitative analysis of SC outcomes	mixed	No
Jia et al. (2017)		X		Enjoyment with app, motivation for PA	mixed	Yes
Liu et al. (2019)	X			Goal setting, goal attainment	mixed	No
Miller & Mynatt (2014)	X			Self-efficacy	positive	No
Patel et al. (2016)	X			Goal achievement	mixed	Yes
Tong et al. (2018)	X			Qualitative analysis of SC outcomes	mixed	No
Wu et al. (2015)		X		Attitude towards PA	mixed	No
This study		*X*		*Benign and malicious envy, goal setting*	*?*	*Yes*

Table 1. Overview of Studies Measuring Affective, Cognitive or Goal-related Outcomes of SC

Social Comparison Theory

Social comparison is defined as "the process of thinking about information about one or more people in relation to the self" (Wood 1996). First proposed by Festinger (1954), SCT describes that there is a natural drive within us to compare upwards to better performing individuals. When there is a discrepancy between an individual and a superior other, the individual uses the information to self-evaluate their standing and abilities, which leads to action to reduce that discrepancy (Festinger 1954). Since the seminal work from Festinger, researchers have focused on the cognitive and affective consequences of social comparison (Gerber et al. 2017). In summary, this research has found that people generally choose to compare with people who are superior to them in some way, which has subsequent consequences on a person's cognitive appraisals about their abilities and emotion.

Who user's compare to is especially important for obtaining accurate self-evaluations about their abilities. Festinger (1954) proposes that individuals choose similar others as comparison targets. While his original theoretical statement emphasizes similarity regarding performance (e.g., comparing to others who take a similar number of steps per day), some of his discussion focuses on similarity regarding related attributes (e.g., gender and age). Consequently, researchers were troubled with operationalizing similarity. The proxy model of social comparison aimed to overcome this problem by distinguishing between similarity on two dimensions - the dimension of *performance* and the dimension of *related attributes* (Wheeler et al. 1997). Performance refers to how similar the comparison others have performed at the task at hand (e.g., do the comparison targets take a similar number of steps per day as me?). Related attributes refer to how similar the others are on attributes known to influence performance (e.g., are the comparison targets similar to me regarding age and gender?). The proxy model of social comparison proposes that individuals who are similar on the performance dimension and on the related attributes dimension will be the best comparison targets because they determine likelihood for success (Wheeler et al. 1997).

Benign and Malicious Envy

Several researchers have found envy to be a prominent affective consequence of social comparison (e.g., Krasnova et al. 2015; van de Ven 2017). Originally, envy was described as an unpleasant and painful emotion in which one feels inferior, resentful, and hostile (Smith and Kim 2007). However, more recent research suggests that two distinct forms of envy with distinct behavioral patterns prevail. On the one hand, benign envy is an emotion that leads to positive improvement for oneself through a moving-up motivation. On the other hand, malicious envy leads to hostile feelings toward the envied person through motivations aimed at pulling-down the other from the superior position (van de Ven et al. 2009). Social comparison has the potential to yield both forms of envy (van de Ven 2017; van de Ven et al. 2009).

From a theoretical standpoint, there are two reasons to distinguish between benign and malicious envy. The first is grounded in *appraisal theory* (Roseman 1996), which states that specific emotions are caused by a specific mix of appraisal perceptions of the situation. Emotions with different appraisals are considered distinct emotions. Perceived control of the situation is a crucial appraisal when considering the subsequent effect on the feeling of envy. Perceived control refers to one's perceived ability to do something about the situation (van de Ven 2016). Some researchers even argue that low perceived control is a necessary condition for envy to occur (Ortony et al. 1988; Smith 1991). In fact, perceived control is an appraisal that can distinguish between feelings of benign and malicious envy (van de Ven et al. 2012). The second reason to distinguish between the two types of envy is grounded in a *functional approach to emotions* (Cosmides and Tooby 2000). This functional approach comes from Arnold (1960), who defined emotions as felt action tendencies, and Frijda (1993), who argued that changes in action readiness are the distinguishing factor of emotions. The functional approach to emotions implies that very distinct action tendencies are unlikely to be caused by the same emotion. For example, the action tendency to improve oneself through a moving-up motivation, which is associated with benign envy or the action tendency to pull-down others from the superior position, which is associated with malicious envy.

The research summarized in this section suggests that distinguishing between benign and malicious envy is a suitable theoretical basis for understanding the impact of social comparison features in mHealth. The distinct action tendencies as a result of benign and malicious envy are likely to play a key role in goal-setting behavior. We propose that using this theoretical basis could explain the mixed results of social comparison features in mHealth research. As opposed to looking at the direct effect of social comparison on physical

activity behavior, we aim to better understand the theoretical reasons why this occurs. We do this by identifying two similarity dimensions and theorizing about their impact on benign and malicious envy. We propose that these two emotions have unique consequences on goal-setting behavior.

Research Model and Hypotheses

In light of the existing gaps in the literature, we aim to understand social comparison and its influence on goal-setting behavior through benign and malicious envy. We rely on literature from SCT and the affective consequence of envy to develop our research hypotheses. Based on these hypotheses, we have conceptualized our research model as depicted in Figure 1.

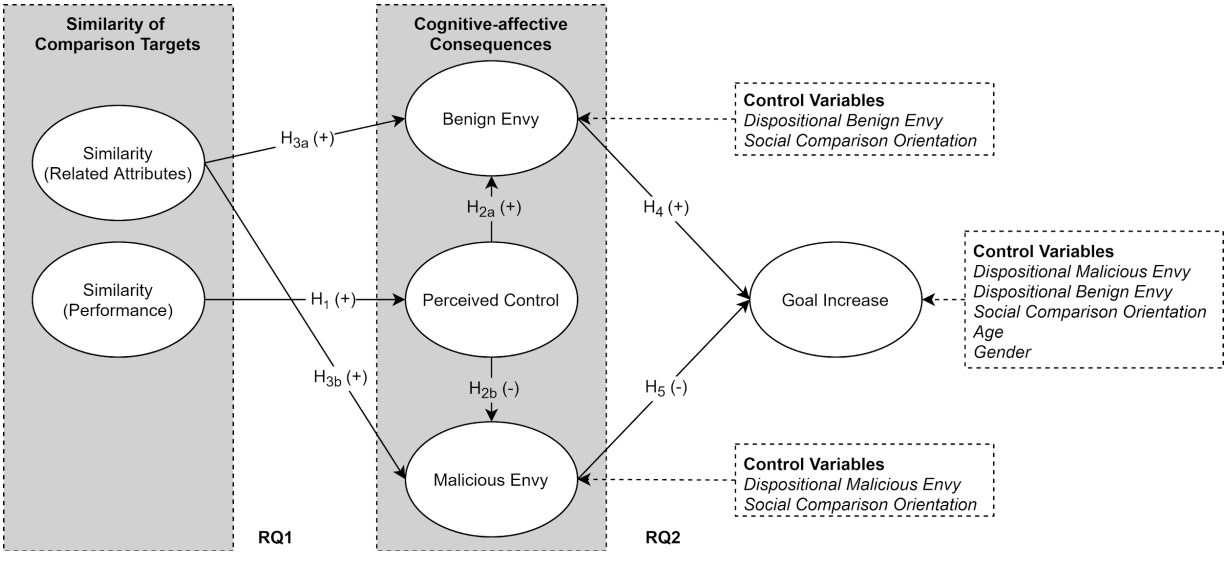

Figure 1. Research Model

The proxy model of social comparison proposes that the comparer assesses how similar they are on the performance dimension in order to determine likelihood for success or attainability (Wheeler et al. 1997). Consistent with this, we propose that when there is a small discrepancy regarding the performance comparison information on a leaderboard (e.g., higher similarity in step-count), achieving the same step-count as better performing others will seem attainable. This appraisal of the situation is important for self-evaluation and determining what one is capable of doing (Festinger 1954). If the comparer perceives similarity on the performance dimension, they will also appraise the situation as being attainable and therefore experience higher perceived control of the situation (van de Ven et al. 2012). Conversely, if there is a large discrepancy regarding the performance comparison information on a leaderboard (e.g., lower similarity in step-count), achieving the same step-count as the better performing others can seem almost impossible and therefore the individual will appraise the situation as having low ability to control it. Consequently, we hypothesize:

H1: Similarity on the performance dimension will be positively associated with appraisals of perceived control.

Appraisals that lead to certain emotions are subjective perceptions of the situation (Scherer et al. 2001). In our context, perceived control is an appraisal of the situation regarding one's standing in comparison to others and the perceptions of their ability to attain the same step count. It is the appraisal of the situation itself that leads to specific emotions (Roseman 1996; van de Ven et al. 2011). We expect that depending on the appraisal of perceived control of the situation individuals will experience one of two distinct emotions – benign or malicious envy. We propose that individuals that perceive high control over attaining a higher step count will also feel more benign envy because there is an opportunity to improve, which seems attainable (van de Ven et al. 2011, 2012). The key distinction is not the attainability of the position of the

superior other, but rather whether the person who compares upwards perceives the situation to be within their control. The opportunity is appraised as within one's control and therefore individuals will experience benign envy, characterized as motivations to improve oneself. Conversely, we propose that individuals that perceive low control over attaining a higher step count will experience more malicious envy because they do not have the opportunity to act constructively (Smith 1991). Analogue to benign envy, it is not the lack of attainability of the position of the superior other, but rather whether the person who compares upwards perceives the situation to be within their control. The opportunity to improve is appraised as being out of one's control and therefore individuals will experience malicious envy characterized as hostile feelings towards the individuals performing better. Moreover, if the opportunity to improve is appraised as out of one's control, they will feel little motivation to improve themselves. Therefore, we hypothesize:

H2a: Appraisals of high perceived control will lead to more feelings of benign envy.

H2b: Appraisals of low perceived control will lead to more feelings of malicious envy.

Festinger (1954) proposes that comparing to others similar in age and gender is a more relevant comparison target and people actually compare themselves more often when they are similar on related attributes. The reason behind this is that information regarding such similar comparison targets reveals more information about one's own performance. Since users have only limited access to relevant information such as athletic ability or effort when using a leaderboard, they draw on related attributes to put their own performance in relation to that of others (Wheeler et al. 1997). In this regard, related attributes are seen as factors that help to determine sufficient levels of performance. If a comparison target that is similar with regard to related attributes has shown better performance, this likely produces the feeling that one's own performance is not sufficient. However, if the comparison target is different, information on that target's performance yields less information about one's own performance since other levels of physical activity might be considered to be more appropriate for them. As a consequence, comparing to similar others on related attributes has a higher likelihood of provoking an emotional response than comparing with dissimilar others. Thus, it can potentially increase feelings of both benign and malicious envy (van de Ven et al. 2009). This makes the similarity of related attributes a double-edged sword. On the one hand, if individuals compare their step count to others on a leaderboard that are the same age and gender, they will make more comparisons (Festinger 1954) and are likely to be confident that they can also achieve the same step count (Wheeler et al. 1997). In this case, comparing with similar others will lead to feelings of benign envy, characterized as the motivation to improve oneself because similar others accomplished it. On the other hand, if individuals compare their step count to others on a leaderboard that are the same age and gender, this may lead to the comparer doubting that their abilities really match individuals with the same related attributes (Salovey and Rodin 1984). In this case, they will begin searching for factors that might mitigate the success of others. For example, the comparer will recall all negative aspects of individuals performing better and will perceive them as being of little worth (Salovey and Rodin 1984). This results in the consequence of malicious envy, characterized by hostile feelings aimed at pulling the other down. Consequently, we hypothesize:

H3a: Similarity on the related attributes dimension will be positively associated with benign envy.

H3b: Similarity on the related attributes dimension will be positively associated with malicious envy.

Benign envy is associated with the distinct action tendency to improve oneself (van de Ven et al. 2009). This is evident in that individuals experiencing benign envy focus their attention on the object they envy the person for (e.g., having a high step count) (Crusius and Lange 2014). Focusing on the object of envy is what motivates one to improve. People experiencing benign envy actually work longer on tasks, perform better and plan to study more (van de Ven et al. 2011). Thus, when given the opportunity to increase their goals, we propose that individuals experiencing benign envy will also be more likely to increase their step count goal because their attention is focused on a higher step-count. In this scenario, the social comparison information acts as social feedback, in which individuals can evaluate their abilities in comparison to others, appraise the situation as being within their control and experience the emotion of benign envy or the motivation to improve themselves. This will be evident in a goal increase, in which they set higher and more ambitious goals for themselves. Therefore, we hypothesize:

H4: Feelings of benign envy will be positively associated with a goal increase.

Malicious envy is associated with the distinct action tendency to pull others down or wishing for others to fail (van de Ven et al. 2009). This is evident in that individuals experiencing malicious envy focus their

attention on individuals who are performing better (not on the object they envy as is the case with benign envy) (Crusius and Lange 2014). Because malicious envy is characterized with an attentional focus on others and the wish for others to fail, it has been thought of as the more undesirable emotion that can deplete self-regulatory resources (Crusius and Lange 2014; Hill et al. 2011). In this scenario, the social comparison information acts as social feedback, in which individuals evaluate their abilities in comparison to others, appraise the situation as being out of their control and experience the emotion of malicious envy or the tendency to pull others down. This focus on others and the experience of negative emotions will deplete self-regulatory resources and be evident in a negative effect on goal increase. Therefore, we hypothesize:

H5: Feelings of malicious envy will be negatively associated with a goal increase.

Methods

Data Collection

We employed an experimental approach to test the research hypotheses. Data were collected using an online survey administered by a third party organization (Chandler and Shapiro 2016). In line with suggestions in literature, we restricted participation to users with a high reputation (at least 99% approval ratings and at least 5,000 conducted tasks) in order to ensure high data quality (Peer et al. 2014). We also included an attention check question to remove responses of participants who were not reading the questions and simply clicking an answer choice (Thomas and Clifford 2017). Because we collected data through an online survey, procedural methods were used to control for common method bias (CMB). We applied ex ante recommendations of Podsakoff, MacKenzie, Lee, and Podsakoff (2003) to control for CMB, including instructing participants that answers are fully anonymized, that they should take their time to carefully and honestly answer the questions and that no right and wrong answers exist; counterbalancing question orders; using existing, reliable measures; randomizing items; and proximal separation (i.e., different pages) of measurements for independent and dependent variables.

After answering demographic questions, participants were randomized to receive one of four different leaderboards. The leaderboard was framed as being part of an existing mHealth app (see Figure A-1 in the Appendix). It included ten rank positions, with the participant always being placed on rank five. Participants were placed on rank five to ensure they could compare both upwards and downwards (Wu et al. 2015). The social comparison information shown to each group differed with respect to low or high similarity of other people on the leaderboard in terms of *performance* (step count) and *related attributes* (age and gender). An overview of the leaderboard manipulation is shown in Table 2.

		Similarity of performance	
		low	*high*
Similarity of related attributes	*low*	Group 1	Group 3
	high	Group 2	Group 4

Table 2. Leaderboard Manipulation

Participants in groups with high similarity on the performance dimension were shown a leaderboard where the top and bottom rank had a step count that is 10% higher or lower than theirs, respectively. In groups with low similarity on the performance dimension the top rank had a step count that is 80% higher than that of the participant. These values were determined based on a pre-test on the extent to which the leaderboard manipulations impacted perceived similarity on the performance dimension. The step count increments between ranks were consistent above and below the user rank respectively. To infuse realism, the increments were multiplied with a random factor between .95 and 1.05 and rounded to the nearest whole number.

Participants in groups with high similarity on the related attributes dimension were shown a leaderboard where everyone was of the same gender and also of an age not differing more than five years from theirs. Contrary, the leaderboard for the groups with low similarity on the related attributes dimension included only people that are of the different gender and differing at least 10 years in age. The genders of the other people on the leaderboard were not explicitly shown. Rather, they could be derived from their names, as we took caution to only use names that could be unambiguously assigned to either gender. As an example,

Figure A-1 in the appendix shows the four leaderboards corresponding to the four different groups for a participant that is a 40-year-old male and has an average daily step count of 10,000. Participants then completed questions related to the other variables in our model.

Operationalization of Variables

When possible, we adapted measures from prior studies and used multi-item scales to improve reliability and validity. We illustrated in a pre-test that the different leaderboard manipulations described above impact mental states (e.g., perceived similarity). Lench et al. (2014) argue that it is better to show that a specific mental state (e.g., perceived similarity) produces an outcome rather than to simply show that the manipulation produces both the mental state and the final outcome. Consistent with this reasoning, we used perceived similarity of performance and perceived similarity of related attributes as our independent variables. This allows individual variation in responses to the different leaderboards to be included in the experimental approach rather than a source of error that should be minimized in between-subject designs (Lench et al. 2014). The items used to measure perceived similarity of performance and related attributes are specified in the Table A-1 in the appendix. Additionally, all other items (benign envy, malicious envy and perceived control) were adapted measures from prior studies and can also be found in the Table A-1 in the appendix. Goal increase was measured as a binary variable. If a participant's goal increased after viewing the social comparison information they were coded as 1.

The survey also captured demographic variables including age and gender. We controlled for the potential influence of other variables that are not central to this study but that are likely to influence envy or goal-setting behavior based on prior research. This includes dispositional benign envy, dispositional malicious envy (Lange and Crusius 2015) and social comparison orientation (Gibbons and Buunk 1999). Besides the emotion of envy, which we focus on in our study, researchers have found use for measuring dispositional benign and malicious envy, which measures individual differences in the tendency to experience envy (a personality trait) (Lange and Crusius 2015). Additionally, we control for social comparison orientation, which is a stable personal trait that describes the extent to which people generally make comparisons about their opinions, abilities and general aspects of themselves (Gibbons and Buunk 1999). We used the measures from prior studies to measure these variables, which can be found in Table A-1 in the appendix.

Results

Overall, we gathered responses from 285 participants residing in the U.S. 42 responses were excluded from analysis because participants failed to correctly answer the attention-check question. Of the 243 remaining participants, 96 were female and 147 were male. On average, participants were 36.55 years old (min. 20 years, max. 69 years), had taken 5,579 steps per day during the last seven days and reported to have a daily step count goal of 6,950 steps. 148 participants reported that they had assessed their step counts via a smartphone application, 66 used a dedicated activity tracker, 26 participants self-assessed their step counts and 3 participants used another (undefined) means to keep track of their step counts.

The survey results were used to validate both, the construct measurement scales and the proposed theoretical relationships. First, we assessed the measurement scales for validity and reliability (Table 3). Two indicators of the *social comparison orientation* construct were eliminated from analysis since they displayed outer loadings below .6. Furthermore, two indicators of the construct had loadings between .6 and .7, but we retained the indicators due to the explorative nature of our study (Hair et al. 2013), and because the construct's composite reliability and Cronbach's Alpha were above the recommended threshold of .7 (Hair et al. 2011). Besides that, all indicators fulfilled the minimum loading requirements between the indicator and its corresponding underlying factor, showing convergent validity. All constructs showed sufficient composite reliability (CR) values greater than .7 and, thus, exceeded the suggested thresholds (Nunnally 1978). The average variance extracted (AVE) for each construct was greater than the suggested minimum of .5 (Fornell and Larcker 1981) and the square root of each construct's AVE exceeded the inter-construct correlations, demonstrating adequate discriminant validity (Table 3). In addition, the heterotrait-monotrait (HTMT) ratio of correlations showed only values below the threshold of .85 for all constructs, also suggesting no discriminant validity problems (Henseler et al. 2014).

Construct	CR	AVE	Inter-construct correlations										
			1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)
1) Similarity (Related Attributes)	.975	.907	.953										
2) Similarity (Performance)	.923	.858	.142	.926									
3) Perceived Control	1	1	.068	.266	1								
4) Malicious Envy	.936	.831	.166	-.146	-.109	.911							
5) Benign Envy	.933	.776	.288	.185	.342	.282	.881						
6) Goal Increase	1	1	.042	-.030	.160	.106	.207	1					
7) Dispositional Malicious Envy	.938	.752	.059	-.086	-.168	.459	-.082	.083	.867				
8) Dispositional Benign Envy	.927	.719	.268	.082	.258	.355	.401	.198	.101	.848			
9) Social Comparison Orientation	.922	.568	.107	.114	.148	.468	.227	.088	.314	.528	.754		
10) Age	1	1	.072	.004	-.011	-0.122	.006	-.055	-.251	.006	-.163	1	
11) Gender	1	1	-.072	-.099	-.019	.089	-.022	-.006	.096	-.022	.007	-.088	1

Table 3. Construct Reliability and Correlations

The effects of the leaderboard manipulations on perceived similarity were as expected and consistent with the pre-test. Those who received a high similarity of performance leaderboard perceived a higher degree of performance similarity (Group 3, M =5.8, SD = 1.05) (Group 4, M =5.9, SD = .91) than those who received the low similarity leaderboard (Group 1, M = 4.5, SD = 1.33) (Group 2, M =5.1, SD = .97). There was a statistically significant difference between the high group means and the low group means as determined by one-way ANOVA ($F(3,238) = 20.35$, $p < .00$). Those who received the high similarity of related attributes leaderboard perceived a higher degree of related attributes similarity (Group 2, M =6.0, SD = .91) (Group 4, M =6.1, SD =.89) than those who received the low similarity leaderboard (Group 1, M =1.8, SD = 1.19) (Group 3, M =2.0, SD =1.26). There was a statistically significant difference between the high group means and the low group means as determined by one-way ANOVA ($F(3,238) = 293.63$, $p < .00$).

To test our hypotheses and assess our model, we adopted PLS-SEM and used the SmartPLS software, version 3.3.0 (Ringle et al. 2015). Given the exploratory nature, our PLS-SEM is considered an appropriate data analysis approach (Urbach and Ahlemann 2010). The significance of the structural path estimates was assessed using bootstrapping with 5,000 subsamples and bias-corrected, accelerated confidence intervals (Ringle et al. 2015). We tested the structural model by evaluating the direct effects and the explained variances (R^2). While assessing the model, we controlled for *dispositional benign envy*, *dispositional malicious envy*, *social comparison orientation*, *age* and *gender*. Figure 2 shows the identified direct effects.

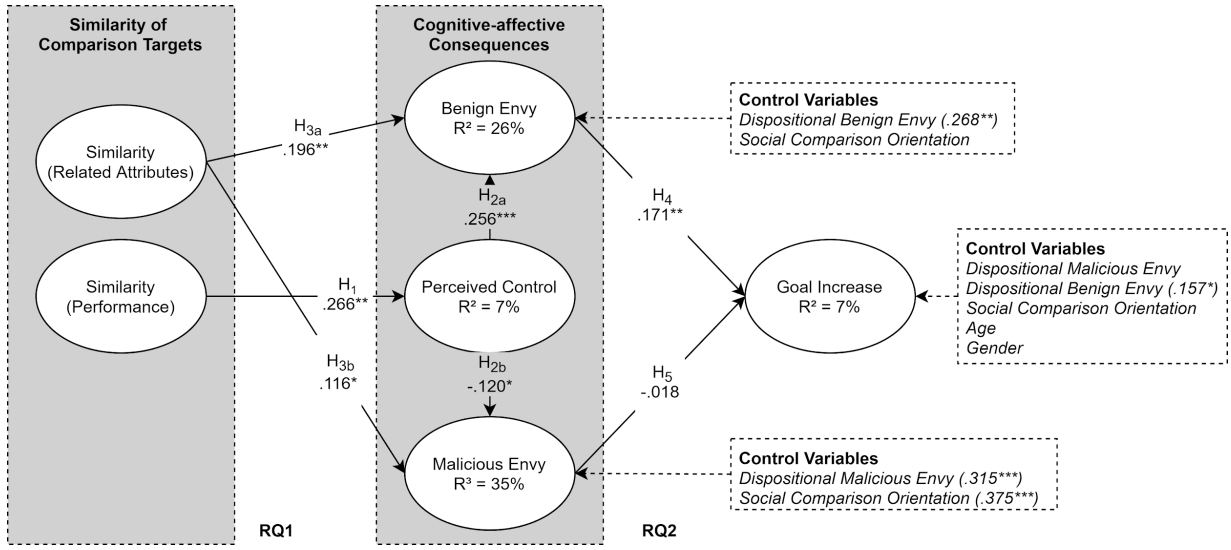

Figure 2. Analysis Results (Structural Model)

*Significant at 5%; ** significant at 1%; *** significant at .1% or lower

The results show that *similarity (performance)* positively influences *perceived control* (.266; p < .01; [.103; .414]), **supporting H1.** Furthermore, *perceived control* showed a positive effect on *benign envy* (.256; p < .001; [.129; .380]), **supporting H2a** and a negative effect on *malicious envy* (-.120; p <.05; [-.217; -.030]), **supporting H2b**. We also found that *similarity (related attributes)* positively influences both, *benign envy* (direct effect: .196; p < .01; confidence interval [.077; .312]) and *malicious envy* (.116; p < .05; [.007; .230]), **supporting H3a and H3b**. *Benign envy* positively influences *goal increase* (.171; p < .01 [.058; .285]), **supporting H4**, but *malicious envy* showed no significant effect on *goal increase* (-.018; p = .822; [-.172; .137]), **not supporting H5**. Among the five control variables, only *dispositional benign envy* showed an association with *goal increase*. As expected, *benign envy* was influenced by *dispositional benign envy* and *malicious envy* was influenced by *dispositional malicious envy*. Furthermore, *social comparison orientation* influenced *malicious envy*. In terms of explained variances (R^2), our model explains 7% of *perceived control*, 26% of *benign envy*, 35% of *malicious envy*, and 7% of *goal increase*.

To provide deeper insights into the impact of *similarity* and the mediating role of *envy* and *perceived control*, we conducted a mediation analysis. Again, we used bootstrapping with 5,000 subsamples and bias-corrected, accelerated confidence intervals while controlling for *dispositional benign envy*, *dispositional malicious envy*, *social comparison orientation*, *age* and *gender*. The results reveal that the effect of *similarity (performance)* on *benign envy* is fully mediated by *perceived control* (specific indirect effect: .063; p < .05; [.018; .136]; direct effect: .071; p = .346; [-.069; .229]) and that the effect of *perceived control* on *goal increase* is partially mediated by *benign envy* (specific indirect effect: .038; p < .05: [.010; .085]; direct effect: .122; p < .05; [.015; .218]). For the overall influence of *similarity (performance)* on *goal increase* mediated via *perceived control* and *benign envy*, no significant effect was found (specific indirect effect: .010; p = .106; [.002; .029]; direct effect: -.084; p = .233; [-.216; .057]). No significant effect was found for the influence of *similarity (performance)* on *goal increase* mediated via *benign envy* (specific indirect effect: .030; p = .073; [.005; .075]; direct effect: -.039; p = .575; [-.169; .106]), although the p-value was close to the threshold of .05. Also, for the effect of *similarity (performance)* on *malicious envy* no significant mediation via *perceived control* was found (specific indirect effect: -.022; p = .163; [-.063; 0]; direct effect: -.163; p < .01; [-.277; -.045]).

Discussion

Principal Findings

In this work, we aimed to better understand the inconclusive findings on the extent to which social comparison features impact goal-setting behavior by focusing on the similarity of comparison targets and the affective consequences of benign and malicious envy. Our findings show that the impact of social comparison features on goal-setting behavior is to some extent driven by two distinct feelings of envy and that envy in mHealth is driven by the degree of similarity to comparison targets. Our study yields three key findings, which are summarized in Table 4.

Previous research gaps	**Key Findings**
Extant research shows that social comparison can increase as well as decrease individuals' motivation towards physical activity. However, we know little about how the design of social comparison information influences these outcomes. More research is needed to understand how mHealth apps can evoke positive emotional responses to social comparison (e.g., benign envy) and avoid negative ones (e.g., malicious envy).	Similarity on the related attributes dimension is a double-edged sword, which can increase feelings of both benign and malicious envy.
	Similarity on the performance dimension impacts feelings of benign and malicious envy via two unique pathways related to perceptions of perceived control.
Extant research has treated social comparison in mHealth mainly as a black box and produced contradicting findings. First studies started to investigate the influence of affective and cognitive outcomes of social comparison information. However, more research is needed to understand why social comparison information leads to positive as well as negative outcomes.	Benign and malicious envy have differential impacts on goal increase. While our results indicate a positive relationship between benign envy and goal increase, we did not find a significant influence of malicious envy.

Table 4. Summary of Key Findings

By distinguishing two types of similarity (i.e., similarity on related attributes and similarity on performance) and investigating their impact on the emotional responses of benign and malicious envy, we contribute to

research regarding the impact of social comparison information characteristics on affective and cognitive outcomes. Thereby, we find that similarity on the related attributes dimension may be beneficial as well as detrimental for individuals since it can increase feelings of both benign and malicious envy. Similarity on the performance dimension, on the other hand, may increase benign envy and decrease malicious envy mediated by perceptions of perceived control. Furthermore, our research shows that benign and malicious envy have differential impacts on goal increase behavior. While we found a positive relationship between benign envy and goal increase, our study results did not show a significant influence of malicious envy.

Theoretical and Practical Contributions

Our research findings have several theoretical contributions. First, our research distinguishes between two unique pathways in which performance similarity impacts benign and malicious envy. We find that performance similarity positively impacts appraisals of perceived control and benign envy. Conversely, low perceptions of performance similarity have adverse effects on appraisals of perceived control, which results in malicious envy. We provide theoretical arguments for why it is important to distinguish between the two types of envy and hypothesize why different perceptions of performance similarity will have differential impacts on benign and malicious envy. So far, IS research has focused on envy as a negative emotion in the context of social comparison (Krasnova et al. 2015). Our findings also find support for the effect of social comparison on the positive emotion of benign envy. Toward this end, we further contribute by providing reasons why IS researchers should consider benign and malicious envy as a result of social comparison. Second, we illustrate that benign and malicious envy have differential impacts on goal-setting behavior. This is evident in that benign envy positively predicts goal increase behavior. While the hypothesized negative effect of malicious envy on goal increase was insignificant, it is still evident that malicious envy does not result in increased goal-setting. We attribute these effects to the distinct action tendencies associated with benign and malicious envy. This finding helps explain previous inconclusive findings in mHealth on the extent to which social comparison impacts goal-setting behavior. Third, we identified two similarity dimensions that can be represented in mHealth leaderboards, which also impact users perceived similarity on the associated dimensions. Based on the proxy model of social comparison, we identified similarity on the performance dimension and similarity on the related attributes dimension. We show that manipulating the design of leaderboards on these two dimensions (performance and related attributes) also impacts associated perceptions of similarity. To the best of our knowledge, the separate effects of these two similarity dimensions has not been explored in mHealth research. While researchers have implied that similarity of users may be important to consider when implementing social comparison features, so far only qualitative findings have been presented (Tong et al. 2018).

Our study yields practical implications for how to design mHealth in a way that leads to positive user experiences and avoids negative outcomes (Liu et al. 2017; Schmidt-Kraepelin, Thiebes, Stepanovic, et al. 2019). First, we show that benign envy can play a vital role in fostering mHealth users to set more ambitious goals for themselves. Thus, developers of mHealth apps for physical activity should aim to evoke feelings of benign envy in their users in order for them to enhance their physical activity behavior. Our findings suggest developers may achieve this by carefully selecting comparison targets that are similar with regard to related attributes and performance and, thus, yield relevant social comparison information. Conversely, our results also show that higher levels of similarity with regard to related attributes are associated with higher levels of malicious envy which makes this dimension of similarity a double-edged sword for mHealth app developers. Although our results do not indicate an effect of malicious envy on goal increase behavior, extant research has shown that malicious envy is not a desirable affective response to social comparison information since it largely results in negative consequences, such as reduced cognitive and affective well-being (Krasnova et al. 2015) and decreased motivation (Utz and Muscanell 2018). Our findings also highlight the vital role of perceived control to increase levels of benign envy and decrease levels of malicious envy. Thus, developers of mHealth apps that integrate leaderboard functionalities should implement measures that increase levels of perceived control in their users. This may be achieved by providing social comparison information of others that are similar with regard to their performance. However, developers should also bear in mind that the social comparison information should leave sufficient space for users to adjust their goals to a more ambitious (but still realistic) one.

Limitations and Future Research

We acknowledge several limitations of our study that provide avenues for future research. First, we address the issue of the low R^2 of perceived control. This may be explained by other dimensions of social comparison that are important for impacting perceived control (e.g., comparing to known others, advantaged others or disadvantaged others). Additionally, there may be certain personality traits that inherently make individuals more likely to appraise a situation as being controllable (e.g., agreeableness or conscientiousness). We did not consider such personality factors in our study. Consistent with prior research, we measured perceived control with a single item (Van Dijk & Zeelenber 2002). While PLS-SEM has shown to be able to easily handle single-item constructs, a multiple item measures for perceived control could enhance scale reliability (Hair et al. 2016). Future research should consider measuring perceived control with a multiple item scale. Second, we address the low R^2 of goal increase. There may be other important cognitive-affective factors to consider besides benign and malicious envy that impact goal increase. Envy has been found to be a salient consequence of social comparison and our aim was to distinguish between two distinct feelings of envy to better explain positive and negative impacts on goal increase. Thus, addressing other potential factors did not fit the scope of this study. Additionally, other aspects of goal-setting behavior besides goal increase (e.g., goal-attainment or goal disengagement) might be better explained by benign and malicious envy. Because we used an online sample to test our hypotheses, we were not able to capture goal-attainment or goal disengagement over a longer period of time. Future research can explore these avenues to better understand the impact of social comparison on goal-related behavior. mHealth research proposes that a variety of features can impact goal-setting behavior. For example, social comparison, social support, self-incentives and extrinsic incentives are all expected to contribute to goal-setting behavior (Fallon et al. 2019). We only looked at social comparison and, thus, other mHealth features were not the focus of this study. Future research should explore other mHealth features, affective consequences, and the impact on goal-setting behavior. Third, we address the non-significant negative effect of malicious envy on goal increase. We hypothesized that the feeling of malicious envy will deplete self-regulatory resources and be evident in a negative effect on goal increase. While the negative effect on goal-increase was non-significant, the effect was in the expected direction. Similar to the reasoning explained above, we only focused on one aspect of goal-setting behavior (goal increase). The negative effects of malicious envy could be better explained with other goal-setting behavior outcomes, such as goal disengagement or goal attainment. Future research can capture such outcome measures with a long-term study design to address the impact of malicious envy on other goal-setting behavior over time. Despite the discussed limitations, our study shows that benign and malicious envy are relevant consequences of social comparison and to some extent predictors of goal-setting behavior for physical activity. Further research can consider other systems and domains besides the mHealth context to evaluate if there are generalizable characteristics of the technology and implementation context (e.g., efficiency numbers of employees), which influence the degree of benign and malicious envy.

Conclusion

To sum up, this study aimed to understand the impact of social comparison on the affective consequence of envy and goal-setting behavior. We find that comparing to targets with similar related attributes (age and gender) determines the relevance of the comparison and positively impacts benign and malicious envy. We contribute to mHealth and social comparison research by showing that comparing to targets who are similar on the performance dimension (step count) decreases malicious envy and increases benign envy, based on appraisals of perceived control. That is, if users compare to targets with a similar step count, they appraise the situation as being controllable, whereas if they compare to targets who have a significantly higher step count, they appraise the situation as uncontrollable. Moreover, benign and malicious envy differentially impact goal-setting behavior. While benign envy results in increased goal-setting behavior, malicious envy does not. This study yields promising insights and addresses multiple gaps in general IS literature by affirming existing calls on affective factors that influence user behaviors, providing reasons to distinguish between benign and malicious envy in an mHealth context and increasing our understanding of how social comparison features impact goal-setting behaviors. The obtained findings illustrate the relevance for further research on benign and malicious envy, its antecedents and effects as well as on integrating the concepts of benign and malicious envy into the cumulative tradition of IS research.

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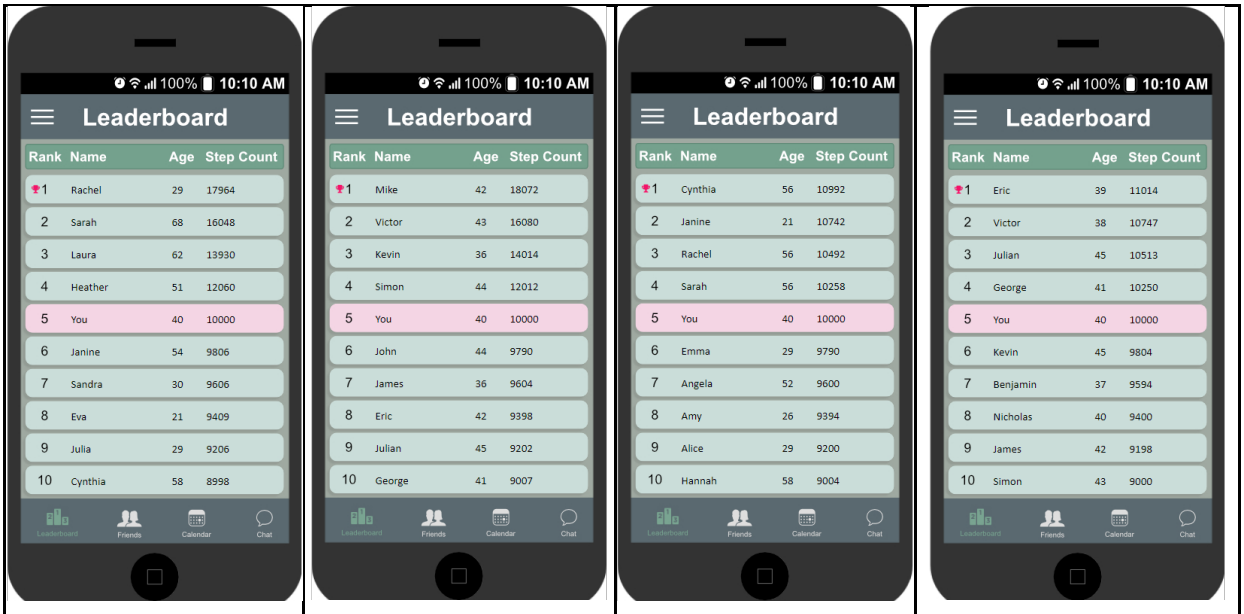
Appendix

ID	Item	Definition	References	α
PERCEIVED SIMILARITY (RELATED ATTRIBUTES)				
SM_1	People on the leaderboard are similar to me in terms of gender.	The extent to which one perceives that comparison targets are similar regarding attributes known to influence performance.	Self-developed based on Martin et al. (2002); Stapel & Koomen (2001)	.966
SM_2	People on the leaderboard are similar to me in terms of age.			
SM_3	People on the leaderboard are a relevant comparison because they are similar to me in terms of age.			
SM_4	People on the leaderboard are a relevant comparison because they are similar to me in terms of gender.			
PERCEIVED SIMILARITY (PERFORMANCE)				
SM_5	People on the leaderboard are similar to me in terms of their average daily step count.	The extent to which one perceives that comparison targets are similar regarding daily step count.	Self-developed based on Martin et al. (2002); Stapel & Koomen (2001)	.835
SM_6	People on the leaderboard take a similar amount of average steps per day as me.			
PERCEIVED CONTROL				
PC_1	There is nothing I could do about increasing my step count (1) there is something I could do about increasing my step count (9)	The extent to which one perceives that they have the ability to do something about a situation.	Van Dijk & Zeelenberg, (2002); Van de Ven et al. (2012); Roseman (1996)	1
BENIGN ENVY				
EN_1	I felt inspired to increase my step count.	The extent to which one experiences feelings that lead to positive improvement for oneself through a moving-up motivation.	Utz & Muscanell (2018); Van de Ven et al. (2009); Van de Ven et al. (2017)	.903
EN_2	I wanted to put in effort to increase my step count.			
EN_3	I wanted to increase my step count.			
EN_4	I thought about what it would be like to increase my step count.			
MALICIOUS ENVY				
EN_5	It was frustrating that others perform more steps than me.	The extent to which one experiences hostile feelings and motivations aimed at pulling-down others from a superior position.	Van de Ven et al. (2017)	.898
EN_6	I was envious that others perform more steps than me.			
EN_7	I was jealous of the others performing more steps than me.			
GOAL INCREASE				
GI_1	Do you want to increase your step count goal?	Whether one increases or does not increase their step count goal after viewing the leaderboard.	Self-developed based on Liu et al. (2019)	1
DISPOSITIONAL BENIGN ENVY				
DP_1	When I envy others, I focus on how I can become equally successful in the future.	The extent to which one experiences a general motivation directed at achieving a standard of excellence.	Lange & Crusius (2015)	.902
DP_2	If I notice that another person is better than me, I try to improve myself.			
DP_3	Envying others motivates me to accomplish my goals.			
DP_4	I strive to reach other people's superior achievements.			
DP_5	If someone has superior qualities, achievements, or possessions, I try to attain them for myself.			

Table A-1. Construct Definitions and Measurement Scales

ID	Item	Definition	References	α
DISPOSITIONAL MALICIOUS ENVY				
DP_6	I wish that superior people lose their advantage.	The extent to which one experiences a general motivation to avoid falling short of a standard of excellence.	Lange & Crusius (2015)	.918
DP_7	If other people have something that I want for myself, I wish to take it away from them.			
DP_8	I feel ill will towards people I envy.			
DP_9	Envious feelings cause me to dislike the other person.			
DP_10	Seeing other people's achievements makes me resent them.			
SOCIAL COMPARISON ORIENTATION				
SO_1	I often compare how my loved ones (boy or girlfriend, family members etc.) are doing with how others are doing	The extent to which one generally makes comparisons about opinions, abilities, and general aspects of themselves.	Gibbons & Buunk (1999)	.905
SO_2	I always pay a lot of attention to how I do things compared with how others do things			
SO_3	If I want to find out how well I have done something, I compare what I have done with how others have done			
SO_4	I often compare how I am doing socially (e.g., social skills, popularity) with other people			
SO_5	I am not the type of person who compares often with others			
SO_6	I often compare myself with others with respect to what I have accomplished in life			
SO_7	I often like to talk with others about mutual opinions and experiences **[excluded from analysis]**			
SO_8	I often try to find out what others think who face similar problems as I face			
SO_9	I always like to know what others in a similar situation would do			
SO_10	If I want to learn more about something, I try to find out what others think about it			
SO_11	I never consider my situation in life relative to that of other people **[excluded from analysis]**			

Table A-1. Construct Definitions and Measurement Scales (Continued)



Low similarity in performance Low similarity in attributes (1)	Low similarity in performance High similarity in attributes (2)	High similarity in performance Low similarity in attributes (3)	High similarity in performance High similarity in attributes (4)

Figure A-1. Exemplary Leaderboard Manipulations (Male; 40 years; 10,000 Daily Steps)