Persuasive Performance Feedback: The Effect of Framing on Self-Efficacy

Eun Kyoung Choe, MIMS[1], Bongshin Lee, PhD[2], Sean Munson, PhD[1], Wanda Pratt, PhD[1], Julie A. Kientz, PhD[1]

[1]University of Washington, Seattle, WA; [2]Microsoft Research, Redmond, WA

Abstract

Self-monitoring technologies have proliferated in recent years as they offer excellent potential for promoting healthy behaviors. Although these technologies have varied ways of providing real-time feedback on a user's current progress, we have a dearth of knowledge of the framing effects on the performance feedback these tools provide. With an aim to create influential, persuasive performance feedback that will nudge people toward healthy behaviors, we conducted an online experiment to investigate the effect of framing on an individual's self-efficacy. We identified 3 different types of framing that can be applicable in presenting performance feedback: (1) the valence of performance (remaining vs. achieved framing), (2) presentation type (text-only vs. text with visual), and (3) data unit (raw vs. percentage). Results show that the achieved framing could lead to an increased perception of individual's performance capabilities. This work provides empirical guidance for creating persuasive performance feedback, thereby helping people designing self-monitoring technologies to promote healthy behaviors.

1. Introduction

Consumer self-monitoring technologies for health have proliferated in recent years. Examples include pedometers for step count,[1,2] sleep tracking devices for sleep duration and quality,[1–3] electronic scales for weight and body fat percentage,[4] and glucometers for blood glucose level.[5] These self-monitoring technologies often provide real-time feedback on a user's current progress, which we call **performance feedback**. Performance feedback provided in varied ways (e.g., text, visual, positive light, negative light) could foster changes in behavior under observation, which is referred to as *reactivity* (or *reactive effect*).[6] Reactivity often manifests in the frequency of the target behavior changing in a desired direction.[6] When properly combined with goal setting,[7] real-time performance feedback is a powerful driver to increase reactivity for health behavior change.

Our objective in this research was to identify ways to present performance feedback that will nudge people toward healthy behaviors. In creating influential, persuasive performance feedback, we were inspired by the well-known "Framing Effects."[8] The key idea is that the way information is framed (e.g., highlighting information in a positive light vs. negative light) influences people's behavior. A classic example is in the framing of the odds of a grueling operation: many would prefer an operation of where the outcome is "90 out of 100 are *alive* after five years" than one where "10 out of 100 are *dead* after five years." Although these two options contain the same information from an expected value perspective, people—even experts (i.e., doctors)—are systematically subject to framing effects and more apt to prefer surgery when described by survival rate than death rate.[9]

Drawing from prior literature and existing self-monitoring technology designs, we identified three types of framing that can be applicable in presenting performance feedback in conjunction with a daily goal. First, we modified *valence of performance*, a classic framing on positive versus negative outcomes as introduced in the example on surgical outcomes. Second, we modified *presentation type* comparing text-only feedback with text combined with visual feedback. Although most prior framing research examined framing using text descriptions, we investigated whether visual elements such as colors and figures can make the valence of performance even more salient than text-only valence descriptions. Third, we varied *data unit*, which has been explored in the context of medical risk communication (e.g., communicating genetic abnormalities[10]). We studied the effect of these framings using a hypothetical scenario of a person receiving his/her daily step count from a pedometer. We chose to use the step count scenario because pedometers are widely available consumer self-monitoring technologies, and thus people could easily understand the meaning of its feedback (i.e., step counts) without training.

In an effort to identify the kind of framing that can nudge people toward healthy behaviors, we conducted an online experiment in which we tested the effect of the three framings described above. In what follows, we provide background on existing self-monitoring technologies and prior framing studies that are relevant to our study. Next, we detail our study and data analysis methods and report on the results. Based on our findings, we suggest design considerations for creating persuasive performance feedback.

2. Related Work

In this section, we provide background on self-monitoring technologies designed for health behavior change, with an emphasis on the feedback they provide. In addition, we outline the theoretical and empirical background of framing research in the context of health decision-making.

2.1. Self-Monitoring Technology

To promote health behavior change, researchers and designers often use technology to monitor health-related activities.[11] Both research and commercial applications have incorporated automated sensing or manual tracking within technology applications to help people monitor and reflect upon their behavior. The field of Personal Informatics[12] and the Quantified Self movement[13] both adopt the approach that through knowledge of one's activities, it becomes possible to reflect on those activities, make self-discoveries, and possibly use that knowledge to make changes. Within the health domain, both research and commercial applications have focused on tracking physical fitness,[1–2,14–17] sleep,[1–3,18] diet,[19,20] smoking,[21] and stress.[22]

These examples have varied ways of providing feedback. For example, the UbiFit[14] project provides an abstract representation of progress through a changing display of flowers on the background screen of a mobile phone, whereas the Lullaby application[18] provides graphs of raw data about a person's sleep environment and awakenings. Applications also differ in whether they make judgments about a person's progress as being either positive or negative. As an example, FitBit,[1] a wearable pedometer and activity tracker, provides a standard, neutral message about a user's progress in the form of step count as well as a more affective display of a flower or emoticon, which also runs from neutral to positive. The Fish N' Steps application[15] uses both positive and negative feedback through a virtual fish avatar that is happy or sad depending on a person's activity levels. Applications also differ in their presentation of data in a way that people can understand. In tracking sleep, ZEO[3] provides an overall "sleep score" each day that is unclear to users how that score is determined, whereas the FitBit sleep tracking feature[1] provides a straightforward number of the hours slept.

Most applications use a variety of performance feedback methods within the same application. FitBit syncs with a website and mobile application, providing a variety of feedback across a range of devices: (1) a text-based notification on how many steps are remaining until the user reaches his/her daily goal (Figure 1, left); (2) a visual progress bar indicating a percentage achieved against the daily goal (Figure 1, center); and (3) a text-based numerical representation of the number of steps taken on the tracking device itself (Figure 1, right). Although many users report on the application's public forums that they are able to use FitBit to successfully motivate themselves to take more steps, it is not clear which type of feedback may be most effective in achieving this success. It is also not clear from the literature which types might be most effective in actually encouraging users to meet their goals or change their behaviors. It is often easier to implement a text-based message than a visual one, but it has not yet been studied whether it is worth the effort to make a visual representation. Thus, our work seeks to systematically determine which types of performance feedback within a health-related context might be the most effective in encouraging people to meet their goals.

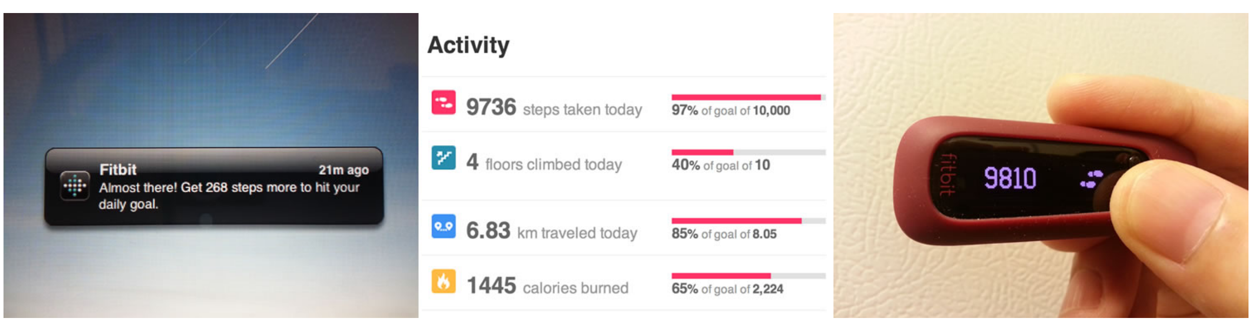

Figure 1. Three types of performance feedback in Fitbit interfaces. A text-based notification on how many steps are remaining until the user meets his/her goal (left); a visual progress bar indicating a percentage of goal achieved (center); and (3) a text-based numerical representation of the total number of steps taken (right).

2.2. Framing Studies

Tversky & Kahneman[8] reveal that presenting the same option but varying the framing of acts, contingencies, or outcomes alters people's decisions. Tversky & Kahneman proposed Prospect Theory to explain the framing effects,[8] stating that people have an irrational tendency to be less willing to take risk with profits than with losses. In other words, people value a sure gain over a probable gain with an equal or greater expected value. In contrast, people prefer a probable loss to a smaller loss that is certain when focusing on the prospect of a loss.

Since Tversky & Kahneman first explained how valence framing influences people's willingness to take risk, framings have been studied in many domains. To better understand when and why different types of framing will have an effect, Levin and colleagues developed a typology of framings and distinguished between three different kinds of framings—risky choice, attribute, and goal framing.[23] Our work is particularly inspired by the *attribute framing*, which affects the evaluation of an object or event characteristic. An example of attribute framing is how we describe the attribute of ground beef, which can be labeled as either "75% lean" or "25% fat." A study shows that people favor the former even though the two labels convey the same information.[24] The most common finding in the attribute framing literature is that positive framing leads to more favorable evaluations than negative framing.[9,24]

In the health domain, Prospect Theory has been used to understand health-relevant judgment and behaviors. Rothman & Salovey classify health behaviors into (1) detection behaviors, (2) prevention behaviors, and (3) recuperative behaviors and state that the influence of framed information on decision-making is contingent on the degree to which performing a health behavior is perceived as risky.[25] For example, early detection behaviors (e.g., mammography, HIV testing) could be regarded more as "uncertain or risky" behaviors than prevention behaviors (e.g., smoking cessation, exercise) because there is a possibility of discovering that one is sick. In accordance with Prospect Theory, empirical studies show that loss-framed messages tend to be more persuasive for promoting detection behaviors whereas gain-framed messages tend to be more persuasive for promoting prevention behaviors.[26] In our case of promoting physical activities (e.g., walking), these findings suggest the use of gain-frame (i.e., emphasizing the benefits of physical activities) because conducting physical activities is considered as a prevention behavior. However, prior research does not address how to best present daily performance feedback that can lead to health-enhancing, self-beneficial decisions. To leverage the power of real-time feedback of self-monitoring technologies, we sought to identify persuasive framing not for the health behavior itself (i.e., walking) but for presenting performance feedback toward the goal (i.e., step count).

Framing is also used in a broad sense, such as varying the *presentation type* or *data unit*. Lipkus & Hollands[27] and Ancker et al.[28] provide an extensive review of literature around the use of *visuals* to enhance health risk communication. Although some visuals can help reduce the amount of mental computation, the authors argue that not all graphics are more intuitive than text. Ancker et al. found that the use of visuals should depend on the purpose of risk communication because some types of visuals are more appropriate for *enhancing the accuracy* of quantitative reasoning whereas others are more suitable for *promoting behavior change.*[28] In addition, data presented with different units (e.g., raw data, rate, percentage) could have a significant impact on people's perception of the data. One study shows that rates (e.g., three per 1000) were easier to understand than proportions (e.g., one in 333) when patients were presented with the risk of genetic abnormalities.[10] This finding suggests that the choice of data unit in designing performance feedback could alter people's health decisions. Some health researchers evaluate the efficacy of different feedback by measuring behavioral intentions.[29] In our work, we provide participants with a hypothetical scenario and measure people's self-efficacy, which is a strong predictor of behavior change and maintenance.[30] Numerous studies have shown that self-efficacy can be enhanced and that this enhancement is related to subsequent health behavior change.[30–32] We therefore chose self-efficacy as our dependent variable as the core purpose of performance feedback is to influence individuals' health behaviors.

3. Research Questions and Experiment Design

We explored whether the framing of feedback on an individual's performance affects his/her self-efficacy. We examined the effects of three types of framing: *valence, presentation type*, and *data unit*. We also suspected that these framings might have different effects at various levels of progress toward one's goals (*distance to the goal*), such as the beginning phase or the ending phase. Thus, we explored the following research questions (RQ).

RQ1. How do different types of performance feedback framing—(1) valence, (2) presentation type, and (3) data unit—influence an individual's self-efficacy?

RQ2. Does the distance to the person's goal influence the framing effect?

To examine these research questions, we designed a 2 (valence: achieved vs. remaining) x 2 (presentation type: text-only vs. text with visuals) x 2 (data unit: raw vs. percentage) x 2 (distance to the goal: low achievement (25%) vs. high achievement (75%)) mixed-design with repeated measures. Valence (VALENCE), presentation type (PRESENTATION), and data unit (UNIT) were between-subjects factors and distance to the goal (DIST) was a within-subjects factor, thereby forming eight different conditions (Table 1).

4. Method

We conducted a mixed-design study as an online experiment. We conducted several iterations with pilot participants before deriving the final questions, scenarios, and feedback designs that are presented here. We explored our research questions in the context of receiving performance feedback on daily step counts from a pedometer where a daily goal was set to 10,000 steps. We chose the step count scenario with the daily goal of taking 10,000 steps because this scenario was relatively easy to understand and could be applicable to a wide audience. Although "10,000 steps a day" is not a magic number, it is easy to understand and applicable for most people to be active, considering the U.S. average daily step count is 5,100.[33]

4.1. Survey Contents and Study Conditions

We created online surveys for the eight conditions. Each survey consisted of three sections—(1) interest in achieving 10,000 steps daily, (2) self-efficacy questions, and (3) demographic questions. To help participants understand the time and effort to achieve 10,000 steps daily, we asked, "Approximately how far do you think is 10,000 steps?" and revealed the answer (5 miles) on the next page. We also explained the time it typically takes to reach 10,000 steps—1 hour 40 minutes for moderate intensity (100 steps per minute), and 1 hour 17 minutes for vigorous intensity (130 steps per minute). We then asked the participants about their interest in taking 10,000 steps daily to maintain a desirable level of physical activity for health.

To situate participants in the context of receiving performance feedback, we provided the following hypothetical scenario:

> *Research has suggested taking 10,000 steps daily for maintaining a desirable level of physical activity for health. Suppose you purchased a pedometer (step counter) to monitor your step count, and set* ***a daily goal of 10,000 steps****. You need to wear it every day in your pocket or on your waist, and it gives you real-time feedback of the* **[*remaining* | *achieved*]** *steps toward your goal.* [The wording (i.e., "remaining" or "achieved") was modified accordingly for each condition.]

Then we showed step count feedback (Table 1) as an image. We manipulated the feedback in the following manner:

- *Valence of Performance*: We varied the valence of performance by describing the performance using the "achieved" frame and the "remaining" frame.
- *Presentation Type*: We created text-only feedback and text with visual feedback. For the text with visual feedback conditions, we provided a progress bar colored in either green or magenta.
- *Data Unit:* We varied step count units by using raw number (steps) and percentage (%).

Table 1. Feedback manipulation for the eight conditions and the number of participants assigned to each condition for the low level of goal achievement (25%) case.

Valence of Performance	Presentation Type	Data Unit	Example feedback (2500 steps)	# of Participants Initially Assigned	# of Participants Included in the Analysis
Achieved	Text-only	Raw	2500 steps achieved	66	49
		Percentage	25% achieved	61	49
	Text with visual	Raw	2500 steps **achieved**	62	50
		Percentage	25% **achieved**	58	49

Remaining	Text-only	Raw	7500 steps remaining	65	50
		Percentage	75% remaining	68	48
	Text with visual	Raw	7500 steps **remaining**	69	58
		Percentage	75% **remaining**	62	47
			Total Number of Participants	**511**	**400**

According to our feedback manipulation, "2,500 steps achieved" in the achieved-frame conditions was equal progress to "7,500 steps remaining" in the remaining-frame conditions and to "25% achieved" in the percentage conditions. Also, the same feedback was provided with and without the visual (progress bar).

Each participant saw two feedback conditions, varying the *distance to the goal* at two levels—25% and 75%—in a randomized order. Feedback manipulation examples in Table 1 show low achievement of goal achievement (25%) case for the eight conditions. The scenario supposed that a participant is receiving the step count feedback on a *weekday at 4:30pm*, which is the time when much of the participants' day had passed, but they could still have time to achieve their goal.

4.2. Measure

After showing each feedback, we measured participants' self-efficacy by asking the following question adopted from Bandura[31]: "Rate how confident you are that you can achieve your daily goal as of now (4:30 PM, weekday)." Self-efficacy was measured on a 11-point Likert-like scale, where 0 = "Certain I cannot meet my goal" and 10 = "Certain I can meet my goal." In addition, we conjectured that participants' interest in taking 10,000 steps daily might be related to their base self-efficacy, so we measured the interest level on a 11-point Likert-like scale at the very beginning of the survey.

It was necessary for participants to understand the feedback so that they could answer the self-efficacy question based on correct understanding of the feedback. To assess whether participants correctly understood the feedback, we included a filtering question. We showed feedback illustrating "3,000 steps remaining" and asked a multiple choice comprehension question (Which of the following correctly describes the above feedback?) and provided three options—(1) Less than 50% of my daily goal remains, (2) More than 50% of my daily goal remains, and (3) None of the above. To filter out those who did not correctly understand the feedback, we placed this question before the self-efficacy question. Finally, we repeated the question, "Approximately how far do you think is 10,000 steps?" at the end of the survey to filter out those who did not pay attention to the wording of our survey.

5. Results

We recruited a convenience sample of 511 participants through word-of-mouth and researchers' social networks. We incentivized participation with the option to enter a drawing for one of four $25 gift cards. Participants were randomly assigned to one of the eight conditions. We removed data from 111 participants according to the following 4 exclusion criteria:

- Did not understand the feedback correctly (i.e., who got the filtering question wrong, 70 participants)
- Did not pay attention to the survey (i.e., who got the repeated 10,000 steps question wrong, 9 participants)
- iPhone/iPad user (due to a bug within the survey application, 7 participants)
- Outside of U.S. (due to the use of different distance metrics, 25 participants)

Among the remaining 400 participants, 53% were male (n = 211) and 43% reported they have experience using a pedometer (n = 172). The participants' ages ranged from 19 to 68 with an average age of 32.7 years old.

We observed that participants' initial interest level (INTEREST) in taking 10,000 steps daily was significantly related to their self-efficacy of achieving the daily goal, $F(1, 391) = 48.64$, $p < .001$. Therefore, we used a mixed-design analysis of covariance (ANCOVA) controlling for the INTEREST as covariate.

We found a significant main effect of DIST on the self-efficacy scale, $F(1, 391) = 110.20$, $p < .001$. This result indicates that, at a set time (i.e., 4:30 pm in our scenario), people who were close to the goal (75% of the goal, $M = 7.65$) were more likely to report higher self-efficacy than those who were further from the goal (25% of the goal, $M = 4.07$). The result indicates that we successfully manipulated DIST at two levels.

5.1. Effect of Valence Framing on Self-Efficacy

We found a significant main effect of VALENCE on self-efficacy after controlling for the effect of INTEREST, $F(1, 391) = 4.07$, $p = .04$. As Figure 2 shows, the result indicates that participants in the achieved-frame condition ($M = 6.05$, 95% CI[5.78, 6.33]) were more likely to report higher self-efficacy than those in the remaining-frame condition ($M = 5.67$, 95% CI[5.41, 5.93]).

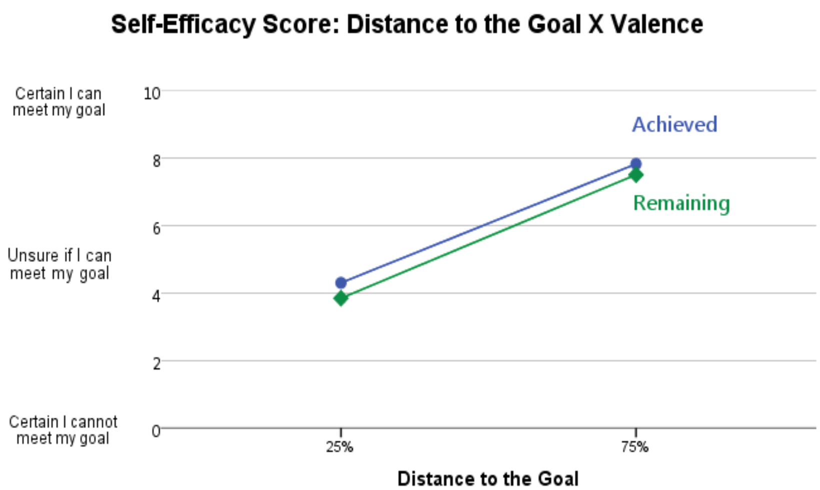

Figure 2. The effect of valence framing on self-efficacy score: participants' self-efficacy was higher when they were shown the achieved framing than remaining framing.

5.2. Effect of Presentation Type Framing on Self-Efficacy

We found a significant main effect of PRESENTATION on self-efficacy, $F(1, 391) = 7.43$, $p = .007$. As Figure 3 shows, participants in the text-only condition ($M = 6.12$, 95% CI[5.85, 6.39]) were more likely to report higher self-efficacy than those in the text with visual condition ($M = 5.60$, 95% CI[5.33, 5.86]).

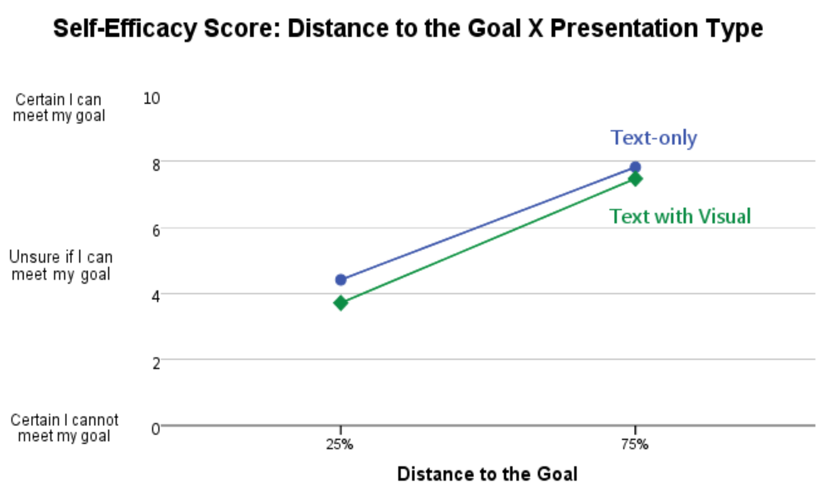

Figure 3. The main effect of presentation type on self-efficacy score: participants' self-efficacy was higher when they were shown the text-only feedback than text with visual feedback.

5.3. Effect of Data Unit Framing on Self-Efficacy

The main effect of UNIT was not significant, $F(1, 391) = 1.62$, $p = .20$. However, we found a significant interaction between UNIT and DIST, $F(1, 391) = 10.09$, $p = .002$. This indicates that a difference in data unit had different effects on the self-efficacy score at different levels of distance to the goal. To break down this interaction, simple contrasts were performed comparing each level of UNIT to one another across different level of DIST. As Figure 4 shows, at the lower level of goal achievement (25%), the feedback showing raw data led to a higher self-efficacy score ($M = 4.37$, 95% CI[4.02, 4.72]) than the feedback showing percentage data ($M = 3.76$, 95% CI[3.41, 4.11]), $F(1, 391) = 5.72$, $p = .02$. However, at the higher level of goal achievement (75%), UNIT had no effect, $F(1, 391) = .38$, $p = .54$.

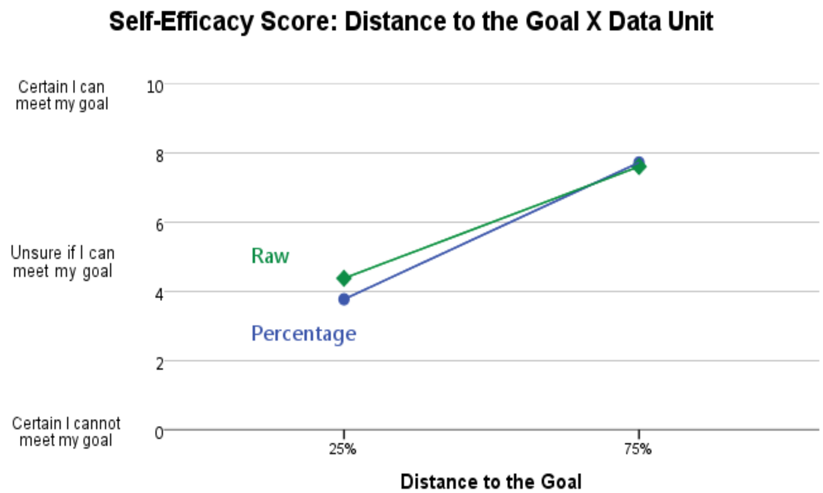

Figure 4. The interaction effect between data unit and self-efficacy score: participants' self-efficacy was higher at the 25% distance to the goal condition when they were shown feedback in a raw data format than in a percentage data format.

6. Discussion

Our study results can guide the design of performance feedback. We identified several framings such as valence and presentation type that are better at enhancing people's self-efficacy than others, though some of these effect sizes were small.

We observed that use of the *achieved* framing could enhance self-efficacy throughout the various levels of goal achievement (25%–75%). This result aligns with previous attribute framing studies of health messages where a positive framing of an object or event usually leads to more favorable evaluations than a negative framing. Self-efficacy is concerned with a person's *beliefs* about one's capabilities of performing a behavior. Thus, we conclude that use of the achieved framing for performance feedback influences these perceptions—not necessarily the true capabilities of performing a task, but *feeling capable of performing a task* to achieve a goal. This result indicates that people are subject to framing not only when evaluating an external object but also when evaluating one's own capability. Validating the claim at more extreme cases toward the both ends of the goal (e.g., 5%, 95%) warrants future research.

We also observed that performance feedback conveyed using text and visuals (i.e., colored progress bar) did not enhance individuals' self-efficacy when compared to text-only feedback. Ancker et al. note that visuals that improve the accuracy of quantitative reasoning appear to be different from visuals that promote behavior change.[28] We suspect that the progress bar in the visual conditions supported the former rather than the latter, and thus enhancing people's quantitative understanding, rather than improving their self-efficacy. Now that this work has provided a better understanding of the role one type of visual plays in conveying performance feedback, our next step is to explore the influence of exaggerated, or even judgmental visuals (e.g., emoticons) on self-efficacy. Because judgmental visuals convey valence information more saliently, positively framed judgmental visuals, in particular, could lead to an improved self-efficacy.

To our surprise, data unit (i.e., raw versus percentage) mattered only at 25% (2,500 steps) of goal achievement but not at 75% (7,500 steps). We suspect that performance feedback shown in a raw data format (e.g., "2,500 steps" achieved) was perceived as a bigger achievement than the same information shown in a percentage format (e.g., "25%" achieved). However, this effect was not observed for the distance to the goal at 75% level. It appears that when performance achievement level approaches the goal, the perception gap resulting from data unit decreases.

The research reported in this paper has some limitations. As is often the case with a convenience sample, sampling bias could have affected our study results. Our sample is biased toward highly educated and technical people. Also, our participants seem to have high interest in physical activities, which is exemplified by their high interest level (M = 7.14) in taking 10,000 steps daily and previous high pedometer usage experience (43%). Previous research reports that framing effects due to valence manipulation might not occur when the research topic has high intrinsic self-relevance to the research population.[26] The high-interest bias in the subject population makes it less likely that we would find a valence framing result, but nonetheless, we observed a significant main effect of valence framing. We note that 5% of participants (n = 20) indicated a self-efficacy scale of 10 (i.e., "Certain I can meet my goal") for both 25% and 75% distance to the goal conditions. For this group of people, framing would not matter much because their self-efficacy is so high they will achieve the goal regardless of feedback types. We included this data in the main analysis because this is valid data, and there will always be people with high self-efficacy. However, when we excluded this data and re-analyzed, we observed a more significant effect of valence framing, $F(1, 371) = 4.49$, p = .035. In any event, the high-interest bias merely supports our finding further.

Related contextual limitations of the research include using the hypothetical scenario and measuring self-efficacy rather than actual behavior. However, because we are still at the early stage of identifying persuasive framing for the design of effective performance feedback, we argue that conducting a field deployment study to measure behavioral outcomes is not the best first approach. Conducting an online experiment using a hypothetical scenario allowed us to recruit a large number of participants with relatively low cost and helped us understand the effect of different framings in a quick time frame. Design implications from this work will help designers and researchers create influential, persuasive performance feedback, which could be embedded in a self-monitoring technology for a long-term deployment study. Also, while we have focused on finding desirable performance feedback in the context of step count, it is possible to think of other performance feedback with different types of goals. For example, how framing is manifested differently depending on different types of goals in different contexts (e.g., "the higher the better" goal as in accumulated step counts, "the lower the better" goal as in smoking cessation, or "the ideal range" goal as in calorie intake) opens up many possibilities for future work.

7. Conclusion

Our objective in this research was to identify the type of framing that could best convey performance feedback to enhance individuals' self-efficacy. We accomplished this goal by conducting an online experiment with 400 participants who were given a hypothetical scenario of receiving a real-time performance feedback of daily step count. We found that valence and presentation type framings were highly related to individuals' self-efficacy. Specifically, an achieved framing led to higher self-efficacy than a remaining framing and a text-only framing led to higher self-efficacy than a text with visual (colored progress bar) framing. Furthermore, we found a significant interaction effect between data unit and distance to the goal, indicating data unit might influence people's perceived level of achievement especially at the early phase (25%) along the course of goal achievement. In designing performance feedback to enhance people's self-efficacy, we recommend using a positive framing with data unit that can increase the perception of one's performance capabilities. This work provides empirical guidance for creating influential, persuasive performance feedback, thereby helping people designing self-monitoring technologies to promote healthy behaviors.

Acknowledgments

We would like to thank our participants as well as Gary Hsieh for suggesting ideas for improving the study design.

References

1. Fitbit. http://www.fitbit.com.
2. larklife. http://lark.com/products/larklife/experience.
3. Zeo. http://myzeo.com.
4. Aria. http://www.fitbit.com/aria.
5. OneTouch UnltraMini. http://www.onetouch.com/onetouch-ultramini.

6. Nelson RO, Hayes, SC. Theoretical explanations for reactivity in self-monitoring. Behavior Modification 1981;5(1):3–14.
7. Locke EA, Latham GP. Building a practically useful theory of goal setting and task motivation. A 35-year odyssey. The American psychologist 2002;57(9):705–17.
8. Tversky A, Kahneman D. The framing of decisions and the psychology of choice. Science 1981;211(4481): 453–8.
9. Marteau TM. Framing of information: its influence upon decisions of doctors and patients. British Journal of Social Psychology 1989;28:89–94.
10. Grimes DA, Snively GR. Patients' understanding of medical risks: implications for genetic counseling. Obstetrics & Gynecology 1999;93(6):910–4.
11. Fogg BJ. Persuasive technology: using computers to change what we think and do. 2003.
12. Li I, Dey A, Forlizzi J. A stage-based model of personal informatics systems. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10). 2010;557–66.
13. Quantified Self. http://quantifiedself.com.
14. Consolvo S, McDonald DW, Toscos T, Chen MY, Froehlich J, Harrison B, Landay JA. Activity sensing in the wild: a field trial of Ubifit garden. In Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI '08). 2008;1797–1806.
15. Lin JJ, Mamykina L, Lindtner S, Delajoux G, Strub H. Fish'n'Steps: encouraging physical activity with an interactive computer game. In Proceedings of the ACM Conference on Ubiquitous Computing (UbiComp '06). 2006;261–78.
16. Jawbone UpBand. https://jawbone.com/up.
17. Nike Fuelband. http://www.nike.com/us/en_us/c/nikeplus-fuelband.
18. Kay M, Choe EK, Shepherd J, Greenstein B, Watson N, Consolvo S, Kientz JA. Lullaby: a capture & access system for understanding the sleep environment. In Proceedings of the ACM Conference on Ubiquitous Computing (UbiComp '12). 2012;226–34.
19. Grimes A, Bednar M, Bolter JD, Grinter RE. EatWell: sharing nutrition-related memories in a low-income community. In Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW '08). 2008;87–96.
20. Mamykina L, Mynatt E, Davidson P, Greenblatt D. MAHI: investigation of social scaffolding for reflective thinking in diabetes management. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). 2008;477–86.
21. Ali AA, Hossain SM, Hovsepian K, Rahman MM, Plarre K, Kumar S. mPuff: automated detection of cigarette smoking puffs from respiration measurements. In Proceedings of the 11th International Conference on Information Processing in Sensor Networks (IPSN '12). 2012;269–80.
22. Morris M, Guilak F. Mobile heart health: project highlight. IEEE Pervasive Computing. 2009;8(2):57–61.
23. Levin IP, Schneider SL, Gaeth GJ. All frames are not created equal: a typology and critical analysis of framing effects. Organizational behavior and human decision processes 1998;76(2):149–88.
24. Levin IP, Gaeth GJ. Framing of attribute information before and after consuming the product. J. Consumer Research 1988;15:374–8.
25. Rothman AJ, Salovey P. Shaping perceptions to motivate healthy behavior: the role of message framing. Psychological Bulletin 1997;121(1):3–19.
26. Krishnamurthy P, Carter P, Blair E. Attribute framing and goal framing effects in health decisions. Organizational Behavior and Human Decision Processes 2001;85(2):382–99.
27. Lipkus IM, Hollands JG. The visual communication of risk. JNCI Monographs 1999;25:149–63.
28. Ancker JS, Senathirajah Y, Kukafka R, Starren JB. Design features of graphs in health risk communication: a systematic review. Journal of the American Medical Informatics Association 2006;13(6):608–18.
29. Schneider TR, Salovey P, Apanovitch AM, Pizarro J, McCarthy D, Zullo J, Rothman AJ. The effects of message framing and ethnic targeting on mammography use among low-income women. Health Psychol. 2001;20(4):256–66.
30. Bandura A. Perceived self-efficacy in the exercise of control over AIDS infection. Evaluation and program planning 1990;13(1):9–17.
31. Bandura A. Guide for constructing self-efficacy scales. Self-Efficacy Beliefs of Adolescents 2006;5:307–37.
32. Strecher VJ, DeVellis BM, Becker MH, Rosenstock IM. The role of self-efficacy in achieving health behavior change. Health Education & Behavior 1986;13(1):73–92.
33. Bassett Jr DR, Wyatt HR, Thompson H, Peters JC, Hill JO. Pedometer-measured physical activity and health behaviors in United States adults. Medicine and science in sports and exercise 2010;42(10):1819.