How to Remind People to Work Out via Feedback: Evidence from a Field Experiment

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Abstract:

Physical activity is a very important aspect of individuals' quality of life. Health and behavioral studies have long sought to induce people to work out and form a habit to exercise. In this study, we design and conduct an 8-week longitudinal field experiment on an *ex post* feedback mechanism to motivate people to exercise. We designed feedback messages in two dimensions. One dimension varied the feedback messages according to whether they attributed the performance to participants' own efforts (i.e., effort attribution treatment), and the other dimension adopted different personal pronoun (either the first-person pronoun, i.e.， "I message" or the second-person pronoun, i.e.，"You message") to examine whether the deictic relational framing of the feedback matters (i.e., deictic relational framing treatment). The experiment used an exercising recording applet embedded in WeChat. We find that for the immediate effect, the "You message + effort emphasized" message performed the best. As for the overall effect when feedback is provided, participants in the "I message" and "You message + effort emphasized" treatment groups achieved their weekly exercise goals in about one more week than participants in the control group. But when feedback is no longer provided, the influence of both treatment groups failed to endure; the influence of the "You message + effort emphasized" treatment even reversed. We also find that the effect of feedback is stronger among participants whose subjective ability of self-control and intrinsic motivation to work out are low.

Key words: work out, feedback, deictic relational framing, attribution theory，field experiment

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1. Introduction

Physical activity is a very important aspect of health management. It not only benefits individuals internally as it improves their quality of life; it also generates meaningful society-wide externalities by reducing group-rated health insurance costs and spending on medical systems (Finkelstein et al., 2009; Royer et al., 2012). Much research has been done on the consequences of physical activity, including its effect on physical health such as chronic diseases and premature death (Warburton et al., 2006), as well as its impact on non-physical health such as cognitive functioning and psychological well-being (Brand et al., 2010; Kayman et al., 1990). Past studies have also found that exercise improves an individual's ability to learn, as well as memory and creativity (Suzuki, 2015).

How to induce people to work out and form a habit to exercise regularly has been a long-term challenge in the field of health management. Developing effective motivating mechanisms – such as monetary incentives, goal setting, commitment contracts and social incentives (Charness and Gneezy, 2009; Normand, 2008; Royer et al., 2015; Babcock and Hartman, 2010) – has thus long been a central focus in the fields of medicine, management, economics, and behavioral science. However, most such efforts are *ex ante* or pre-commitment mechanisms (Charness and Gneezy, 2008; Gneezy et al., 2011; Royer et al., 2015; Patrick et al., 2009; Sirriyeh et al., 2010); few studies in psychology or the health-related literature examine *ex post* mechanisms such as feedback mechanisms – including positive feedback, negative feedback, tailored feedback, as well as feedback regarding attributions of achievement (van't Riet et al., 2009; Gallagher and Updegraff, 2012; McCall and Ginis, 2004; Bauer et al. 2010; Fishbach and Finkelstein, 2012).

Feedback has been found to be critical to determining an individual's commitment to their goal, as well as the level of effort they invest and their degree of persistence (Fishbach and Finkelstein, 2012). In this study, we investigate how *ex post* feedback might encourage people to work out. More specifically, we examine the effect of the *content* of feedback messages – which is cost saving, scaleable and easy to implement – on people's exercise motivation and performance. We conducted an 8-week field experiment in which we designed feedback content in two dimensions. One dimension varied the feedback messages according to whether attributed the exercise performance to

the participant's own efforts (effort attribution treatment), and the other dimension used a "I" or "You" message to examine whether the deictic relational framing of the feedback matters (i.e., deictic relational framing treatment). We also varied the content of the feedback based on the participants' actual performance of working out in the last week, providing positive (vs. negative) feedback when they achieved (vs. failed to complete) their weekly exercise goal.

Our design is motivated by classic attribution theory (Weiner, 1974) and the literature on deictic relational framing (Hayes, 1984; Hayes et al., 2001). According to attribution theory (Weiner, 1974), people usually explain their success or failure in the following three underlying aspects: locus of control (internal/external), stability (stable/unstable), and controllability (controllable/ uncontrollable). For example, when someone achieves a success, other people may give him feedback that attributes the success to his own effort or talent. Effort is internal, unstable and controllable, while talent is internal, stable and uncontrollable. More importantly, the type of feedback might induce different processes and directions of attribution of an individual's success or failure (Weiner, 1976), which could in turn influence their affective responses, subjective expectancy of future outcomes, and motivation to persist (Fishbach and Finkelstein, 2012). Therefore, we vary the feedback message by emphasizing whether to attribute the outcomes to participants' own efforts.

For the "I" and "You" framing, we draw on the literature on deictic relational framing (Hayes, 1984; Hayes et al., 2001) and varied the deictic relationship by either highlighting "I" or "You" when providing feedback. "I" frames provide feedback to participants by emphasizing first-person pronouns (e.g., "*[We!!] are so happy/sorry that*…."), whereas "You" frames use second-person pronouns to describe the feedback (e.g., *"[You!!] make us so happy/sorry that*…."). The frames of the feedback may have different affective consequences, such as fear or pride. Gordon (1970) first introduced the "I" versus "You" framing effect in the context of parent–child interactions and found that using an "I" frame to give negative feedback message is less likely to evoke resistance and rebellion than using "You". Kubany et al. (1992a, 1992b, 1995) further confirmed the difference induced by "I" versus "You" frames in other close relationships and populations such as adolescents and undergraduates (Kubany et al., 1992a, 1992b; Kubany et al., 1995). Prior research has also shown that affective consequences influence individuals' performance and pursuit of goals (Baumeister et al., 2007;

Higgins, 1987; Cai et al., 2018; Ockenfels et al., 2015). Therefore, we expect that emphasizing an "I" versus "You" frames in feedback messages will strongly influence their ability to motivate individuals to exercise, as they may trigger different degrees of affective responses and psychological reactions.

We developed an exercise recording application, "Dong Qi Lai"[3], which was embedded in WeChat as showing in Figure 1. We used the applet to conduct an 8-week longitudinal field experiment in China. This experiment used a five-group between-subject design that randomly assigned participants to one of the five groups to receive different feedback messages. The four treatment feedback types were "I frame + effort emphasized", "You frame + effort emphasized", "I frame + no effort emphasized", and "You frame + no effort emphasized". The control group received no feedback. In the first 5 weeks of the experiment, participants received *ex post* feedback every Monday based on their exercise performance recorded in the applet in the previous week. No feedback was provided in the last 3 weeks of the experiment. We find that for the immediate effect, when participants failed to achieve their exercise goal during the previous week, the "You frame + effort emphasized" feedback (i.e., *You exercised ** times last week and haven't achieved your goal, [you!!] make us so sorry for your lack of effort!*) significantly motivated participants to reach their goal the following week compared to the control group. As for the overall effect, based on the total number of weeks that participants achieved their goals during the first 5 weeks with feedback provided, the "I frame + no effort emphasized" (i.e., *You exercised ** times last week and (haven't) achieved your goal, [we!!] are so happy (sorry)*) and "You frame + effort emphasized" feedback messages (i.e., *You exercised ** times last week and (haven't) achieved the goal, [you!!] make us so happy (sorry) for your (lack of) effort!*) performed better than the control group, especially among those with lower levels of self-control.

The positive effects of the "I frame + no effort emphasized" and "You frame + effort emphasized" feedback documented in earlier weeks were not sustained in the second half of the experiment when messages were no longer provided. After controlling for the first 5-week performance, the influence of the "You frame + effort emphasized" message became negative and yielded a *lower* performance than the control group in the last 3 weeks without reminder messages. To further investigate the

[3] The three Chinese characters "Dong Qi Lai" means "Let's move."

composition of the enduring effect, we conduct a path analysis and find that the "I message" and "You frame + Effort emphasized" messages helped participants form a habit of exercising during the treated periods, which led them to continue to exercise in the long run. Body mass index (BMI) changes induced by more exercise in the first 5 weeks influence the amount of exercise done in the last 3 weeks as well. However, these channels may be offset by the messages' direct negative effect in the long run.

Our paper makes three main contributions to the literature. First, to the best of our knowledge, our study is the first to create an *ex post* feedback mechanism design by incorporating both attribution theory and deictic relational framing, showing that "I" and "You" frames and effort emphasized messages can interactively alter individuals' psychological responses toward the feedback – and, consequently, their further motivation to adhere to their workout program. In a second contribution, we identified differences in the effectiveness of feedback framing under positive and negative outcome conditions and find that "You frame + effort emphasized" feedback performs the best when people failed to achieve their exercise goal the previous week. We exploit the panel nature of the data set to test the immediate effect of positive/negative feedback conditional on the performance of the previous week, which better captures the real-world dynamics of working out in people's daily lives and shows how the nudging intervention affects repeated actions. Third, this paper shows the immediate, overall and enduring effects of each feedback frame on inducing people to work out. By assessing individual differences in habit formation, physical changes and psychological experience during the experiment using a path analysis approach, we were able to investigate the potential explanations underlying such effects. Our findings advance our understanding of (1) the psychological process of feedback interventions and (2) how to use feedback to motivate people to obtain their goals more generally.

The remainder of the paper is structured as follows. Section 2 summarizes the relevant literature and introduces our hypotheses. Section 3 describes the experimental design, Section 4 presents the immediate, overall and enduring effects. Section 5 discusses the findings and concludes.

2. Related literature and behavioral predictions

Our experiment seeks to inform the design of effective behavioral mechanisms that remind people to work out. The health management and behavioral literature describes many ways to remind people to exercise, such as providing financial (Charness and Gneezy, 2009; Gneezy et al., 2011) or prosocial incentives (e.g. step donation, see Yuan et al., 2021) and social incentives (e.g. peer effects or social comparison through leaderboards, see Aral and Nicolaides, 2017; Wu et al., 2015), self-funded commitment contracts (Royer et al., 2015), fines for inadequate performance (Fehr et al., 2001; Fehr and Gächter, 2002), goal setting (Bandura and Cervone, 1983; Normand, 2008; Annesi, 2002), and sending text message reminders (Patrick et al., 2009; Sirriyeh et al., 2010; Calzolari and Nardotto, 2017). Most of them are *ex ante* (or pre-commitment) mechanisms, which do not change in response to the individual's performance.

Since sending messages is effective and cost efficient, messages have been used in many behavioral mechanism studies, such as *ex ante* messages in nudging behavior like online loan repayment (Du et al., 2020), fee payment (Fellner et al., 2013), rule compliance (Apesteguia et al., 2013), COVID-19 vaccinations (Dai et al., 2021), and *ex post* messages to promote energy conservation (Aydin et al., 2018), provide public goods (Chen et al., 2010), and reduce tax delinquency (Perez-Truglia and Troiano, 2018; Antinyan et al., 2021). The content and framing of message reminders are very important (Karlan et al., 2015; Karlan et al., 2016; Bursztyn et al., 2015; Chen et al., 2017). For instance, text message reminders that convey lenders' positive expectations have both a short-term and enduring effect on online loan repayment, but reminders that convey information about negative consequences do not (Du et al., 2020). Prior work has also assessed the relative effectiveness of gain-framed and loss-framed messages (Hossain and List, 2012; McCall and Ginis, 2004; Hong et al., 2015). For instance, Milkman et al. (2021) reported that interventions make impacts on getting flu shots when they were framed as reminders to get flu shots that were already reserved for the patient.

We focus on *ex post* feedback mechanisms by designing feedback message content to induce people to exercise. To determine what type of content may be effective, we take effort attribution and

"I" and "You" frames into consideration on the basis of attribution theory and deictic relational framing.

Different approaches to attributing achievements may influence affective responses, subjective expectancy of success, and motivational consequences (Weiner, 1976; Fishbach and Finkelstein, 2012). Affective responses are also found to influence individuals' performance (Cai et al., 2018; Ockenfels et al., 2015). According to Weiner (1980), effort is internal, unstable and controllable, and ability is internal, stable and uncontrollable. He suggests that attributing people's failure to a lack of ability generates a feeling of incompetence and decreased performance, whereas attributing failure to a lack of effort gives rise to guilt and shame and increased (or maintained) performance. Multiple studies have revealed that attributing success to one's own efforts is correlated with achievement motivation and positive post-failure striving (Powers et al., 1985; Mueller and Dweck, 1998; Diener and Dweck, 1980; Dweck, 1975). Dweck (1975) created an experimental problem-solving situation and found that attributing performance to effort enables helpless children to exert greater effort to deal with failure. Mueller and Dweck (1998) performed six studies which demonstrated that students who were praised for their intelligence were more likely to regard their intelligence as a fixed trait and were less motivated to achieve than those who were praised for their effort.[4]

Further, Dweck (2008) theorizes that there are two types of mindsets. People with a *fixed* mindset believe intelligence is innate and unchanging, and that failure confirms a lack of intelligence; thus they are more likely to fear challenges. Those with a *growth* mindset believe intelligence is malleable and changeable, and tend to seek challenges for anything can be learned through effort. Many studies have shown that students with growth (vs. fixed) mindsets performed better (Claro et al., 2016; Andersen and Nielsen, 2016; Hochanadel and Finamore, 2015; Alvarado et al., 2019). Haimovitz and Dweck (2017) find that praise for intelligence and abilities fosters a fixed mindset, while praise for effort or strategies fosters a growth mindset.

[4] Effort attribution theory shares insights with compensation contract theory in the sense that agents' efforts are correlated with the controllability filters in the compensation contract, e.g., Shields et al. (1989).

In our study, if participants exercised three or more times in a week, they achieved the suggested goal for that week. In the effort emphasized groups, we attributed participants' performance to their own effort, which may make them more motivated to perform better (Andersen and Nielsen, 2016). Thus, when participants receive effort emphasized feedback, they may interpret previous good or poor performance as the result of their effort (or lack thereof) and be motivated to maintain or increase their effort. Therefore, for the immediate effect of feedback reminders,[5] we propose the following hypothesis:

Hypothesis 1 (H1): *To remind people to work out, feedback messages that emphasize effort work better than those that do not.* ***(Effort attribution hypothesis)***

For "I" versus "You" frames, we draw from the literature on deictic relational framing (Hayes, 1984; Hayes et al., 2001). Deictic framing is a relational operant that allows distinctions between I and You, as well as the abstraction of the speaker's perspective (Holmes et al., 2004; Vilardaga, 2009). Since message framing has been found to have important influences on people's affective responses and behavior (van't Riet et al., 2010; Schneider et al., 2001; Rothman and Salovey, 1997) as well as critical economic effects (Hallsworth et al., 2015; Du et al., 2020), it is very important to investigate the affective responses of "I" versus "You" frames. According to Gordon (1970), I-statements are less apt to provoke resistance and rebellion, and are less threatening than You-statements in parent–child relationships. Burr (1990) indicated that "I" messages can be used to describe subjective reactions, beliefs, aspirations etc., locating the feeling inside the speaker's own feeling, while "You" messages seek to locate a feeling, thought, or problem in the receiver. Several studies have demonstrated that people own their emotions by using "I" rather than "You" messages in conflict situations. For example, Kubany and colleagues conducted a series of studies in conflict situations and provided evidence of "I" versus "You" messages in close relationships and populations such as adolescents and undergraduates. They found that accusatory "You" messages were rated as more likely to evoke animosity and antagonistic behavior than assertive "I" messages (Kubany et al., 1992a, 1992b;

[5] Since most prior research examines the effect of messages after an intervention, our hypotheses only focus on the immediate effect. We explore the overall effect and enduring effect in the analysis section.

Kubany et al., 1995). Wood (2015) further stated that "I" language is a cornerstone of effective conflict management, and advised people to take responsibility for their emotions. Rogers et al. (2018) obtained similar results from lab experiments involving university students.

Thus, "I" messages are much less likely to provoke resistance or rebellion than "You" messages when there is a negative situation. Since affective consequences have an effect on people's performance, the "I" frame may be better able to nudge participants to work out in negative situations (i.e., when they failed to achieve the exercise goal the previous week) than the "You" frame. Therefore, for the immediate effect of feedback reminders, we propose a second hypothesis:

Hypothesis II (H2): *To remind people to work out, the "I" frame works better than the "You" frame when participants failed to achieve their goal the previous week* ***(Deictic relational framing hypothesis (negative outcomes))***

However, researchers have also determined that when people take credit (or retain responsibility) for positive outcomes (i.e., the "I" frame), but place responsibility on others (i.e., the "You" frame) for negative outcomes, recipients evaluate the speakers less favorably (Tetlock, 1980; Forsyth et al., 1981). Thus, "I" and "You" frames may perform differently in positive situations. Bippus and Young (2005) tested negative and positive emotional scenarios in a lab experiment and found that, for recipients, there are no significant differences between ways of phrasing negative emotions, but they appreciate being given credit for speakers' positive emotions ("You" frame). Thus, the "You" frame may be more likely to work better in positive situations when participants managed to achieve their exercise goal the previous week in our study. Therefore, for the immediate effect of feedback reminders, we propose a third hypothesis:

Hypothesis III (H3): *To remind people to work out, the "You" frame works better than the "I" frame when participants achieved their goal the previous week.* ***(Deictic relational framing hypothesis (positive outcomes))***

Since no previous study has tested the combination of "Effort" and "I-You" frame, we do not

formulate a hypothesis on the effect of "I frame + effort emphasized" and "You frame + effort emphasized."

While previous studies have used lab experiments, we conducted a field experiment to test the effectiveness of the "I" versus "You" frames in both positive *and* negative situations and extend the deictic framing effect to an unfamiliar relationship – project organizers and participants. Moreover, we combine "I" and "You" frames with effort attribution to examine whether deictic framing interacts with effort attribution in facilitating exercise behavior. We test the immediate effect and overall effect when feedback is provided, and also examine the extent to which the influence of feedback messages persists in the long run when feedback is removed.

3. The field experiment

We conducted an 8-week longitudinal field experiment at a large public university in China from April 1–June 2, 2019. We recruited 271 students for the project by placing recruiting advertisements on WeChat, the country's most popular social network platform. Those who attended the project introduction meeting received a 10 RMB stipend,[6] after which they decided whether to be involved in the project; 181 students chose to participate. All participants were asked to sign a consent form that included a project description, payment rules, data confidentiality and authorization, etc.[7]

The study participants used our Dong Qi Lai applet to report their daily exercise information (including place, duration, and activity) by uploading a selfie at the beginning and end of their workout. We verified the exact exercise duration by calculating the beginning and ending time and comparing it with the duration reported by the participants. We use the objective calculated duration in the analysis if it differs from the self-reported duration. Only reports with qualifying photos and at least 30 minutes' exercise duration are considered to meet the exercise requirement and counted as a successful goal achievement. Participants were not able to view other participants' report information;

[6] During our experiment period, the exchange rate for USD to RMB is around 6.9; so 10 RMB is about 1.45 USD, and 100 RMB is about 14.5 USD.
[7] The consent form is provided in the online appendix.

thus there was no observation learning effect or social comparison effect.

3.1 Treatment design

Figure 2 illustrates the timeline of our experiment, which included three meetings: the recruiting and introduction meeting, a mid-term meeting held during the 5th week, and the final meeting held in the 9th week.[8] We conducted a baseline survey about participants' exercise habits at the introduction meeting, and measured participants' BMI and conducted a personality survey at all three meetings.[9] In each week of the experiment, participants submitted evidence of their exercise using the Dong Qi Lai applet. Each Sunday, we sent a survey via email and WeChat to assess their feelings after each week's exercises, and sent out weekly exercise feedback messages the following day.[10]

Every participant was promised a 100 RMB reward if they attended all three meetings and finished all the weekly surveys, regardless of whether they reported their exercise. We suggested a goal of exercising three times a week for at least 30 minutes each time. An extra 10 RMB reward would be provided for each week they achieved their goal. The extra reward was designed to be fairly small so it would not dominate the effect of the feedback messages on participants' exercise behavior.

[Insert Figure 2 here.]

Week 0 was the test run week, during which we tested the recording applet as well as participants' understanding of the requirements and experimental procedure. From Weeks 1 to 5, we sent feedback messages to different groups on Monday based on their exercise performance (i.e., goal achievements) recorded in the applet in the previous week.[11] To investigate the enduring effect of messages, we asked them to report their exercise but no longer sent feedback messages after Week 5.

The core of our experiment is the various feedback messages sent to the participants according to their goal achievement in the previous week. The message contents followed a 2 × 2 between-subjects

[8] The second and third meetings were held at least three times during the week to accommodate participants' schedules.
[9] BMI was calculated by dividing the square of height into weight. The analysis uses only use the initial personality survey data.
[10] In the weekly survey, we asked questions about participants' perceptions of their achievement this week and their feelings about exercise, etc. Detailed questionnaires of all surveys are provided in the online appendix.
[11] Since participants' goal achievements during Week 4 affect the goal reports for Week 5, we sent feedback messages on Monday of Week 5 for the last time. Week 0 was a test-run week, and thus was excluded from our analysis.

design that combined two factors: (1) whether the goal achievement status was attributed to participants' own efforts (*effort emphasized vs. no effort emphasized*) and (2) whether an *I* or *You* frame (deictic relational framing) was used to emphasize praise (blame) for the happiness (pity) of achieving (failing to achieve) their goal.[12] Participants in the control group received the same reward arrangement as those in the treatment groups, but did not receive any feedback messages. The 181 participants were randomly assigned to one of the five groups. To prevent participants in different groups from finding out about the differences in the feedback messages, participants who were friends, lovers or classmates were assigned to the same group and distributed evenly in each group as much as possible.

Table 1 reports the group assignments. *G_I* represents the group receiving the "I frame" feedback message without effort emphasized; the *G_You* group received the "You frame" feedback message without effort emphasized; *G_I.Eff* received the "I frame" feedback message with effort emphasized; *G_You.Eff* received the "You frame" feedback message with effort emphasized, and *G_Contr* did not receive any feedback messages.

[Insert Table 1 here.]

3.2 Randomization check

Table 2 reports the results of the randomization check that compared personal characteristics across five groups in dimensions including gender, participants' exercise habits before the experiment (*ExTimeBefore*), whether the participant was involved in the campus exercise program (*CampusExProg*),[13] and BMI. *ExTimeBefore* is the product of average exercise times per week in the past 2 months and average exercise duration each time, which were self-reported by participants in the baseline meeting. The *F* tests indicate similar distributions of *Gender*, *CampusExProg, ExTimeBefore*, and *BMI* among the participants across the five groups.[14] Thus, the data passed the randomization

[12] Please see the online appendix for detailed original messages in Chinese along with the corresponding translated messages.

[13] *CampusExPro*g was an indicator coded 1 if the participant was involved in the campus exercise program, which required 28 workouts per semester; all freshmen and sophomores were supposed to join it. We still count the exercise report regardless of whether it constituted part of the campus exercise program or not.

[14] The F-statistic is insignificant for all four variables, failing to reject the hypothesis of similar distribution across groups (results available upon request).

checks.

[Insert Table 2 here.]

4. Analysis and main results

To investigate effects of the messages, we conducted a series of analyses of the immediate, overall and enduring influences. For the immediate effect, we investigated participants' immediate reaction to the feedback messages, which were based on whether they achieved their exercise goals in the previous week. From the overall perspective, we examined the overall influence of feedback messages on participants' goal achievements during the first 5 weeks when messages were provided. Finally, we assessed the messages' enduring effect when feedback messages were not provided in the last 3 weeks, and explore the underlying mechanisms.

4.1 Immediate effect

4.1.1 Previous week's goal achievements and feedback message influences

First, we examine the immediate effect of the feedback messages on participants' performance the following week. Since whether the participants successfully achieved their goals the previous week could affect their goal achievements in the current week, we use the weekly panel data of the first 5 weeks, and include goal achievement in the previous week (*LagGoalW*) as a predictor of goal achievement for the current week (*GoalW*) to check whether goal achievements persist across weeks, i.e., whether those who achieved their goal in the previous week are more likely to do so again in the current week.[15] To test whether the influence of feedback messages could vary based on previous goal achievements and to examine Hypotheses 2 and 3, in addition to the standalone treatment group indicators (i.e., *G_I*, *G_You*, *G_I.Eff* and *G_You.Eff*),[16] we include the interaction terms of *LagGoalW* and the treatment group indicators. Specifically, we estimate a mixed cross-sectional regression and employ the following equation:[17]

[15] The panel for the analysis includes Week 2 to Week 5 data, as Week 1's goal achievement indicator is L*agGoalW* for Week 2.
[16] *G_Contr* is the indicator for the control group that serves as the benchmark and thus is not included in the model.
[17] Participants' goal achievements in the current week and previous week are panel data. However, group indicators and

$$GoalW_{it} = \beta_0 + \beta_1 LagGoalW_{it} + \beta_2 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i + \beta_5 G\_You.Eff_i + \beta_6 LagGoalW_{it} \times G\_I_i + \beta_7 LagGoalW_{it} \times G\_You_i + \beta_8 LagGoalW_{it} \times G\_I.Eff_i + \beta_9 LagGoalW_{it} \times G\_You.Eff_i + \gamma X_i + w_t + \varepsilon_{it} \quad (1)$$

Where $GoalW_{it}$ is an indicator of participants' goal achievement in the current week, which equals 1 for those who achieved the suggested goal of the week. X_i is a vector of control variables for participant *i,* including *ExTimeBefore*, *Gender*, and *CampusExProg*. Weekly panel data allow us to control for time-variant factors that affect all participants, such as weather and campus events, by including weekly fixed effects, denoted by w_t. Standard errors are clustered at the participant level.

In Equation (1), the coefficient on *LagGoalW*, β_1, estimates the persistency of goal achievement for the control group across weeks. The coefficients on the standalone group indicators, β_2,…, β_5, reflect the effect of feedback messages on the goal achievements this week (compared with the control group) for those who failed to achieve the goal the previous week (negative condition). The sum of the coefficients on the standalone group indicators and the corresponding interaction terms with *LagGoalW*, $\beta_2 + \beta_6, \ldots \beta_5 + \beta_9$, estimate the influence of the messages for participants who achieved their goals last week (positive condition) compared to the control group. The coefficients on the interaction terms of group indicators and *LagGoalW*, $\beta_6, \ldots \beta_9$, account for the differences in the treatment messages' influence (compared with the control group) between participants who failed versus succeeded in achieving their exercise goals the previous week.

The estimation of Equation (1) is reported in Table 3. The estimated coefficient on *LagGoalW* is positive and significant at the 1% level, which illustrates the persistence of exercise behavior over time and suggests individuals may exhibit behavioral momentum (Jin et al., 2020; Trump et al., 2021). After controlling for goal achievement persistency (*LagGoalW*), only the coefficient on *G_You.Eff* remains significantly positive. This finding suggests that for those who failed to achieve their goal last week, only the "You frame + effort emphasized" feedback message has an effect (compared to the

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control variables such as *ExTimeBefore*, *Gender*, and *CampusExProg* are all cross-sectional data. So, we run a mixed cross-sectional regression with errors clustered at the participant level.

control group). Specifically, the estimation of the linear probability model shows that for those who failed to achieve their goal the previous week, on average, the likelihood of achieving their goals for the participants in "You frame + effort emphasized" treatment group is 12.5% higher than for those in the control group. A potential explanation is that when participants failed to achieve their exercise goals last week, for the "You frame + effort emphasized" feedback message, both "You" and "effort" were internal, unstable and controllable factors for message receivers; participants may immediately react to the message and increase their level of effort to avoid guilt (Baumeister et al., 1994). Thus, the "You frame + effort emphasized" message may have a stronger immediate effect when participants fail to achieve their goals last week.

To estimate the messages' influence when participants achieved their goal the previous week, on the right side of the table we report the magnitude and level of significance of the sum of the coefficients on the group indicators and their corresponding interaction terms with *LagGoalW*. i.e., $\beta_2 + \beta_6, \ldots \beta_5 + \beta_9$. None of the groups report a significant sum of the coefficients, indicating that no messages have an effect if the participant managed to achieve their goal the previous week. This might be because those who achieved their goal the previous week are more likely to continue the habit or momentum in the next week, so various feedback messages may have little impact. The estimation of the coefficients on the interaction terms shows that the difference in treatment messages' impacts on goal achievement (compared with the control group) between participants who failed and succeeded in achieving their goals in previous week is insignificant.

The F-tests reported in the bottom half of Table 3 allow us to compare the estimated influences between "no effort" versus "effort emphasized" and the "I frame" versus "You frame." We find that Hypothesis 1 is supported under "I frame" when participants succeeded in the last week in the sense that the "I frame + effort emphasized" message outperforms the "I frame" message (*G_I + LagGoalW*G_I v.s. G_I.Eff + LagGoalW*G_I.Eff*, F=2.99*). We find that "I frame" messages work better when participants failed to achieve their goal last week (*G_I v.s. G_You*), as Hypothesis 2 predicts, and "You frame" messages work better when participants succeeded last week (*G_I + LagGoalW*G_I v.s. G_You + LagGoalW*G_You*), as predicted in Hypothesis 3, although the coefficients are not statistically different. When combining "effort" and "I-You" framed messages

under negative outcomes, i.e. when participants failed in the last week, we find something very interesting: "You frame + effort emphasized" is statistically better than "I frame + effort emphasized" (*G_I.Eff v.s. G_You.Eff*, F=3.17) and the "I frame" message also outperforms the "I frame + effort emphasized" message (*G_I v.s. G_I.Eff*, F=2.55). This is different than the prediction in hypothesis 1. These findings suggest that simply combining two working mechanisms does not necessarily have a positive impact, so it is better to design and test the nudge mechanisms for specific situations before implementing them.

In summary, the results in Table 3 show that exercise behavior persists over time. Previous goal achievement significantly increases the probability of goal achievement in the current week. It is more interesting to find the asymmetric effect of treatment messages given a different previous week's performance. When the participants succeed in the previous week, none of the messages has any significant influence in encouraging goal achievement. But when the participants failed in the previous week, the "You frame + effort emphasized" feedback message has a positive effect.

[Insert Table 3 here.]

4.1.2 Moderating effect of sense on the messages' immediate effects

Since the experience of exercise might influence participants' goal achievements, we analyze the moderating effect of sense on the immediate effects in this section. On the one hand, if a participant obtains a sense of satisfaction and achievement from exercising, they are more likely to be self-motivated to work out, which weakens the immediate influence of the messages. On the other hand, positive past experiences can decrease participants' reluctance to exercise, which makes it easier to motivate them with the messages. In this section we analyze the results of the weekly surveys completed by the participants during the experiment – specifically Questions 9 and 10 asked about their sense of satisfaction about the exercises, and Questions 3 and 4 focused on their sense of achievement after the exercises (see Online Appendix for the full survey).

In this analysis, we first construct indicators for participants' sense (*Sense*) using four proxies which correspond to the four questions (3, 4, 9, 10). The first two proxies focus on participants'

general sense of satisfaction, i.e., whether they feel positive (*Feel*) during the exercises and enjoy them (*Enjoy*).[18] The other two proxies focus on their sense of achievement, i.e. whether they feel their exercise ability has improved (*Ability*) and whether they consider themselves more powerful (*Power*).[19] Then we include the four standalone sense proxies and their interaction terms with group indicators in the regression one by one. The interaction terms capture the incremental influences of the messages on participants when they have a positive experience in the experiment. Since the satisfaction and achievement surveys were conducted weekly, we use the weekly panel data for the first 5 weeks in Table 4 and estimate a mixed cross-section regression with standard errors clustered at the participant level.[20] Specifically, we estimate the following equation:

$$\begin{aligned} GoalW_{it} = \quad & \beta_0 + \beta_1 Sense_{it} + \beta_2 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i \\ & + \beta_5 G\_You.Eff_i + \beta_6 Sense_{it} \times G\_I_i \\ & + \beta_7 Sense_{it} \times G\_You_i + \beta_8 Sense_{it} \times G\_I.Eff_i \\ & + \beta_9 Sense_{it} \times G\_You.Eff_i + \beta_{10} LagGoalW_{it} \\ & + \gamma X_i + Week_t + \varepsilon_{it} \end{aligned} \qquad (2)$$

Sense refers to one of the four indicators, i.e. *Feel*, *Enjoy*, *Ability* and *Power*. The results are reported in Table 4. All the coefficients of group indicators are insignificant, indicating that our treatments do not work when people sense negatively during the experiment. To identify the influences on participants who sense positively, we report the statistics of the sum of the coefficients on the group indicators and their interaction terms with sense proxies at the bottom half of the table. It shows that the "You" frame and "You frame + effort emphasized" feedback messages have significant positive influences on participants who feel positively or enjoy exercising during the experiment. To investigate how the messages' encouraging effect varies with positive or negative sense, we examine the interaction terms between sense proxies and group indicators. For instance, the coefficients on the interaction terms *Sense*G_You.Eff* are positive, ranging from 0.037 to 0.116, suggesting that the "You frame + effort emphasized" feedback message is more likely to have an encouraging effect (compared with the control group) for participants who sense positively during the

[18] The variable *Feel* corresponds to Question 10, provided in online appendix. *Feel* is coded 1 if the participant answered refreshed, relaxed or passionate, and 0 otherwise. The variable *Enjoy* corresponds to Question 9 and is coded 1 if the score is above the median, and 0 otherwise. Both questions are only compulsory for those who exercised the previous week.

[19] The variables *Powerful* and *Ability* correspond to Questions 3 and 4. They are both coded 1 if the scores are above the median, and 0 otherwise. Both questions are compulsory. There are 18 participants who did not complete a survey each week, so we leave the values of *Sense* to be null for the unfinished weeks.

[20] For the achievement variables, the questions in the weekly survey are compulsory. For the satisfaction variables, the questions in the weekly survey are only compulsory for participants who exercised the previous week. So, the number of observations differed between them as report in Table 4.

exercises than those who do not. But the coefficients are not significant, probably due to the limited sample size.

In summary, after controlling for the previous week's performance, we find that "You" frame and "You frame + effort emphasized" feedback messages have significant positive influences on participants who feel positive or enjoy exercising during the experiment, but none of the four treatment messages works when people sense negatively during the experiment.

[Insert Table 4 here.]

4.2 Overall effect

4.2.1 Overall effect of messages

In addition to the immediate effect of feedback messages on goal achievements in the next week, we examine their effect on the overall goal achievements during the first 5 weeks when messages were provided. Table 5 reports the descriptive statistics of the total number of weeks that the participants achieved their exercise goals in the first 5 weeks (*Goal5W*).[21] Both the mean and median of *Goal5W* for all four treatment groups are higher than those of the control group. They are highest for *G_I* and *G_You.Eff*, followed by *G_I.Eff* and *G_You*.[22] This evidence demonstrates that "I" frame and "You frame + effort emphasized" feedback has a significantly positive influence on goal achievement when feedback messages are provided.

[Insert Table 5 here.]

Next, we include the control variables and estimate a cross-sectional regression. Specifically, we regress group indicators (*G_I*, *G_You*, *G_I.Eff* and *G_You.Eff*) on *Goal5W* and estimate the following equation:

$$Goal5W_i = \beta_0 + \beta_1 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i + \beta_5 G\_You.Eff_i + X_i + \varepsilon_i \quad (3)$$

[21] Since participants' goal achievements in Week 4 take effect on exercise reports for Week 5 and we sent messages for the first 5 weeks, we take the fifth week into account when comparing the exercise-encouraging effects of different messages. For example, if individual *i*'s *Goal5W is 3, it means that he/she achieved the* exercise *goals in 3 of the first 5 weeks.*

[22] The *t*-test shows that the means of *Goal5W* for *G_I* and *G_You.Eff* are significantly higher than that of the control group at the 5% level ($t = 2.104$ and 2.061). The Wilcoxon test shows that the differences of *Goal5W* between treatment groups and the control group are significant in terms of median except for *G_You*.

Again, we control for *ExTimeBefore*, *Gender*, and *CampusExProg*. We also control for the heteroscedasticity of the residuals by introducing White robust standard errors for this regression as well as all the following regressions. The results are reported in Table 6.

The coefficients on *G_I* and *G_You.Eff* are positive and significant at the 5% level, suggesting that participants from *G_I* and *G_You.Eff* achieved their goals in significantly more weeks than those in the control group. In terms of the economic magnitude, on average, participants in *G_I* and *G_You.Eff* achieved their goals in about one more week (i.e., 61% and 60% of the mean of the control group, respectively) than participants who received no messages during the first 5 weeks of the program.[23] The coefficients on *G_You* and *G_I.Eff* are positive but not significant at the 10% conventional level. The cross-sectional regression results confirm the results in Table 6 that "I" frame and "You frame + effort emphasized" feedback messages encourage participants to complete the exercise goals more than the control group. Thus, the encouraging effect of the "You frame + effort emphasized" message group still holds for the overall effect. To test the differences in the effects between the treatment groups, we provide the pairwise comparisons between the coefficients on the treatment group indicators in the right half of Table 6, and find no significant differences between any two treatment groups.[24]

In summary, the analysis revealed that "I frame" and "You frame + effort emphasized" feedback messages work better in motivating participants to achieve their exercise goal for the period when feedback messages are provided.

[Insert Table 6 here.]

4.2.2 Moderating effect of self-control on messages' overall effect

In this section, we consider how participants' self-control affects the influence of the messages. The more self-control a participant has, the more likely it is that she can achieve the exercise goals without

[23] We calculate economic magnitude by dividing the coefficients on *G_I*/*G_You.Eff* by the mean of *Goal5W* of the control group, i.e. 0.996/1.639 and 0.987/1.639.

[24] As a robustness check, we also use goal achievement in the first 4 weeks (*Goal4W*) instead of 5 weeks as the dependent variable to avoid any potential confounding effects from the interim meeting of the program held in the 5th week. The results show that the coefficients on *G_I* and *G_You.Eff* are still positive and significant at the 5% level. The coefficient on *G_I.Eff* is positive and significant at the 10% level.

reminders from the messages. Thus, we expect the influence of the messages to decrease for participants with high levels of self-control. Our measurement of self-control, *SelfCon*, is based on the baseline personality survey. *SelfCon* is coded 1 if one's self-control score is above the sample average, and 0 otherwise.[25] *SelfCon* passed the randomization check, showing no significant differences between groups. We include *SelfCon* and its interaction terms with group indicators in the regression and estimate the following equation:

$$\begin{aligned} Goal5W_i = \quad & \beta_0 + \beta_1 SelfCon_i + \beta_2 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i \\ & + \beta_5 G\_You.Eff_i + \beta_6 SelfCon_i \times G\_I_i \\ & + \beta_7 SelfCon_i \times G\_You_i \\ & + \beta_8 SelfCon_i \times G\_I.Eff_i \\ & + \beta_9 SelfCon_i \times G\_You.Eff_i + \gamma X_i + \varepsilon_i \end{aligned} \qquad (4)$$

Similar to Equation (1), the coefficients on the group indicators, $\beta_2,\ldots,\beta_5$, reflect the effect of feedback messages on participants' goal achievements in the following week (compared with the control group) for those with low levels of self-control. The sum of the coefficients on the standalone group indicators and the corresponding interaction terms with *LagGoalW* estimate the influence of the messages for participants with high levels of self-control. The coefficients on the interaction terms $\beta_6, \ldots \beta_9$ capture the differences in the treatment messages' influence (compared with the control group) on participants classified as having high versus low levels of self-control.

The results are reported in Table 7. The coefficient on *SelfCon* is significantly positive, suggesting that participants with high levels of self-control are more likely to achieve their workout goals. The coefficients on all group indicators are positive and significant at the 10% to 1% levels. These results show that all treatment messages motivate participants with low levels of self-control to achieve their exercise goals. For example, the coefficient of *G_You.Eff* is 1.369, indicating that for low-self-control participants, the "You frame + effort emphasized" feedback message encourages goal achievement for 1.369 weeks more than the control group. To examine the influence of the messages on participants with a high degree of self-control, we report the sum of the coefficients on group indicators and their interaction terms with *SelfCon* in the right half of the table. None of the coefficients' sums is significant, suggesting that none of the messages had an effect on participants

[25] Self-control is scored from 0 to 4 based on answers to Questions 2 to 5 (see online appendix). The self-control score raises by an additional point if the participant's answer is above 4 in Question 1, below 4 in Question 2, and "Yes" in Question 3 or Question 4.

with high levels of self-control. To investigate the difference in treatment messages' encouraging effect for participants with different levels of self-control, we examine the coefficients on the interaction terms of *SelfCon* and group indicators. All the coefficients on the interaction terms are negative, which suggests that *SelfCon* weakens the impact of the treatment messages. But only the coefficient on *SelfCon*G_I* is significantly negative, indicating that the encouraging effect of the "I frame" message (compared with the control group) is significantly weaker for participants with high levels of self-control (-2.357, $P<0.05$).

In summary, the results in Table 7 demonstrate that all the treatment messages encourage participants who lack of self-control to achieve their exercise goals. But the influence of the messages diminishes for participants with high levels of self-control.

[Insert Table 7 here.]

4.2.3 Moderating effect of gender on messages' overall effect

Gender may also be an important factor that moderates the messages' influence on achieving exercise goals. As introduced in Section 3, *Gender* is coded 1 if the participant is female, and 0 otherwise. We include *Gender* and its interaction terms with group indicators in the regression and estimate the following equation:

$$\begin{aligned} Goal5W_i = \quad & \beta_0 + \beta_1 Gender_i + \beta_2 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i \\ & + \beta_5 G\_You.Eff_i + \beta_6\, Gender_i \times G\_I_i \\ & + \beta_7\, Gender_i \times G\_You_i + \beta_8 Gender_i \times G\_I.Eff_i \\ & + \beta_9 Gender_i \times G\_You.Eff_i + \gamma X_i + \varepsilon_i \end{aligned} \qquad (5)$$

The coefficients on the interaction terms $\beta_6, \ldots \beta_9$ capture the differences in the messages' influence on females compared with males. X_i includes *ExTimeBefore* and *CampusExProg*. The results, provided in Table 8, illustrate that none of the coefficients of the group indicators is significant – which indicates that our treatments do not work for males during the first 5 weeks. To identify the messages' influence on females, we report the statistics of the sum of the coefficients on the group indicators and *Gender* terms on the right half of the table. The results suggest that all the messages have a significant positive influence on females except the "You" frame message. When considering the interaction term, the coefficient of *Gender*G_I.Eff* is 2.636, significant at the 5% level, indicating that the "I frame + effort emphasized" message (compared with the control group)

encourages females to achieve their exercise goals for 2.636 weeks more than males in the first 5 weeks. This result suggests that females are more motivated by the "I frame + effort emphasized" message than males. In addition, the coefficient of *Gender*G_You.Eff* is positive but insignificant; thus females are more likely to achieve their goals in the "You frame + effort emphasized" message group than males, though the difference is not significant at conventional levels.

In summary, females are in general more likely to be motivated by all the messages except for the "You" frame message to achieve their goals, but males do not significantly respond to the messages.

[Insert Table 8 here.]

4.3 Enduring effect

After the fifth week, we no longer sent messages to the participants but kept recording their exercise status to allow us to observe the enduring effects of the messages after participants stopped receiving them.

4.3.1 Enduring effects of the messages

To investigate the enduring effect of the messages, we run a series of regressions on goal achievements in Weeks 6 to 8 (*GoalW6*/*GoalW7*/*GoalW8*) and the total number of goals achieved during Weeks 6 and 8 (*GoalW6-8*).[26] Since previous immediate-term results show that the goal achievement persisted, we also control for the total number of goals achieved during Weeks 1 and 5 (*Goal5W*) in the regression. Thus, we estimate the following equation:

$$Y_i = \beta_0 + \beta_1 Goal5W_i + \beta_2 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i + \beta_5 G\_You.Eff_i + \gamma X_i + \varepsilon_i \quad (6)$$

Where Y_i refers to *GoalW6*, *GoalW7*, *GoalW8* and *GoalW6-8*. The coefficients of group indicators $\beta_2,\ldots,\beta_5$ reflect the effect of the feedback messages on goal achievement in Weeks 6 to 8 compared to the control group.

[26] They are cross-sectional regressions. Specifically, for the dependent variables *GoalW6*/*GoalW7*/*GoalW8*, model (6) is a linear probability model at the same time.

Table 9 provides the regression results. The coefficient on *G_I* is negatively significant in the 6th week but insignificant in the last 3 weeks combined, suggesting that the influence of the "I" frame did not last in the long run, and even reversed in the first week when the messages ceased. More interestingly, the coefficients on *G_You.Eff* are significantly negative in Weeks 6 and 8 as well as for Weeks 6 to 8 combined. For example, controlling for other factors, participants in the *G_You.Eff* group achieved their goals in 0.452 fewer weeks than those in the control group for Weeks 6 to 8 combined. This result shows that the enduring effect of the "You frame + effort emphasized" message is opposite to its immediate and overall effect. A potential explanation is that the possible reactions and intense emotions generated by the "You" frame (Kubany et al., 1992a, 1992b) in negative conditions become dominant when the messages end, which makes participants reluctant to keep exercising.

In summary, these results show that the encouraging influences of "I" frame and "You frame + effort emphasized" feedback messages in the immediate and overall effect do not endure when the messages cease. Moreover, the influence of "You frame + effort emphasized" feedback reverses and results in lower performance in the long run.[27]

[Insert Table 9 here.]

4.3.2 Moderating effect of self-control on messages' enduring effect

In this section we investigate whether participants' self-control and gender affect the messages' enduring effects, i.e., whether the messages' influence on goal achievement in the final 3 weeks of the experiment varies based on participants' self-control and gender. First, we include *SelfCon* and its interaction terms with group indicators in the regression and estimate the following equation:

[27] In addition, we adopt a difference-in-difference design to estimate the enduring effects of the messages, i.e. the change in goal achievement after we stop sending the messages, compared with the time-series change of goal achievement of the control group. The results also indicate that the enduring effects of "I" frame and "You frame + effort emphasized" messages quickly fade in the last 3 weeks. The online appendix contains more details.

$$
\begin{aligned}
Y_i = \quad & \beta_0 + \beta_1 SelfCon_i + \beta_2 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i \\
& + \beta_5 G\_You.Eff_i + \beta_6 SelfCon_i \times G\_I_i \\
& + \beta_7 SelfCon_i \times G\_You_i \\
& + \beta_8 SelfCon_i \times G\_I.Eff_i \\
& + \beta_9 SelfCon_i \times G\_You.Eff_i + \beta_{10} Goal5W_i \\
& + \gamma X_i + \varepsilon_i
\end{aligned} \tag{7}
$$

Where Y_i refers to *GoalW6*, *GoalW7*, *GoalW8* and *GoalW6-8*. X_i includes *Gender*, *ExTimeBefore*, and *CampusExProg*. The coefficients on the interaction terms capture the differences in messages' long-term influences on participants with different levels of self-control. Table 10 displays the regression results.

We find that generally, all the coefficients on *G_I* and *G_You.Eff* are negative. The coefficients on *G_I* are significantly negative in the 6th week and last 3 weeks combined, and the coefficients on *G_You.Eff* are significantly negative in the 6th, 8th and last 3 weeks combined. These results suggest that participants with weak self-control in the *G_I* and *G_You.Eff* groups were less likely to achieve their exercise goals when we stopped sending messages compared with the control group. Thus, in terms of participants with weak self-control, their intrinsic motivation is likely to be crowded out by "I frame" message and "You frame-effort emphasized" message. It's consistent with the ideas in Bénabou and Tirole (2006) and Deci (1975), who claimed that extrinsic incentives could decrease motivation and reduce long-term performance. As for the interaction terms of *SelfCon* and group indicators, none of the coefficients on the interaction term with *G_I* and *G_You.Eff* is significant, while the sums of *G_I* and *G_You.Eff* and their interaction terms are also insignificant. Thus, the reversal of the enduring effect of "I frame" and "You frame + effort emphasized" messages is not significant for participants with high levels of self-control. Meanwhile, however, the coefficient on *SelfCon*G_I.Eff* is significant in the 7th week, suggesting a lower possibility of achieving goals for participants in the *G_I.Eff* group (compared with the control group) with strong self-control than those with low self-control. In all, in terms of participants with high self-control, the reversal of the enduring effect of messages is generally less observed.

[Insert Table 10 here.]

4.3.3 Moderating the effect of gender on messages' enduring effect

Here we explore whether gender affects the messages' enduring effects. Similar to Section 4.3.2, we include *Gender* and its interaction terms with group indicators in the regression and estimate the following equation:

$$\begin{aligned} Y_i = \quad & \beta_0 + \beta_1 Gender_i + \beta_2 G\_I_i + \beta_3 G\_You_i + \beta_4 G\_I.Eff_i \\ & + \beta_5 G\_You.Eff_i + \beta_6 Gender_i \times G\_I_i \\ & + \beta_7 Gender_i \times G\_You_i \\ & + \beta_8 Gender_i \times G\_I.Eff_i \\ & + \beta_9 Gender_i \times G\_You.Eff_i + \beta_{10} Goal5W_i \\ & + \gamma X_i + \varepsilon_i \end{aligned} \tag{8}$$

Where Y_i refers to *GoalW6*, *GoalW7*, *GoalW8* and *GoalW6-8*. X_i includes *ExTimeBefore* and *CampusExProg*. The coefficients on the interaction terms capture differences in the messages' long-term influences on participants of different genders. Table 11 shows the regression results.

We find that nearly all the coefficients of the group indicators are negative, but only those on *G_I*, *G_I.Eff* and *G_You.Eff* are significantly negative in the 7th week; the coefficient on *G_You.Eff* is also significantly negative in the last 3 weeks combined. This finding suggests that male participants in *G_I, G_I.Eff* and *G_You.Eff* are less likely to achieve their exercise goals in Week 7 compared with the control group. In addition, male participants in *G_You.Eff* achieve fewer of their goals in the last 3 weeks combined. As for the interaction terms of *Gender* and group indicators, only the coefficient of *Gender*G_You.Eff* is significantly positive in the 7th week, suggesting that the long-term negative effect of the "You frame + effort emphasized" message is significantly weaker for female participants than for male participants. According to Eckel et al. (2008) and Chew et al. (2013), females are more responsive to negotiation contexts and more likely to reach an agreement than males, which offer some explanations for our results that the enduring effect of the "You frame + effort emphasized" message reverses less for female participants than males.

[Insert Table 11 here.]

4.3.3 Path analysis

To explore the possible mechanisms of the messages' influence on long-term goal achievement, we

conduct path analyses in this section from the perspectives of habit building and positive feedback (including habit formation and sense). First, we consider the encouraging effect of the messages on long-run goal achievement that originates from habit building. Since path dependency may exist in behavioral decisions (Jin et al., 2020), we expect that habit building encouraged by the messages may influence long-term goal achievement. Second, we investigate the channel of positive feedback using an objective measure, BMI change, and a subjective measure, sense. We expect that people may perform better if they observe improvements in weight and sense.

(1) Habit formation and message influences

The previous results show that there is consistency in exercise behavior. Exercise habits built in the first 5 weeks may change participants' exercise behavior in the long run. Since participants did not receive feedback messages during the last 3 weeks of the study, this gives us the opportunity to separate the messages' direct influence in the long term and how this influence took effect through the exercise habit built in the first 5 weeks. To do so, we conduct a path analysis to divide the overall effect of messages in encouraging goal achievement into a *mediated* path, i.e., how the goal achievement encouraged by the messages in the first 5 weeks (*Goal5W*) influences goal achievement in the last 3 weeks (*GoalW6-8*), and a *direct* path, i.e. how the message influence persists in the long run beyond the possible *mediated* path(s) we consider.

We simultaneously estimate the following system of equations:

$$Goal5W_i = \alpha_0 + \alpha_1 G\_I_i + \alpha_2 G\_You_i + \alpha_3 G\_I.Eff_i + \alpha_4 G\_You.Eff_i + \gamma X_i + \varepsilon_i, \quad (9a)$$

$$GoalW6-8_i = \beta_0 + \beta_1 G\_I_i + \beta_2 G\_You_i + \beta_3 G\_I.Eff_i + \beta_4 G\_You.Eff_i + \beta_5 Goal5W_i + \gamma X_i + \varepsilon_i \quad (9b)$$

Where X_i is a vector of control variables, including *ExTimeBefore*, *Gender*, and *CampusExProg*. In this framework, α_1 to α_4 measure the strength of the mediated path from group indicators (*G_I* to *G_You.Eff*) to *Goal5W*, which is represented by the path from "Group indicators" to "*Goal5W*" (path #a1) in Appendix Figure 2(a). In Equation (9b), β_5 measures the strength of the mediated path from *Goal5W* to *GoalW6-8* after controlling for other contemporaneous effects, which is

represented by the path from "*Goal5W*" to "*GoalW6-8"* (path #a2) in Figure 2(a). Thus, the influence of the messages on *GoalW6-8* through the channel of *Goal5W* is the product of the standardized coefficients β_5 and α_1 (to α_4 respectively), i.e., the total mediated path of p(*Group indicators→Goal5W*)*p(*Goal5W→GoalW6-8*) (path #a1-2), which measures the mediated effect of the message on long-term goal achievement through the channel of habit building encouraged by messages during the first 5 weeks. In addition, β_1 to β_4 measure the direct path from group indicators (*G_I* to *G_You.Eff*) to *GoalW6-8* (path #a3). The total influence of group indicators on long-term goal achievement includes both the influence through the direct path, i.e., p(*Group indicators*, *GoalW6-8*) (path #a3), and the influence through the total mediated path, i.e. p(*Group indicators→Goal5W*)*p(*Goal5W→GoalW6-8*) (path #a1-2).

Panel A of Table 12 reports the results. The mediating paths of p(*G_I→Goal5W*) and p(*G_You.Eff→Goal5W*) (path #a1) are significantly positive at the 5% level, confirming the previous result that "I" frame and "You frame + effort emphasized" feedback messages have an encouraging effect during the first 5 weeks. p(*Goal5W→GoalW6-8*) (path #a2) is significantly positive at the 1% level, which is consistent with our conjecture that exercise habits built in the past are sustained in the long run. The total mediated paths of p(*G_I→Goal5W*)*p(*Goal5W→GoalW6-8*) and p(*G_You.Eff→Goal5W*)*p(*Goal5W→GoalW6-8*) (path #a1-2) are significantly positive, which suggests that a significant factor contributing to the exercises in the last 3 weeks is the goal achievements encouraged by "I" frame and "You frame + effort emphasized" feedback messages in the first 5 weeks (i.e., the "habit building").

However, the messages' long-term influence in the direct paths, i.e. p(*Group indicators*, *GoalW6-8*) (path #a3), are negative, and significant at the 1% level for the direct path of "I" frame and "You frame + effort emphasized". Thus the messages' direct effect offsets the positive influences of the total mediated path (path #a1-2). Therefore, the influence of the messages through the total path (calculated by the aggregation of direct path and total mediated path) is insignificant for all the messages.

(2) Positive feedback and message influence

In addition to habit building, another potential channel for creating an enduring effect of the messages is positive feedback. If the participants receive positive feedback during the exercises, such as losing weight or feeling good, they may be more willing to keep exercising even when they no longer receive these messages. To check this possibility, we further expand Equation (8) with another two channels, change in BMI and sense.

To test the channel of BMI change, we construct an indicator, *BMIchange*, which equals 1 if the participant's BMI drops during the first 5 weeks. A decrease in BMI suggests the participant lost weight during the experiment. Specifically, we establish the following equation system:

$$Goal5W_i = \alpha_0 + \alpha_1 G\_I_i + \alpha_2 G\_You_i + \alpha_3 G\_I.Eff_i + \alpha_4 G\_You.Eff_i + \gamma X_i + \varepsilon_i, \quad (10a)$$

$$BMIchange_i = \beta_0 + \beta_1 G\_I_i + \beta_2 G\_You_i + \beta_3 G\_I.Eff_i + \beta_4 G\_You.Eff_i + \beta_5 Goal5W_i + \gamma X_i + \varepsilon_i, \quad (10b)$$

$$GoalW6-8_i = \gamma_0 + \gamma_1 G\_I_i + \gamma_2 G\_You_i + \gamma_3 G\_I.Eff_i + \gamma_4 G\_You.Eff_i + \gamma_5 Goal5W_i + \gamma_6 BMIchange_i + \gamma X_i + \varepsilon_i \quad (10c)$$

Similar to Equation (9), α_1 to α_4 measure the strength of the mediated path from group indicators (*G_I* to *G_You.Eff*) to *Goal5W,* which is represented by the path from "Group indicators" to "*Goal5W*" (path #b1) in Appendix Figure 2(b). β_5 in the second equation measures the strength of the mediated path from *Goal5W* to *BMIchange* after controlling for the messages and other contemporaneous effects, which is represented by the path from "Goal5W" to "*BMIchange"* (path #b2) in Figure 2(b). The product of the standardized coefficients β_5 and α_1 (to α_4 respectively), i.e., the mediated path of p(*Group indicators→Goal5W*)*p(*Goal5W→BMIchange*) (path #b1-2), captures the influence of the messages on *BMIchange* through the channel of *Goal5W*. Furthermore, γ_6 in the third equation measures any encouraging effect of positive feedback in terms of *BMIchange* on long-term goal achievement, i.e., the path from "*BMIchange*" to "*GoalW6-8*" (path #b3). Thus, p(*Group indicator→Goal5W*)*p(*Goal5W→BMIchange*)*p(*BMIchange→GoalW6-8*) (path #b1-2-3) captures the total influence of the messages on long-term goal achievement through BMI change.

Column (1) in Panel B of Table 12 provides the estimated results. P(*Goal5W→BMIchange*) (path #b2) is positive and significant at the 1% level, indicating that goal achievement in the first 5 weeks significantly decreased participants' BMI. p(*G_I→Goal5W*)*p(*Goal5W→BMIchange*) and p(*G_You.Eff→Goal5W*)*p(*Goal5W→BMIchange*) (path #b1-2) are significantly positive, suggesting that "I" frame and "You frame + effort emphasized" feedback messages led to impactful consequences, i.e., participants' BMI decreased through encouraging exercise. p(*BMIchange→GoalW6-8*) (path #b3) is positively significant at the 10% level, demonstrating that the BMI decrease in the first 5 weeks encouraged participants to keep exercising in the long run. However, since the significance level for several links in the mediated path for *BMIchange* is marginal, the total mediated path for *BMIchange* for all groups is insignificant (path #b1-2-3). These results suggest that although some messages contributed to BMI decreases, and BMI decreases further encouraged exercise in the long run, the messages' influence on long-run goal achievement through BMI decreases is marginal. The influence of the messages on long-run goal achievements through total paths (calculated by the aggregation of path #b1-4, path #b1-2-3 and direct path of group indicators to long-term goal achievements) is also insignificant.[28]

BMIchange is an objective measure of positive feedback for participants through exercises. Our survey about participants' sense towards the exercises provides proxies for feedback on participants' subjective perspectives. Next, we replace *BMIchange* with the four sense proxies (*Feel*, *Enjoy*, *Ability* and *Power*) constructed based on the survey at the end of Week 5 and re-estimate Equation (9).[29] The results using *Feel* as the mediated variable are reported in Column (2) in Panel B of Table 12. There is no evidence that subjective feelings are valid paths for the messages' influence in the long run. The results using the other three proxies are similar and thus not reported.

[Insert Table 12 here.]

In summary, we conduct path analysis to explore potential mechanisms of the messages'

[28] The direct path here is the same as the direct path in Figure 3(a), as it represents the direct effect of messages on goal achievement in Weeks 6 to 8, i.e., p(*Group indicators*, *GoalW6-8*) (path #a3). For brevity, we do not mark the direct path in Figure 3(b).

[29] The sense proxies are different from those in session 4.1.2, as those were constructed based on the weekly surveys of the first 5 weeks and were run in mixed cross-sectional regressions.

influences on long-run goal achievements. Although we do not find evidence that the messages have a significant overall encouraging influence on long-run goal achievements, we determine that habit building and BMI change induced by more exercise in the first 5 weeks help participants achieve their long-term exercise goals. This finding sheds light on future research those designs regarding how to motivate people to work out.

5. Conclusion

This study examines the role of *ex post* feedback messages in influencing individual exercise behavior. Using a 2 x 2 framework based on the interaction of "effort" attribution and "I" and "You" frames, we discuss how different types of feedback messages encourage people to work out and the possible mechanisms.

Our field experiment shows that, in the immediate term, when participants who failed to achieve their goal the previous week, "You frame + effort emphasized" feedback messages have a significant positive impact on inducing them to achieve their exercise goals the following week. But for participants who met their goal in the previous week, none of the treatment messages had any significant influence in encouraging goal achievement. When we combine both dimensions into a single feedback message design, we find that the general findings from previous studies may not necessarily hold. Therefore, it is very important to design and test for nudging mechanism designs before applying them in practice, and not just simply combine ideas from previous studies.

As for the overall effect, our field experiment shows that "I" frame and "You frame + effort emphasized" feedback messages are more effective at encouraging participants to achieve their exercise goals while feedback messages are provided. Our investigation further finds that all the treatment messages encourage participants who lack the self-control to achieve their goals, but the influence of the messages diminishes for participants with high levels of self-control. This finding is particularly important because it identifies the condition under which providing reminders facilitates behavior. As an extrinsic stimuli, the motivating power of feedback messages hinges on the strength of people's intrinsic motivation. Specifically, when there is sufficient ability and/or intrinsic

motivation to persist, the type of extrinsic stimuli (i.e., feedback content) has much less influence on behavior efficiency because the intrinsic motivation dominates. However, if there is a lack of self-control and/or intrinsic motivation, the extrinsic stimuli (i.e., reminders, incentives) dominates; in this case, the type of feedback messages matters.

In the long run, we find that the encouraging effect of the "I frame" and "You frame + effort emphasized" feedback messages in the immediate term and overall effect do not endure after participants no longer receive them. Moreover, the influence of "You frame + effort emphasized" feedback even reverses and discourages performance in the long run. The path analyses show that although we do not find evidence that the messages have a significant overall encouraging influence on long-run goal achievement, we determine that habit building and BMI change induced by more exercise in the first 5 weeks help encourage participants to exercise in the long run. This finding sheds light on future research those designs regarding how to motivate people to work out.

In summary, this field experiment reveals that feedback messages are not very effective for those who have high levels of self-control or previously performed well, as their previous success already constitutes a form of positive feedback, so the extra positive feedback through messages adds little extra value. But when people did not perform well, especially those who lack self-control, feedback messages (especially the "You frame + effort emphasized" message) remind them of the cause of the negative outcomes (i.e., lack of effort), and induce them to perform better in the next period. These findings are also consistent with prior research on the interplay between extrinsic incentives and intrinsic motivation (Deci, 1975; Frey and Jegen, 2001; Bénabou and Tirole, 2006). The critical role of feedback messages we found is that they enable people who lack of self-control to build a habit and experience achievement (a kind of spontaneous positive feedback) by reminding them of the discrepancy. However, the benefit of feedback messages in encouraging people to work out may not be long lasting when people no longer receive messages. Fortunately, through path analysis, we find that if these messages help participants form a habit of exercising or decrease their BMI during the treated periods, these two channels may lead them to continue to exercise in the long run. These findings suggest that it is plausible to achieve a positive outcome by inducing those who lack self-control or self-motivation to build an exercise habit through effective feedback messages.

Our study represents the first attempt to design an *ex post* feedback mechanism that incorporates both attribution theory and deictic relational framing and use it in health management. Our field experiment and analyses advance our understanding of attribution theory and deictic relational framing in influencing people's behavior in the context of exercise. Our study also discusses the influence of messages conditional on participants' previous goal achievement and their self-control and experiences during the process, which highlights the interactive influences between *ex post* messages and other factors. Our study complements prior research on attribution theory and deictic relational framing by not only illustrating the overall influence of message design but also discussing the enduring influence when people no longer receive messages, which sheds light on how to design personalized feedback messages to motivate people to better manage their health, and highlights directions for future research on long-term intervention mechanism design.

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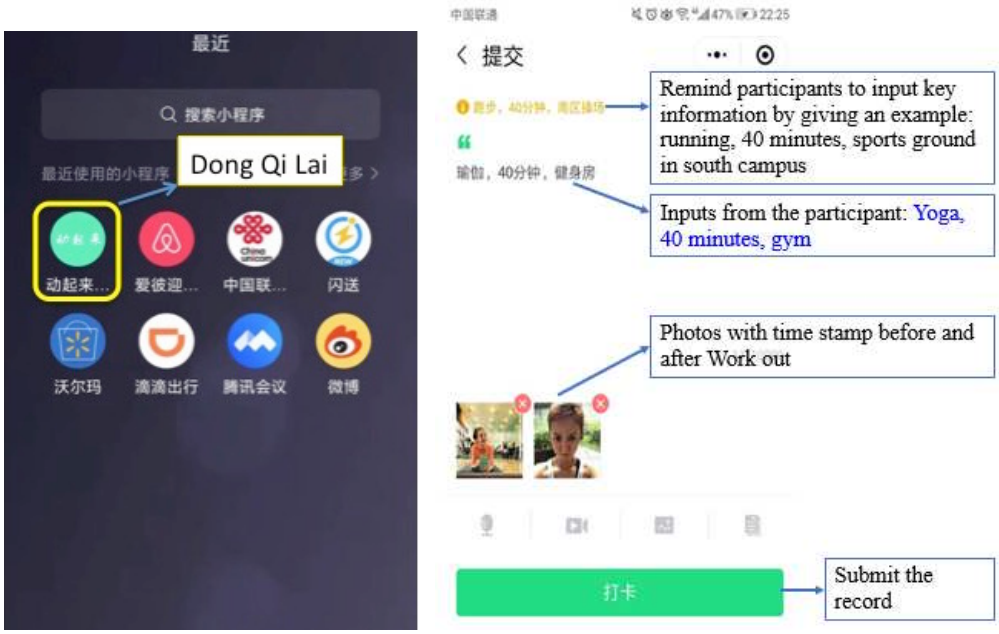
Appendix:

Fig. 1 "Dong Qi Lai" applet in Wechat



Notes. The figure on the left is the icon of Dong Qi Lai applet in Wechat. The figure on the right is a sample of how to fill a work out record on Dong Qi Lai applet.

Fig. 2 Timeline of experimental intervention

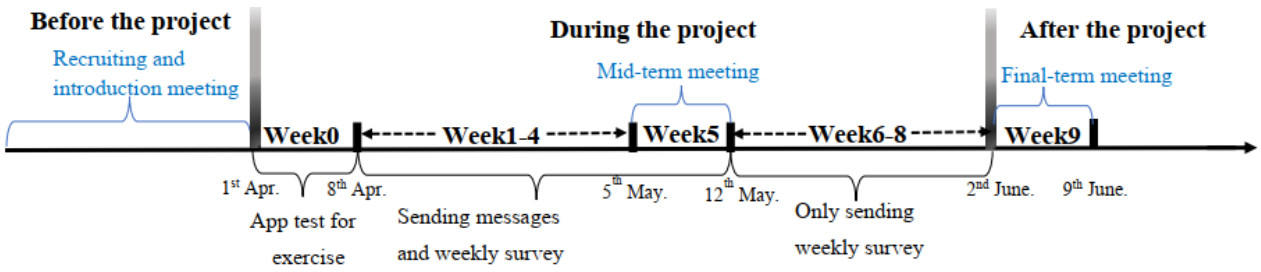


Fig. 3 Path analysis

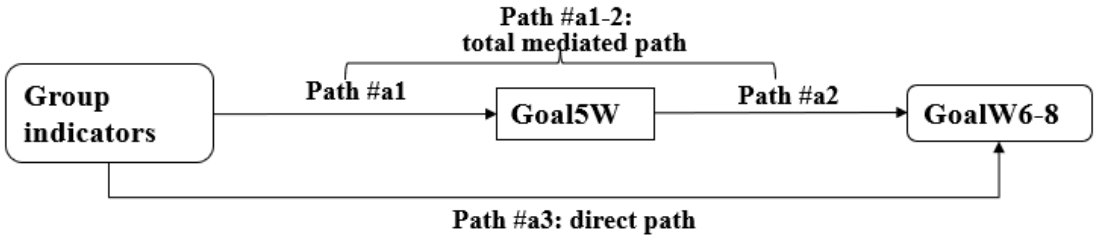


Fig. 2 (a) Message influences through habit formation

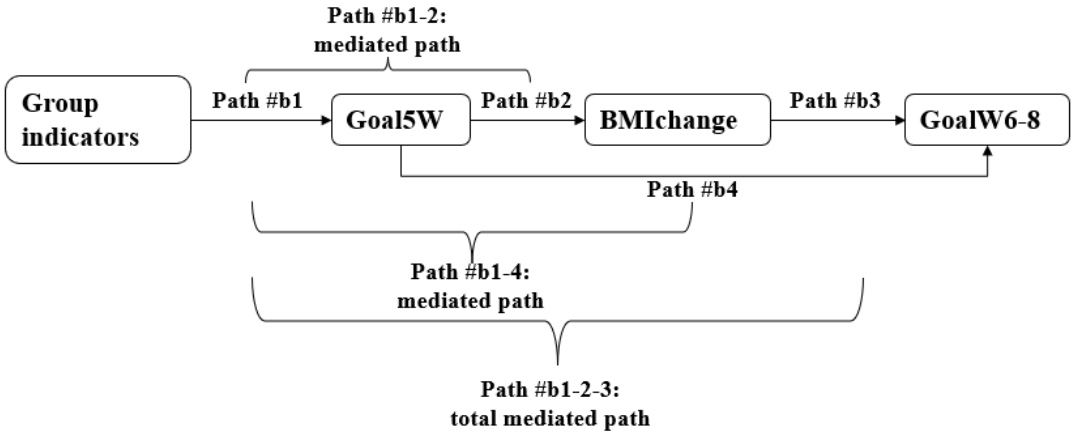


Fig 2. (b) Message influences through positive feedback

Table 1 (a). Treatments

	"I" frame	**"You" frame**
No effort emphasized	*G_I* (36 participants)	*G_You* (36 participants)
Effort emphasized	*G_I.Eff* (37 participants)	*G_You.Eff* (36 participants)
Control group	*G_Contr* (36 participants)	

Table 1 (b). The Content of Feedback Messages

		"I" frame	**"You" frame**
No effort emphasized	Achieve the suggested goal last week	You exercised ** times last week and achieved the goal, *[we!!] are so happy!*	You exercised ** times last week and achieved the goal, *[you!!] make us so happy!*
	Fail to achieve the suggested goal last week	You exercised ** times last week and haven't achieved the goal, *[we!!] are so sorry!*	You exercised ** times last week and haven't achieved the goal, *[you!!] make us so sorry!*
Effort emphasized	Achieve the suggested goal last week	You exercised ** times last week and achieved the goal,	You exercised ** times last week and achieved the goal, *[you!!] make us so*

		[we!!] are so happy for your effort!	*happy for your effort!*
	Fail to achieve the suggested goal last week	You exercised ** times last week and haven't achieved the goal, *[we!!] are so sorry for your lack of effort!*	You exercised ** times last week and haven't achieved the goal, *[you!!] make us so sorry for your lack of effort!*
Control group	Achieve the suggested goal last week	No feedback messages	
	Fail to achieve the suggested goal last week	No feedback messages	

Table 2. Randomization check

Group	Gender (female=1)	CampusExProg (involved=1)	ExTimeBefore (hours per week)	BMI
G_I	0.69	0.61	2.31	21.12
G_You	0.81	0.56	1.88	21.71
G_Contr	0.72	0.44	2.39	22.25
G_I.Eff	0.78	0.51	2.23	21.83
G_You.Eff	0.72	0.5	2.46	22.45

Table 3. Previous week's goal achievement and message influences

Dep. Var. =	*GoalW*		
LagGoalW	0.690***		
	(0.086)		
G_I	0.106		
	(0.067)		
*LagGoalW*G_I*	-0.154	*G_I + LagGoalW*G_I*	-0.048
	(0.124)		(0.088)
G_You	0.066		
	(0.055)		
*LagGoalW*G_You*	-0.054	*G_You + LagGoalW*G_You*	0.013
	(0.116)		(0.086)
G_I.Eff	0.001		
	(0.047)		
*LagGoalW*G_I.Eff*	0.079	*G_I.Eff + LagGoalW*G_I.Eff*	0.080
	(0.110)		(0.081)
G_You.Eff	0.125*		
	(0.072)		

*LagGoalW*G_You.Eff*	-0.107	*G_You.Eff* + *LagGoalW*G_You.Eff*	0.017
	(0.135)		(0.088)
ExTimeBefore	0.005		
	(0.006)		
Gender	0.003		
	(0.036)		
CampusExProg	0.017		
	(0.027)		
Intercept	0.032		
	(0.057)		
Weekly fixed effects	Yes		
Number of Observations	724		
adj. R^2	0.426		
Diff. of *G_I v.s. G_You*	F=0.029	Diff. of *G_I* + *LagGoalW*G_I v.s. G_You* + *LagGoalW*G_You*	F=0.57
Diff. of *G_I.Eff v.s. G_You.Eff*	F=3.17$^{\#\#}$	Diff. of *G_I.Eff* + *LagGoalW*G_I.Eff v.s. G_You.Eff* + *LagGoalW*G_You.Eff*	F=0.77
Diff. of *G_I v.s. G_I.Eff*	F=2.55$^{\#}$	Diff. of *G_I* + *LagGoalW*G_I v.s. G_I.Eff* + *LagGoalW*G_I.Eff*	F=2.99$^{\#\#}$
Diff. of *G_You v.s. G_You.Eff*	F=0.56	Diff. of *G_You* + *LagGoalW*G_You v.s. G_You.Eff* + *LagGoalW*G_You.Eff*	F=0.00

Notes. This table reports the results of a mixed cross-sectional regression from Weeks 1 to 5. Since Week 1 is the previous week of Week 2, the panel begins from Week 2. GoalW(Dep. Var.) is an indicator of the goal achievement in the current week, and LagGoalW denotes the goal achievement in the previous week. Standard errors in parentheses are clustered at the participant level.
**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed. $^{\#}$p < 0.10; $^{\#\#}$p < 0.05; $^{\#\#\#}$p < 0.01, one-tailed.*

Table 4. Moderating effect of *sense* on the messages' immediate effects

Dep. Var. = GoalW	*Sense =*			
	Satisfaction		Achievement	
	(1)	(2)	(3)	(4)
	Feel	*Enjoy*	*Ability*	*Power*
Sense	-0.096	0.005	0.180**	0.170**
	(0.065)	(0.066)	(0.070)	(0.075)
G_I	0.051	0.023	0.047	0.014
	(0.084)	(0.069)	(0.061)	(0.062)
*Sense*G_I*	0.043	0.060	-0.100	-0.009
	(0.106)	(0.107)	(0.093)	(0.102)
G_You	-0.025	-0.008	0.017	0.020
	(0.088)	(0.061)	(0.060)	(0.063)
*Sense*G_You*	0.135	0.106	-0.014	0.003
	(0.106)	(0.095)	(0.100)	(0.101)
G_I.Eff	0.097	0.029	0.030	0.078
	(0.071)	(0.068)	(0.060)	(0.062)
*Sense*G_I.Eff*	-0.053	0.058	-0.060	-0.126
	(0.096)	(0.103)	(0.093)	(0.099)
G_You.Eff	0.026	0.023	-0.005	0.036
	(0.077)	(0.084)	(0.064)	(0.066)
*Sense*G_You.Eff*	0.116	0.099	0.084	0.037
	(0.096)	(0.110)	(0.106)	(0.106)
LagGoalW	0.591***	0.597***	0.611***	0.608***
	(0.044)	(0.044)	(0.040)	(0.040)
ExTimeBefore	0.003	-0.000	0.002	0.003
	(0.006)	(0.006)	(0.006)	(0.005)
Gender	0.026	0.027	0.031	0.020
	(0.040)	(0.040)	(0.035)	(0.035)
CampusExProg	0.004	0.018	0.012	0.017
	(0.032)	(0.033)	(0.028)	(0.028)
Intercept	0.128	0.079	-0.002	-0.009
	(0.077)	(0.070)	(0.058)	(0.063)
Weekly Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	573	567	672	672
adj. R^2	0.355	0.353	0.418	0.414
*G_I + Sense*G_I*	0.094	0.083	-0.054	0.005
	(0.066)	(0.082)	(0.070)	(0.073)
*G_You + Sense*G_You*	0.110*	0.098	0.004	0.023
	(0.060)	(0.076)	(0.076)	(0.072)
*G_I.Eff + Sense*G_I.Eff*	0.043	0.087	-0.030	-0.047
	(0.066)	(0.078)	(0.070)	(0.071)
*G_You.Eff + Sense*G_You.Eff*	0.142**	0.122*	0.079	0.072
	(0.062)	(0.069)	(0.073)	(0.072)

Notes. This table reports the results of a mixed cross-sectional regression from Weeks 1 to 5. Since Week 1 is the previous week of Week 2, the panel begins from Week 2. GoalW(Dep. Var.) is an indicator of the goal achievement in the current week. Standard errors in parentheses are clustered at the participant level.
**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 5. Descriptive statistics of *Goal5W*

					Comparison with *G_Contr*	
Group	N	Mean	Median	Std.dev.	T-test	Wilcoxon test
G_I	36	2.639	3	1.959	$t = 2.104$**	$z = 2.264$**
G_You	36	2.278	2	2.120	$t = 1.293$	$z = 1.450$
G_Contr	36	1.639	0	2.072	-	-
G_I.Eff	37	2.432	2	2.205	$t = 1.583$	$z = 1.877$*
G_You.Eff	36	2.639	3	2.045	$t = 2.061$**	$z = 2.121$**

*Note. *p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 6. Overall effect regression

Dep. Var. =	*Goal5W*		
G_I	0.996**	*G_I vs. G_You*	0.362
	(0.495)		(0.491)
G_You	0.634	*G_I vs. G_I.Eff*	0.222
	(0.508)		(0.481)
G_I.Eff	0.774	*G_I vs. G_You.Eff*	0.008
	(0.500)		(0.474)
G_You.Eff	0.987**	*G_You vs. G_I.Eff*	-0.140
	(0.489)		(0.504)
ExTimeBefore	0.084	*G_You vs. G_You.Eff*	-0.353
	(0.076)		(0.497)
Gender	0.399	*G_I.Eff vs. G_You.Eff*	-0.214
	(0.390)		(0.484)
CampusExProg	0.137		
	(0.315)		
Intercept	1.087**		
	(0.540)		
Number of Observations	181		
adj. R^2	0.006		

Notes. This table reports the results of a cross-sectional regression. Goal5W (Dep. Var.) is the total number of weeks that the participants achieved their exercise goals in the first 5 weeks. Since we send messages for the first 4 weeks and participants' goal achievements of Week 4 take effect on exercise reports for Week 5, we should take the fifth week into count. Standard errors are shown in parentheses.

**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 7. Moderating effect of self-control on the messages' overall effect

Dep. Var. =	*Goal5W*		
SelfCon	1.764**		
	(0.737)		
G_I	1.948***		
	(0.602)		
*SelfCon*G_I*	-2.357**	*G_I + SelfCon*G_I*	-0.409
	(1.009)		(0.797)
G_You	1.034*		
	(0.572)		
*SelfCon*G_You*	-0.769	*G_You + SelfCon*G_You*	0.265
	(1.117)		(0.952)
G_I.Eff	1.118*		
	(0.578)		
*SelfCon*G_I.Eff*	-0.724	*G_I.Eff + SelfCon*G_I.Eff*	0.395
	(1.024)		(0.842)
G_You.Eff	1.369**		
	(0.613)		
*SelfCon*G_You.Eff*	-1.050	*G_You.Eff + SelfCon*G_You.Eff*	0.318
	(1.000)		(0.775)
ExTimeBefore	0.056		
	(0.080)		
Gender	0.602		
	(0.387)		
CampusExProg	-0.058		
	(0.315)		
Intercept	0.410		
	(0.596)		
Number of Observations	181		
adj. R^2	0.039		

Notes. This table reports the results of a cross-sectional regression. Goal5W(Dep. Var.) is the total number of weeks the participants achieved their exercise goals in the first 5 weeks. Standard errors are shown in parentheses.

**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 8. Moderating effect of gender on the messages' overall effect

	Goal5W		
Gender	-0.685		
	(0.884)		
G_I	0.148		
	(1.064)	*G_I + Gender*G_I*	1.317**
*Gender*G_I*	1.169		(0.533)
	(1.189)		
G_You	0.617		
	(1.168)	*G_You + Gender*G_You*	0.740
*Gender*G_You*	0.123		(0.546)
	(1.295)		
G_I.Eff	-1.230		
	(0.988)	*G_I.Eff + Gender*G_I.Eff*	1.406**
*Gender*G_I.Eff*	2.636**		(0.533)
	(1.132)		
G_You.Eff	-0.048		
	(1.017)	*G_You.Eff + Gender*G_You.Eff*	1.383**
*Gender*G_You.Eff*	1.431		(0.552)
	(1.163)		
ExTimeBefore	0.076		
	(0.084)		
CampusExProg	0.168		
	(0.322)		
Intercept	1.878**		
	(0.844)		
N	181		
adj. R^2	0.023		

Notes. This table reports the results of a cross-sectional regression. Standard errors are shown in parentheses.

**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 9. Enduring effects of the messages

	(1)	(2)	(3)	(4)
Dep. Var. =	*GoalW6*	*GoalW7*	*GoalW8*	*GoalW6-8*
G_I	-0.134*	-0.032	-0.104	-0.270
	(0.074)	(0.066)	(0.080)	(0.168)
G_You	-0.016	0.034	-0.041	-0.023
	(0.077)	(0.069)	(0.071)	(0.146)
G_I.Eff	-0.032	-0.036	0.004	-0.064
	(0.058)	(0.061)	(0.076)	(0.133)
G_You.Eff	-0.144**	-0.092	-0.216***	-0.452***
	(0.072)	(0.071)	(0.079)	(0.163)
Goal5W	0.176***	0.176***	0.160***	0.513***
	(0.010)	(0.011)	(0.012)	(0.024)
ExTimeBefore	0.005	0.010	0.005	0.019
	(0.010)	(0.008)	(0.011)	(0.023)
Gender	-0.017	0.007	-0.035	-0.045
	(0.050)	(0.049)	(0.057)	(0.124)
CampusExProg	-0.086*	-0.026	-0.004	-0.117
	(0.048)	(0.045)	(0.050)	(0.108)
Intercept	0.055	-0.056	0.032	0.031
	(0.067)	(0.061)	(0.074)	(0.151)
Number of Observations	181	181	181	181
adj. R^2	0.567	0.583	0.497	0.678

Notes. They are cross-sectional regressions. Specifically，for columns (1) to (3), the regressions are linear probability models. Standard errors are shown in parentheses.

**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 10. Moderating effect of self-control on messages' enduring effect

	(1)	(2)	(3)	(4)
	GoalW6	*GoalW7*	*GoalW8*	*GoalW6-8*
G_I	-0.214**	-0.048	-0.113	-0.375*
	(0.094)	(0.092)	(0.091)	(0.208)
*SelfCon*G_I*	0.193	0.039	0.032	0.264
	(0.143)	(0.131)	(0.172)	(0.344)
G_You	0.001	0.044	-0.071	-0.025
	(0.092)	(0.091)	(0.070)	(0.151)
*SelfCon*G_You*	-0.062	-0.001	0.099	0.037
	(0.161)	(0.128)	(0.162)	(0.325)
G_I.Eff	0.021	0.064	-0.045	0.040
	(0.059)	(0.065)	(0.071)	(0.114)
*SelfCon*G_I.Eff*	-0.165	-0.285**	0.152	-0.298
	(0.139)	(0.144)	(0.180)	(0.350)
G_You.Eff	-0.202**	-0.066	-0.289***	-0.557**
	(0.085)	(0.096)	(0.088)	(0.173)
*SelfCon*G_You.Eff*	0.121	-0.072	0.174	0.224
	(0.150)	(0.145)	(0.169)	(0.354)
SelfCon	0.043	0.117	-0.027	0.133
	(0.104)	(0.090)	(0.122)	(0.219)
Gender	-0.020	0.005	-0.027	-0.042
	(0.052)	(0.052)	(0.059)	(0.132)
Goal5W	0.177***	0.175***	0.157***	0.510***
	(0.010)	(0.011)	(0.012)	(0.024)
ExTimeBefore	-0.000	0.006	0.004	0.009
	(0.010)	(0.009)	(0.011)	(0.023)
CampusExProg	-0.070	-0.019	-0.008	-0.096
	(0.047)	(0.046)	(0.049)	(0.105)
Intercept	0.045	-0.092	0.044	-0.003
	(0.065)	(0.067)	(0.072)	(0.142)
N	181	181	181	181
adj. R^2	0.575	0.587	0.491	0.679
*G_I + SelfCon*G_I*	-0.020	-0.009	-0.081	-0.111
	(0.109)	(0.091)	(0.146)	(0.274)
*G_You + SelfCon*G_You*	-0.061	0.044	0.029	0.012
	(0.132)	(0.088)	(0.149)	(0.292)
*G_I.Eff + SelfCon*G_I.Eff*	-0.144	-0.221*	0.107	-0.258
	(0.126)	(0.127)	(0.167)	(0.327)
*G_You.Eff + SelfCon*G_You.Eff*	-0.144	-0.138	-0.114	-0.333
	(0.126)	(0.106)	(0.145)	(0.308)

Notes. They are cross-sectional regressions. Specifically, for columns (1) to (3), the regressions are linear probability model. Standard errors are shown in parentheses.
**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 11. Moderating effect of gender on messages' enduring effect

	(1) *GoalW6*	(2) *GoalW7*	(3) *GoalW8*	(4) *GoalW6-8*
G_I	-0.047	-0.143*	-0.133	-0.323
	(0.107)	(0.082)	(0.127)	(0.261)
*Gender*G_I*	-0.126	0.159	0.040	0.073
	(0.140)	(0.119)	(0.160)	(0.337)
G_You	-0.048	-0.135	-0.027	-0.210
	(0.145)	(0.124)	(0.147)	(0.387)
*Gender*G_You*	0.034	0.231	-0.020	0.244
	(0.173)	(0.149)	(0.167)	(0.414)
G_I.Eff	-0.026	-0.133**	0.067	-0.092
	(0.091)	(0.060)	(0.141)	(0.213)
*Gender*G_I.Eff*	-0.013	0.141	-0.083	0.045
	(0.116)	(0.096)	(0.168)	(0.269)
G_You.Eff	-0.083	-0.369***	-0.162	-0.614**
	(0.131)	(0.117)	(0.123)	(0.286)
*Gender*G_You.Eff*	-0.087	0.387***	-0.075	0.225
	(0.159)	(0.148)	(0.159)	(0.353)
Gender	0.026	-0.178**	-0.009	-0.161
	(0.103)	(0.070)	(0.110)	(0.203)
Goal5W	0.177***	0.175***	0.161***	0.513***
	(0.010)	(0.011)	(0.012)	(0.024)
ExTimeBefore	0.005	0.007	0.005	0.017
	(0.010)	(0.009)	(0.011)	(0.024)
CampusExProg	-0.082*	-0.044	-0.005	-0.131
	(0.049)	(0.046)	(0.051)	(0.111)
Intercept	0.021	0.095	0.010	0.126
	(0.097)	(0.063)	(0.099)	(0.198)
N	181	181	181	181
adj. R^2	0.560	0.587	0.487	0.671
*G_I + Gender*G_I*	-0.173*	0.016	-0.092	-0.25
	(0.094)	(0.086)	(0.100)	(0.214)
*G_You + Gender*G_You*	-0.014	0.096	-0.047	0.034
	(0.091)	(0.081)	(0.082)	(0.154)
*G_I.Eff + Gender*G_I.Eff*	-0.039	0.008	-0.016	-0.047
	(0.071)	(0.075)	(0.091)	(0.163)
G_You.Eff +	-0.17*	0.018	-0.237**	-0.389*

*Gender*G_You.Eff*				
	(0.087)	(0.086)	(0.100)	(0.202)

Notes. They are cross-sectional regressions. Specifically, for columns (1) to (3), the regressions are linear probability models. Standard errors are shown in parentheses.
**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*

Table 12. Path analysis

Panel A. Habit building and message influences

Direct Path (*Dep. Var. = GoalW6-8*)	**Coef.**
p(*G_I→GoalW6-8*)	-0.084
	(0.053)
p(*G_You→GoalW6-8*)	-0.007
	(0.053)
p(*G_I.Eff→GoalW6-8*)	-0.020
	(0.053)
p(*G_You.Eff→GoalW6-8*)	-0.141***
	(0.053)
Mediated Path for *Goal5W* (*Dep. Var. = Goal5W or GoalW6-8*)	
p(*G_I→Goal5W*)	0.191**
	(0.091)
p(*G_You→Goal5W*)	0.121
	(0.092)
p(*G_I.Eff→Goal5W*)	0.150
	(0.092)
p(*G_You.Eff→Goal5W*)	0.189**
	(0.090)
p(*Goal5W→GoalW6-8*)	0.836***
	(0.026)
Total Mediated Path for *Goal5W* (*Dep. Var. = Goal5W*)	
p(*G_I→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.159**
	(0.077)
p(*G_You→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.101
	(0.077)
p(*G_I.Eff→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.125
	(0.077)
p(*G_You.Eff→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.158**
	(0.077)
Total Path (*Dep. Var. = GoalW6-8*)	
p(*G_I→GoalW6-8*) + p(*G_I→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.075
	(0.093)
p(*G_You→GoalW6-8*) + p(*G_You→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.094

	(0.093)
p(*G_I.Eff→GoalW6-8*) + p(*G_I.Eff→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.105
	(0.093)
p(*G_You.Eff→GoalW6-8*) + p(*G_You.Eff→Goal5W*)*p(*Goal5W→GoalW6-8*)	0.017
	(0.093)
Number of observations	181

Panel B. Positive feedback and message influences

	MediatedVar=	
	(1) ***BMIchange***	**(2)** ***Feel***
Mediated Path for *MediatedVar* (*Dep. Var. = MediatedVar or GoalW6-8*)		
p(*Goal5W→MediatedVar*)	0.186***	-0.026
	(0.071)	(0.083)
p(*G_I→Goal5W*)*p(*Goal5W→MediatedVar*)	0.035*	-0.006
	(0.022)	(0.018)
p(*G_You→Goal5W*)*p(*Goal5W→MediatedVar*)	0.023	-0.003
	(0.019)	(0.011)
p(*G_I.Eff→Goal5W*)*p(*Goal5W→MediatedVar*)	0.028	-0.004
	(0.020)	(0.012)
p(*G_You.Eff→Goal5W*)*p(*Goal5W→MediatedVar*)	0.035*	-0.003
	(0.022)	(0.011)
p(*MediatedVar→GoalW6-8*)	0.095**	0.008
	(0.043)	(0.051)
Total Mediated Path for *MediatedVar* (*Dep. Var. = GoalW6-8*)		
p(*G_I→Goal5W*)*p(*Goal5W→MediatedVar*) *p(*MediatedVar→GoalW6-8*)	0.003	0.000
	(0.003)	(0.000)
p(*G_You→Goal5W*)*p(*Goal5W→MediatedVar*) *p(*MediatedVar→GoalW6-8*)	0.002	0.000
	(0.002)	(0.000)
p(*G_I.Eff→Goal5W*)*p(*Goal5W→MediatedVar*) *p(*MediatedVar→GoalW6-8*)	0.003	0.000
	(0.002)	(0.000)
p(*G_You.Eff→Goal5W*)*p(*Goal5W→MediatedVar*) *p(*MediatedVar→GoalW6-8*)	0.003	0.000
	(0.003)	(0.000)
Total Path (*Dep. Var. = GoalW6-8*)		
p(*G_I→Goal5W*)*p(*Goal5W→GoalW6-8*) + p(*G_I→Goal5W*)*p(*Goal5W→MediatedVar*)	0.076	0.116

*p(*MediatedVar*→*GoalW6-8*) + p(*G_I*→*GoalW6-8*)		
	(0.093)	(0.106)
p(*G_You*→*Goal5W*)*p(*Goal5W*→*GoalW6-8*)		
+ p(*G_I*→*Goal5W*)*p(*Goal5W*→*MediatedVar*)	0.078	0.077
*p(*MediatedVar*→*GoalW6-8*) + p(*G_I*→*GoalW6-8*)		
	(0.093)	(0.108)
p(*G_I.Eff*→*Goal5W*)*p(*Goal5W*→*GoalW6-8*)		
+ p(*G_I*→*Goal5W*)*p(*Goal5W*→*MediatedVar*)	0.101	0.096
*p(*MediatedVar*→*GoalW6-8*) + p(*G_I*→*GoalW6-8*)		
	(0.093)	(0.107)
p(*G_You.Eff*→*Goal5W*)*p(*Goal5W*→*GoalW6-8*)		
+ p(*G_I*→*Goal5W*)*p(*Goal5W*→*MediatedVar*)	0.003	-0.060
*p(*MediatedVar*→*GoalW6-8*) + p(*G_I*→*GoalW6-8*)		
	(0.093)	(0.109)
Number of Observations	181	140

Notes. This is a structure equation model. For sense variables, we use data from Week 5 to study whether messages affect goal achievement in Weeks 6 to 8 through the path of sense proxies of Week 5. OIM Standard errors are shown in parentheses.

**p < 0.10; **p < 0.05; ***p < 0.01, two-tailed.*