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# “Run Forrest Run!”: Measuring the Impact of App-Enabled Performance and Social Feedback on Running Performance

*Completed Research Paper*

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## Abstract

*Exercise tracking apps offer a novel and powerful channel to deliver behavioral interventions at a massive scale. As thousands of fitness tracking solutions emerge, the lack of systematic research quantifying their effectiveness on exercise outcomes becomes more prominent. Drawing on the motivation literature, this paper elucidates the effects of app-enabled motivation on fitness improvement. Specifically, this study examines the two most common forms of feedback available to users of exercise tracking apps, namely performance feedback and social feedback. The results of our field experiment reveal strong evidence that performance feedback and social feedback motivate fitness improvement. Furthermore, whereas the effect of social feedback diminishes over time, the effect of performance feedback remains resilient. There theoretical and practical implications of the findings are discussed.*

**Keywords:** Feedback, sub-goals, social facilitation, field experiment

## Introduction

Due to the rise of smart-phone ownership, wireless networks and high speed, cheap data plans, mobile apps for health have grown to capture a global market larger than USD 28 billion in 2017 and is expected to reach about USD 100 billion by 2023 (Research and Markets 2017). As thousands of fitness tracking solutions emerge, the lack of systematic research quantifying their effectiveness on exercise outcomes becomes more prominent. The design of applications tracking exercise behavior has been known to be lacking in theoretical grounding in behavioral research and uses a buffet approach to design feature inclusion based on the status quo (West et al. 2012). The mixed and ad-hoc inclusion of various features in apps has made it difficult to isolate the individual and joint effectiveness of each. Furthermore, more active individuals tend to self-select into the use of such apps, making it difficult to attribute performance improvements to specific features. Prior literature examining the academic scrutiny of mobile health apps has also highlighted small post intervention observation periods and the lack of physiological outcome measurement as the primary drawbacks of existing work (e.g., Bort-Roig et al. 2014). Recent work in behavioral economics has sought to rectify this using incentives and

informational reminders (Calzolari and Nardotto 2016; Mochon et al. 2016). More broadly, our work contributes to the developing stream of information systems (IS) literature that looks at the design considerations of mobile technology and its applications (e.g., Steinbart et al. 2016; Venkatesh et al. 2017).

Past IS research has vastly broadened understanding of technology usage in various contexts (e.g., Li et al. 2013). However, there is a lack of research examining determinants of exercise tracking technology usage. Exercise tracking technologies provide enormous potential for motivating engagement of fitness activities, which helps improve physical fitness. Mobile apps offer a novel and powerful channel to deliver behavioral interventions at a massive scale (Hebden et al. 2012). For example, Keung et al. (2013) examined an exercise tracking app for youth and found that interactive and map-driven exercise games encouraged physical activities. The incorporation of fitness-specific hardware components in mobile devices (e.g., motion sensors and heart rate monitors) has greatly instigated the development of exercise tracking apps. With the increasing awareness of active lifestyle, exercise tracking apps represent a large mobile app market. Indeed, according to PEW, approximately one in five smartphone users utilized at least one app to track their progress towards some fitness goals, and 38% of health app users had downloaded at least one app for exercise tracking (Fox and Duggan 2012). With the increasing popularity of mobile apps, a systematic investigation on the design consideration of tracking app usage is warranted. Accordingly, our first research objective is to identify the common app-enabled motivation designs specific to exercise tracking apps.

Extant studies have mostly focused on the immediate impact of technology usage using cross-sectional studies. Emerging research has begun exploring technology usage over time. For instance, Yan and Tan (2014) found that patients' participation in online communities helped them engage their disease self-management process, and hence leading to improved health conditions. Despite advancing our understanding of the longitudinal impact of technology use, it is often difficult to access the health-related impact of technology use over time. As a result, there is a paucity of research examining the longitudinal impact of technology usage on users' physical fitness. In case of exercise tracking apps, users can be motivated to maintain frequent fitness activities, which are essential to enhancing fitness performance. Thus, our second research objective is to investigate the impact of exercise tracking app usage on physical fitness.

In this paper we examine the two most common forms of feedback available to users of exercise tracking apps, namely performance feedback and social feedback (Bort-Roig et al. 2014). Specifically, we focus on in-exercise objective performance appraisal and subjective comments provided by on-platform social connections via a popular running app, Endomondo. While other forms of feedback are seen in mobile apps, these two components represent the most often employed forms of intervention (Bort-Roig et al. 2014), i.e., progress monitoring and social support. These are also among the top motivations of exercisers for using mobile apps to monitor their physical activity (Payne et al. 2015). Performance feedback during exercise mimics the role of a personal offline trainer, appraising progress, triggering self-consciousness of actual effort expended in physical activity as opposed to perceived effort. It can also potentially act as a goal gradient (Hull 1932), motivating individuals to achieve the next benchmark of progress by dividing a larger goal (i.e., a run) into more achievable sub-goals. While social support is generally able to encourage greater personal effort and induce performance improvements, it can also lead to complacency which dampens performance outcomes. The perceived presence of others in general while performing an activity can facilitate an increase in the actor's drive (Bond and Titus 1983) or even reduce it depending upon apprehension of being evaluated (Cottrell et al. 1968).

A common concern in observational studies on mobile health impacts is the endogeneity of mobile app adoption, usage frequency, and factors that influence long term health behaviors. We overcome this estimation challenges via a randomized field experiment. While experimental studies of online interventions have also been known to suffer from lack of interest/active participation, sporadic exercise logging and short study spans (Bort-Roig et al. 2014), our study was intentionally designed to overcome these shortcomings by utilizing subjects within a uniform organization which circumvents issues of lack of compliance. Our unique study context also allowed us to achieve random feature assignment without concerns of spillovers between treatment conditions. Most observation studies of exercise behavior rely

on self-reporting and exercise diaries which are susceptible to reporting bias, this too is addressed via mandatory standardized monitoring of performance outcomes upheld by the uniform organization.

## Literature Review

### *Motivation through Progress Monitoring*

Human often take up routine activities to achieve certain objectives or goals (e.g., exercising to improve fitness). Although the process to goal achievement might not be enticing, persistence in the process is often necessary because goals can only be achieved by completing the processes. To illustrate, in marathon running, people often complain that training sessions can be repetitive and monotonous, but they can be gratified for reaching the finish line. Despite the gratification derived through goal achievement, people often struggle to stay committed to goals that seem distant or difficult to achieve (Locke et al. 1988). While it is reasonable to assume that people strive to become healthy and fit, unfortunately committing to exercise regimes often seems to be a daunting task (Dorris et al. 2012).

A common strategy that people use to tackle distant or difficult goals (e.g., fitness performance goals) is to create intermediate goals, which are smaller, more proximal goals established as subsets of the overarching goal (Amar et al. 2011; Bagozzi and Edwards 1998). In their seminal study, Amir and Ariely (2008) posit that any task can be characterized by the amount of progress information it embodies. For example, traveling with a global positioning system allows drivers to be aware of their whereabouts and distance to the destinations. Credit card statements provide card holders clear understanding of their progress in paying up debts. Furthermore, Amir and Ariely (2008) postulate that progress information establishes natural intermediate goals (i.e., reaching the next rest point in a long journey), which are often considered more immediate and achievable, compared with the overarching goals (i.e., reaching the destination). Indeed, progress information is widely recognized to be helpful to people recognizing their intermediate achievement, and therefore lead to greater subsequent effort and goal persistence (Goes et al. 2016; Lee et al. 2012).

Theorists suggest that the effects of progress information on increased training effort is especially apparent when intermediate goals are ordered. For example, in uniform service, to prepare for running trials (i.e., to finish a 5-km run within 45 minutes), servicemen often take on jogging exercises. To keep track of progress in exercises, they might break down the entire distance (i.e., 5-km) into multiple intermediate goals (e.g., 1-km intermediate goals). Each of these intermediate goals must be completed sequentially because completing the first intermediate goal (e.g., the first 1-km) is a necessary condition for activating the second intermediate goal (e.g., the second 1-km). In this case, distance progress information (e.g., completing 2-km in 18 minutes in a training) thus provide explicit indications to the servicemen about their advancement to passing the upcoming fitness test. In exercise tracking apps, to stay aware of progress to intermediate goals, users can draw on *performance feedback*, which refers to the objective performance appraisal that is mechanically generated and provided to users during fitness exercises.

### *Motivation through Social Facilitation*

Social facilitation is about an increase in performance due to the presence of others, who might be nonactive observants or active spectators (Allport 1924). Past studies examining social facilitation have showed that the presence of others can enhance performance in a variety of cognitive tasks and motor activities (Guerin 1999). Although different views of social facilitation have emerged, theorists agree that evaluation anxiety and audience support are important mechanisms to explain performance increase. Evaluation anxiety centers on individuals' sense of uncertainty on performance-based evaluation by a passive audience. Whereas active spectators might explicitly or implicitly provide individuals feedback about their performance, nonactive observants essentially denies individuals from assessing the merits of their self-presentation (Bond and Titus 1983; Schmitt et al. 1986). This lack of understanding can make individuals highly anxious about others' evaluation and hence motivating them to maintain the best possible efforts in upholding competent imagines.

Audience support is often conceptualized as the praise and encouragement made by active spectators of individuals' performance (Kanouse et al. 1981). Whereas praise focuses on acknowledging competent performance, encouragement often is future-focused and emphasizes on motivating sustained and/or improving performance. Ample evidence suggests that praise motivates performance improvement by enhancing individuals' perceptions of competence and making individuals feel good about themselves (Ryan and Deci 2000). Because of the positive experience of being praised, individuals are likely to continue to demonstrate the praised performance to sustain the attention and approval of the audience. Encouragement is often considered a form of intangible social support, which provides individuals with a bolster to their sense of self-esteem (Freeman et al. 2014). The effects of encouragement on increasing performance can be explained through the notion of distraction (Andreacci et al. 2002). For example, in physical training, individuals might focus on physical sensations, such as pain or exhaustion. Encouragement provides a dissociative cognitive mechanism through which individuals' focus on the physical activities are altered to the presence of others, and hence distracting them from the discomfort and making the activities less aversive (Scott et al. 1999). In exercise tracking apps, *social feedback*, which refers to the subjective comments provided by on-platform social connections, makes users aware of the presence of others during fitness exercises.

## **Hypothesis Development**

This research is grounded in the motivation literature to explain the effects of performance feedback and social feedback on fitness performance. Furthermore, we examine the mediating role of sustained usage on the relationship between the two types of feedback and fitness performance.

### ***The Effect of Performance Feedback***

Awareness of intermediate achievement is known to enhance goal persistence (Amar et al. 2011; Bagozzi and Edwards 1998). Specifically, when people are notified about achieving intermediate goals, they are likely gratified by the progress and become confident about achieving the overarching goal. As a result, they may be highly motivated to persist goal pursuit. On the contrary, when people are unaware of intermediate achievement, they would not experience progress gratifications, and hence might doubt the achievability of overarching goal.

In exercise tracking apps, when performance feedback is available, users are provided with objective progress information during fitness exercises, and such progress information leads users to be aware of their achievements of intermediate goals, i.e., completing 2 kilometers of a run. We offer two explanations for the effect of performance feedback on improving fitness performance. First, an overarching fitness goal (e.g., to complete a 5km jog within 45 minutes) provides a natural reference point according to which people evaluate effectiveness of physical exercises (e.g., jogging activities) (Carver and Scheier 2004). Accordingly, with performance feedback, users become aware of intermediate achievements during jogging exercises, which can bolster their self-efficacy with respect to the overarching fitness goal. Second, performance feedback provides users with recurring progress information, which serve as reinforcing signals that users are committed to achieving the overarching fitness goal, thereby motivating elevated efforts in fitness exercises (Fishbach and Dhar 2005). Therefore, we posit

*H1a: Performance feedback will lead to improved fitness performance.*

### ***The Effect of Social Feedback***

The social facilitation literature suggests that compared with the absence of others, performing physical activities with the presence of others can lead to performance improvement. The presence of others makes individuals aware about audience observability on their task performance, and hence elevating individuals' evaluation anxiety. At times, the audience can provide individuals with praises and encouragement, which motivate them to sustain the recognized activities and thereby leading to performance improvement. Yet, with the absence of others, individuals are essentially performing activities in private and hence will not be overly concerned about social evaluations (Rudman 1998).

In exercise tracking apps, as mentioned earlier, social facilitation can be realized through social feedback, which does not only highlight the virtual presence of others but also facilitate their participations during users' fitness exercises. The presence of active spectators can keep users motivated in fitness exercises by keeping up their perceptions of competence and feeding them with distractions from physical exhaustions. Accordingly, when social feedback is available, to sustain social attention and approval, users are likely motivated to keep up their efforts in fitness exercises. By contrast, when social feedback is unavailable, users' fitness exercises largely remain private, and hence are unlikely to experience social facilitation. We thus hypothesize the following:

*H1b: Social feedback will lead to improved fitness performance.*

### ***The Temporal Aspect of Sustained Motivation***

Whereas performance feedback is mechanically generated by exercise tracking apps, social feedback is made available through others' active participations. The generation of performance feedback, as aforementioned, is triggered based on some predetermined conditions (e.g., distance-triggered). Accordingly, provision of performance feedback is expected to be highly structured and hence is unlikely to diminish over time. Hence, we expect the effects of performance feedback on improving fitness performance to be sustained over time.

In contrast, provision of social feedback is relatively unstructured. According to the social support deterioration model, support givers are limited by finite cognitive resources that can be depleted over time, and hence leading to burnout (Kaniasty and Norris 1993). In such a case, givers are likely to distinctly reduce the availability of support (Lepore et al. 1991). Likewise, over time, virtual spectators are likely to be decreasingly enthusiastic in following users' fitness exercises and providing praises and encouragement. Indeed, past research examining social support has noted the transient nature of praise and encouragement from peers. For instance, Henderlong and Lepper (2002) have explicitly cautioned on the reliability of social support, which can dissipate as soon as the audience is not as generous in providing approval.

*H2a: The respective effects of performance feedback and social feedback on fitness performance varies over time, i.e., performance feedback leads to a sustained improvement to fitness performance; social feedback improves fitness performance in a curvilinear fashion, improving it up to an optimal point and impairing it thereafter.*

Recent IS research has emphasized on the mediating role of usage experience on the relationship between technological features and distal outcomes (e.g., Liu et al. 2017). In this study, we postulate that sustained app usage will mediate the effects of performance feedback and social feedback on fitness performance. Our rationale is that performance and social feedback augments exercise experience with explicit competence recognition and social connectivity. The enhanced exercise experience is likely to entice users to continue using exercise tracking apps. Since usage of exercise tracking app is fundamentally coupled with performance of fitness exercises, sustained app usage implies high physical activeness that is essential to improving fitness performance. Therefore, we posit:

*H2b: Performance and social feedback leads to sustained app usage which in turn mediates improvement in fitness performance.*

## **Methodology**

We employed a commercially available exercise tracking app (called "Endomondo" in the Apple App Store and Google Play) to conduct a field experiment to test the hypotheses. The exercise tracking app helped users track their jogging activities and provided audio feedback on their performance (i.e., total tracked distance and time, average speed, as well as speed in the last kilometer). Additionally, the app facilitated social sharing of users' jogging activities by pushing notifications to their friends' phones. Friends can then respond with text messages, which were made available to users in the audio form.

Eight hundred and twenty-five male adults, who were active national servicemen, completed the longitudinal field experiment that lasted 18 months. As part of the national service responsibilities,

subjects were required to periodically report for military training and duties. Additionally, servicemen were required to complete mandatory annual physical fitness tests that involved a 2.4 km run. Servicemen would be rewarded for satisfactory test performance (cash awards ranging from about USD 75 to USD 300, depending on performance). However, if they should fail the tests, they would be ordered to attend remedial physical trainings.

We randomly assigned subjects to different treatment and control conditions. The imposition of draft in Singapore implies that the sample was representative of the average young male population of the country. The tests were conducted in a controlled environment, which provided us with outcomes free from biases and errors associated with self-reported values. The first group of servicemen comprised of the control condition who were asked to document their running activity via Endomondo, no feedback features were enabled. Members of the performance feedback (PF) condition were given contemporaneous in-exercise auditory notification per kilometer of activity. Those in the social feedback (SF) condition had their run shared in real-time with other servicemen who were asked to provide textual feedback. This was read out by the app in-exercise to the recipient. In the final condition, both social and performance feedback were provided simultaneously (PF\*SF). Commanding officers conducted regular spot checks on soldiers' mobile app to see if they had adhered to the use of their treatment app features.

At the beginning of the 18-month period, a training session was conducted through which the exercise tracking app was installed on subjects' smartphones. At the training session, subjects were instructed to make several adjustments to the app features. By embedding the specific settings for experimental conditions within the list of adjustment, subjects were less aware of the manipulations. Specifically, for subjects allocated to the baseline condition, they were instructed to use the app to track their jogging activities with the audio coach muted. For the performance feedback condition, subjects were asked to use the tracking feature with the audio coach enabled. To facilitate social feedback, during the training session, subjects were instructed to populate the in-app friend list with four friends who were participating in the experimental condition. They were encouraged to add other friends to their friend list after the training session. Subjects were told to strictly follow the experimental instructions and use the app as much as possible throughout the 18 months. Additionally, they reported their age, past physical fitness test results, weight, and height. After the briefing, subjects undertook a two kilometers leisure jog with the exercise tracking app tracking their participations.

As depicted in Figure 1, in each 6-month period (for 18 months), subjects completed the physical fitness tests. In addition to their 2.4 kilometer run timing, their app usage (i.e., total tracked distance and total tracked time) in the 6-month period was captured and their app settings (i.e., social feedback was disabled/enabled) were verified with their allocated experimental conditions.

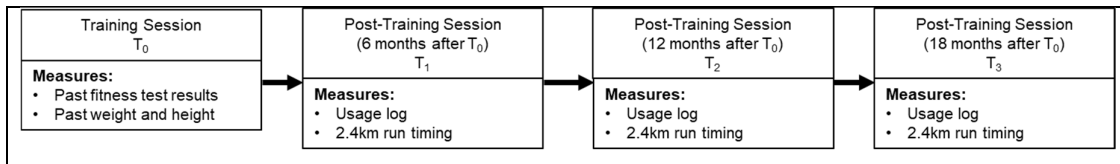


Figure 1. Experimental Procedure

## Data Analysis

We performed randomization checks on age, income, military rank and education prior to group assignment. The treatment conditions were spread over several battalions to ensure uniformity in behavior and exercise routines. Soldiers within the same company were assigned to the same condition to ensure that contamination due to within inter-subject interactions for the social feedback condition do not cause contamination. After conducting the experiment, we further matched treated soldiers with counterparts in the control condition, based on their prior running times and historical BMIs from past 5 IPPT tests using Coarsened Exact Matching (CEM) with multiple treatment conditions (Iacus et al. 2012). Our primary analysis examined the impact of treatment dummies on logged run times in seconds

for individuals as recorded in the IPPT tests, with wave fixed effects. The same analysis is repeated with the addition of individual random effects, which is suited to the conditions of a randomized experiment. The results are reported in Table 1. We further analyzed the role of different levels of social feedback, by considering the counts of feedback received in a given time period.

We found that both PF and SF features improved running performance. Specifically, the presence of PF yielded a reduction of 3% in long term run times, and the SF feature yielded a 1.8% reduction (Model 1). However, the impact of SF disappears upon the addition of random effects. The non-significant interaction term in Model 2 also suggest that the two features do not hold synergistic effects when offered in parallel. Therefore, H1a and H1b are supported.

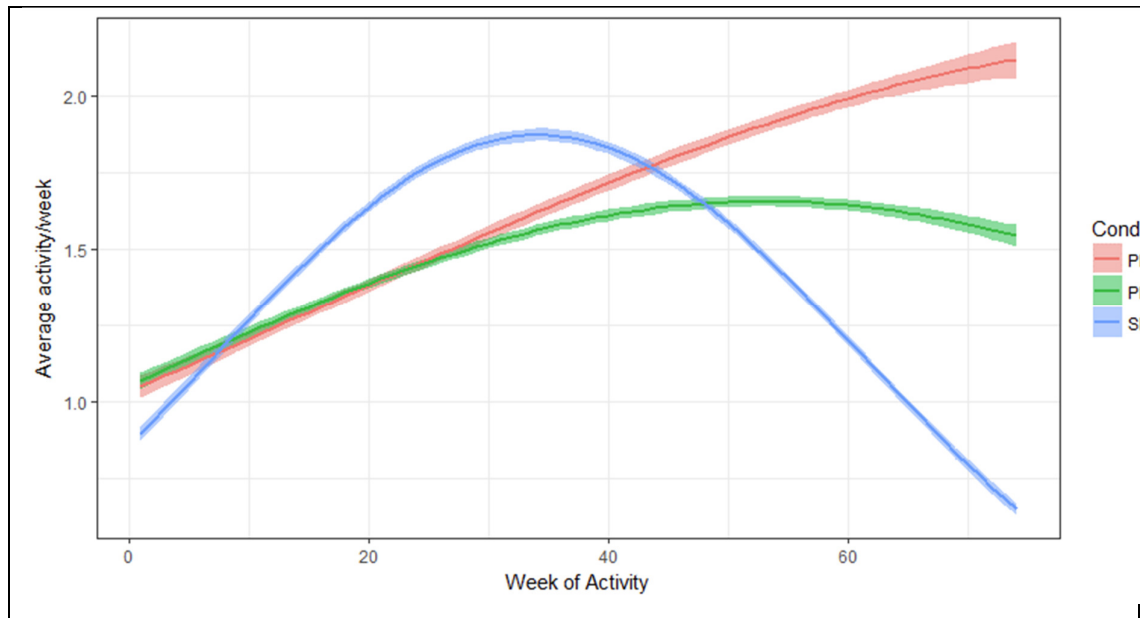
**Table 1. Regression Results for Matched Treated and Control Subjects**

	<i>Dependent variable</i>			
	<i>log(RunTime)</i>		<i>UsageFrequency</i>	<i>log(RunTime)</i>
	<i>Treatment Dummies</i> (1)	<i>Treatment Dummies</i> (2)	<i>2SLS 1<sup>st</sup> stage</i> (3)	<i>2SLS 2<sup>nd</sup> stage</i> (4)
PF	<b>-0.0316***</b> (0.0056)	<b>-0.0315**</b> (0.0154)	<b>15.0014***</b> (1.8206)	
SF	<b>-0.0185***</b> (0.0060)	-0.0228 (0.0156)	<b>8.4088***</b> (1.6356)	
PF:SF	<b>0.0184**</b> (0.0077)	0.0236 (0.0214)	<b>-13.6358***</b> (2.9014)	
UsageFrequency (6 months)				<b>-0.0022***</b> (0.0005)
Observations	1,983	1,983	1,983	1,983
R <sup>2</sup>	0.9371	0.9375	0.2807	0.9146
Adjusted R <sup>2</sup>	0.9365	0.9369	0.2734	-0.2804
Residual Std. Error (df = 1962)	0.0446	0.0445	17.7180	0.0519
Time FEs	✓	✓	✓	✓
Individual Res		✓		
<i>Note: *p&lt;0.1; **p&lt;0.05; ***p&lt;0.01</i>				

The joint feedback condition fared better than pure social support in terms of sustenance of exercise participation and in garnering social support. Our results suggest that while social support is more effective than performance feedback in short term gains to exercise activity it is surpassed by it over time. Joint feedback was found to be non-additive of its comprising components and is also less effective in the long run when compared to performance feedback alone. Therefore, H2a is supported.

The impact on running performance was likely to be brought about by increased frequency of exercising, in turn precipitated by the different app delivered treatments. We tested this by instrumenting app usage frequency with treatment conditions. We found evidence of performance and social feedback increasing exercise frequency (Model 3) leading to gains in performance (Model 4). These findings were robust to tests for weak instruments (Stock and Yogo 2002). A day by day analysis of exercise frequency over time by condition revealed that while PF led to a sustained rise in app usage, SF conditions showed a curvilinear relationship with time (see Figure 2). This was found to stem from a decline in social feedback received per activity over time. Therefore, in sum, H2b is supported.





**Figure 2. Weekly Activity Rate Per Condition: Moderation of Impact by Time**

## Future Research

This study is operationalized using subjects who were national servicemen. This subject pool allows us to conduct periodic observations of servicemen's weight, height, and fitness, which are often difficult, if not impossible, to perform over an extended time period. Furthermore, we were supported by an established management structure in operationalizing the study. It is worthy to note that our subjects were working adults and their service responsibilities were compulsory but independent from their fulltime jobs. Therefore, unlike career servicemen, our subjects consisted of people with diversified demographics. Future research is encouraged to extend this study to specific organizational settings, such as corporate wellness programs and school fitness curriculum, as well as the female populations.

## Theoretical Implications

### *Motivations Induced by App-Enabled Feedback*

We contribute not only to the IS research stream but also to the motivation literature by formalizing two forms of app-enabled feedback that powerfully drive motivations. Motivation is essential to behavioral change and sustaining change behaviors over time. However, most of these past studies focus on post-event motivation strategies and hence motivation mechanisms that can be administrated during events are largely ignored. Our study is meaningful in that it is among one of the first to examine the motivations induced by app-enabled feedback during app usage. Furthermore, past research lacks a systematic investigation into the subtle difference between objective feedback and subjective feedback. This study contributes significantly to the motivation literature by showing how competence-based motivation and social-based motivation can be induced independently in exercise tracking apps. First, this study demonstrates that completion of sub-goals can be highlighted to emphasize the sense of progress. Performance feedback notifies users about their completion of intermediate distance goals. Since intermediate distance goals are relatively proximal, frequent reinforcement of achievement signals enhances users' beliefs about improving fitness performance, and hence strengthening their commitment in goal pursuit. Second, this study shows that social facilitation can powerfully induce motivations. Social feedback does not only facilitate virtual presence of others but also make available others' comments to users during fitness exercises. Be it mere presence or a participatory audience, users are aware of being under social evaluation, and hence becoming especially motivated in

demonstrating their commitment to goal pursuit. Overall, this study enriches the motivation literature to the context of exercise tracking apps by identifying feedback design considerations and applications.

### ***Fitness performance Improvement***

This study formally examines fitness performance improvement through usage of exercise tracking apps. The lack of attention to the physical outcomes of technology usage is surprising when one considers that the usage of exercise tracking apps is fundamentally coupled with fitness activities. Drawing on Liu et al. (2017), we provided contextualized explanations of experiential outcomes and instrumental outcomes specific to exercise tracking app usage. Specifically, we focus on app usage frequency to deliberate experiential outcome and fitness performance improvement to represent instrumental outcome. Experiential outcome is about the proximal effects of feature designs. Whereas well-designed app features can motivate physical activeness, inept features might inhibit behavioral change and hence increasing the vulnerability of relapses. Instrumental outcome is about the distal effects of feature designs. Useful and easy to use exercise tracking apps can help improve physical fitness, which can be helpful to reducing healthcare expenditures.

### **Managerial Implications**

Our findings provide practitioners with valuable insights into how to design motivation features that drive sustained outcomes in using mobile apps. In particular, we advocate that app-enabled motivation features should be carefully incorporated into usage experience. Recall that, in our study, performance feedback and social feedback powerfully improve fitness performance. However, social feedback becomes less influential in driving fitness performance improvement over time, while the effect of performance feedback remains resilient. This result is an important reminder that social connectivity might provide considerable usage traction, but socially driven motivation might not be entirely sustainable. Thus, app designers must carefully consider the specific development strategies to maintain users' interests over time.

It is worth noting that when performance and social feedback is offered in parallel, compared with when offered independently, the effect on improving fitness performance was stronger. Although conventional wisdom suggests the significance of both competence and social motivations, their synergistic power is not yet widely known. Our study clearly shows that the concurrent provision of both types of feedback is a necessary condition to maximize the motivational effects. Performance feedback helps maintain the sense of progress, which is vital for users to strategize their exercise behaviors during fitness activities. Social feedback emphasizes social attention during fitness exercises and hence motivates users to exercise hard for optimal self-presentation. Whereas performance feedback is mechanically generated by exercise tracking apps, social feedback is made available through others' active participations. It is thus possible that variations in delivery structure and content are important considerations in designing app-enabled motivation features.

### **Conclusion**

Exercise tracking apps offer a novel and powerful channel to deliver behavioral interventions at a massive scale. Yet prior research mostly focuses on adoption of health-related technologies, with less attention paid to understanding the implications beyond usage. Emerging research has begun exploring various app features to encourage active lifestyle. Although IS research deals with numerous aspects of app design considerations, there is a paucity of research on designing app-enabled motivation features. This study represents one of the first attempts to draw on the motivation literature to develop nuanced understanding towards designing features on app-enabled motivation. Our results reveal that performance feedback and social feedback both provide powerful motivations to improving fitness performance. These results serve as a basis for future theoretical development in the area of motivation and yield valuable insights that can guide practice.

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