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Impact of a Regulatory Fit Motivational Virtual Coach on Users during Physical Activity

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Abstract

Introduction: Despite the well-known benefits of physical activity, inactivity remains a challenge. Current technologies, through motivational messages, attempt to address this but often overlook individual differences. *Objective*: To assess the influence of a user's motivational profile on the effectiveness of messages from a virtual coach during exercise. *Method*: 67 participants completed two stepping sessions. A virtual coach provided them with motivational messages, tailored or not to their profile, using vocal and facial expressions. *Results*: The coach's presence did not change overall activity. However, prevention-oriented participants were more responsive to a tailored coach, increasing their activity, and less efficient with a mismatched coach. Intrinsic motivation was pivotal, especially with a promotion agent. *Conclusion*: Personalizing multimodal feedback from a virtual agent proves beneficial. The effect hinges on the user's profile and personality, key elements for physical activity support tools.

Keywords

Regulatory Focus, Virtual Coach, Motivation, Motivational Message

1. Introduction

The benefits of regular physical activity are well-established, with research showing that it can have both preventative and curative effects, improve quality of life, and provide pleasure (Cekin, 2015). However, sedentary lifestyles are becoming increasingly prevalent, with lack of motivation, fatigue, and fear of movement among older adults or those with disabilities being major contribut-

ing factors (Bethancourt et al., 2014).

To address this issue, various interventions have been developed to promote physical activity, such as using mental simulation to help individuals envision themselves engaging in the activity (Meslot et al., 2016), or utilizing motivational interviewing techniques (Kanaoka & Mutlu, 2015). Tailored health messages have also been shown to be effective in encouraging physical activity (Martinez et al., 2013). However, these studies often rely on self-reported measures of behavioral intentions rather than actual behavior change and tend to focus on demographic characteristics rather than the psychological profile of the individual (Gellert et al., 2014).

Research suggests that motivation plays a significant role not only in performance but also in engagement, continuation, and completion of physical activity (Perski et al., 2017). Therefore, understanding the motivational profiles and strategies of individuals is a promising approach to promoting physical activity. The objective of our research is to expand the knowledge of psychological factors that should be considered in the design of technologies, specifically virtual coaches, to promote physical activity. Specifically, we aim to assess the impact of motivational messages displayed by a virtual coach on an individual's motivation and commitment to continue physical activity, with a focus on messages that are better tailored to the user's profile to impact physical activity continuation.

2. Conceptual Background and Hypothesis

2.1. Regulatory Focus Theory (RFT)

Regulatory Focus Theory (RFT) is a theoretical framework developed by Higgins (Higgins, 1997) that explains motivation as a result of self-regulation processes that are aimed at achieving a desired end state. The theory postulates the existence of two distinct and independent self-regulatory guidance systems: promotion focus, which is oriented towards advancement and progress, and prevention focus, which is oriented towards safety and security (Scholer & Higgins, 2011).

According to RFT, individuals have a chronic regulatory focus, which refers to a tendency to prefer one self-regulatory guidance system over the other. However, this preference can change depending on the specific situation or through experimental manipulation (situational regulatory focus) (Shah et al., 1998). The theory also suggests that the motivational strategy can be influenced by environmental factors (Higgins, 2000).

2.2. Regulatory Fit and Its Impact

Regulatory fit theory (RFT) proposes that the match or mismatch between an individual's motivational strategy and the means used to achieve the objective can influence their motivation (Higgins, 2000). When the match is adequate, it produces a state called regulatory fit, which induces in the individual a sense of truth about the objective pursued. A meta-analysis by Motyka et al. (Motyka et al., 2014) found that more than a hundred articles report a strong impact of regulatory fit on people's assessment, intention and behaviour in various fields such

as persuasion (e.g. Lee & Aaker, 2004), consumer purchasing behavior (e.g. Avnet & Higgins, 2003) and health issues(e.g. Rothman et al., 2006).

2.3. Previous Research on Physical Activity and Sport Using RFT

Previous research on the use of Regulatory Focus Theory (RFT) in the field of physical activity and sport has primarily focused on analyzing the links between performance and motivational strategies through different types of instructions or messages. According to a meta-analysis by Motyka et al. (Motyka et al., 2014), studies have supported the hypothesis that a simple, non-personalized message is not sufficient to optimize performance and that an understanding of an individual's motivational orientation is necessary. However, relatively few studies have been conducted under actual practice conditions.

Studies by Latimer et al. (Latimer et al., 2008) and Plessner et al. (Plessner et al., 2009) have shown positive effects of regulatory fit on physical activity performance, but other studies, such as those by Daryanto et al. (Daryanto et al., 2010) and Martinez et al. (Martinez et al., 2013), have yielded mixed results (for a review see Ludolph & Schulz, 2015). A major limitation of these studies is that they often rely on self-reported data, which is prone to errors such as memory bias and social desirability bias (Kay & Grimm, 2017). Additionally, many studies have focused on measuring the impact of regulatory fit on intentions to engage in physical activity rather than on actual behavior change (Pfeffer, 2013).

Despite mixed results, the meta-analysis by Motyka et al. (Motyka et al., 2014) revealed the importance of certain methodological factors, such as a greater effect of regulatory fit on behavior when the experiment is based on an individual's chronic regulatory focus rather than an experimentally induced strategy. However, few researchers have examined the relationship between regulatory focus and the different forms of motivation proposed by Self-Determination Theory (SDT). Further research is needed to fully understand the potential of RFT in promoting physical activity and to identify effective strategies for different individuals based on their motivational orientations.

SDT, proposed by Deci and Ryan (Deci & Ryan, 1985), suggests that motivation is not simply a quantitative concept, but one that can be qualitatively distinguished into different forms. According to SDT, motivation is driven by the satisfaction of three fundamental needs: autonomy, competence, and relatedness (Baumeister & Leary, 1995; Hui et al., 2013) observed a relationship between these fundamental needs and regulatory focus, with promotion-focused individuals placing a greater emphasis on autonomy.

Furthermore, Lalot, Quiamzade, & Zerhouni (Lalot et al., 2019) suggested that there may be an interaction between intrinsic and extrinsic motivations, and message framing (promotion versus prevention). Prevention-oriented individuals may be more sensitive to obligations and duties and thus may respond better to normative pressure and the need for social acceptance. Similarly, promotion-oriented individuals may be more motivated by the desire to achieve one's ideal self, or the need for accomplishment.

In the context of physical activity, Laroche, Roussel, Cury, & Boiché (Laroche et al., 2019) observed similar results, with intrinsic motivations being more effective than extrinsic motivations, regardless of the induced regulatory focus. To fully understand the potential of RFT in promoting physical activity, further research is needed to identify effective strategies for different individuals based on their motivational orientations.

2.4. Research on Virtual Coaching and Its Impact on Health Behavior

Lastly, research in computer science has explored virtual coaching and more particularly the design and contribution of virtual coaches to support individuals in their behaviour change. Kamali et al. (Kamali et al., 2020) presented a systematic review of virtual coaches specifically aimed at improving or maintaining older adults' health. They report promising benefits of applying virtual trainers to promote health behaviour (Luerssen & Hawke, 2018) but also reported the lack of rigorous evaluations. They also observed a lack of consensus regarding the definition of virtual coach and noted the diversity of theoretical frameworks that are used to design e-coaching interventions.

The feedback provided by these systems is also the subject of much research. Several meta-analyses have noted the importance of the underlying theoretical context in designing motivational messages, particularly messages targeting affective attitudes, self-efficacy, and self-regulation (Op den Akker et al., 2015).

In a research on the impact of motivational messages also focusing on virtual coaches, Lucas, Krämer, Peters, Mell and Gratch (Lucas et al., 2018) measured the performance of 212 participants during a fitness bike session in a laboratory experiment. The same positive or negative motivational messages were communicated by a real coach via Skype, a virtual coach, or an avatar. They concluded that the greater the coach's behavioural realism, the more the negative messages are accepted, or even lead to more physical effort than positive messages.

2.5. Objectives of the Current Study and Its Potential Contribution to the Field

The current study aims to investigate the relationship between regulatory focus and motivation in the context of virtual coaching for physical activity. We evaluate the impact of personalized messages delivered by a virtual coach during physical activity and examine the relationship between regulatory focus and motivation. By doing so, we hope to gain a deeper understanding of how virtual coaching can be optimized to suit different individuals based on their motivational orientations. Our specific hypotheses are:

H1: Interventions that include messages framed in terms of promotion versus prevention delivered by a virtual coach will increase engagement and continuation in physical exercise, particularly when the intervention aligns with the participant's regulatory focus.

H2: Individuals with a high level of self-determined motivation will persist more

in physical exercise than those with a low level of self-determined motivation.

H3: Promotion-oriented participants with high levels of intrinsic motivation will be less affected by the fit effect compared to prevention-oriented participants.

H4: The effectiveness of messages framed in terms of promotion versus prevention will depend on the individual's intrinsic and extrinsic motivation for physical activity and regulatory focus profile, with a positive influence on persistence in physical activity for those with high promotion and intrinsic motivation scores, particularly when interacting with a promotion-oriented agent.

3. Method

3.1. Participants

The sample for this study consisted of 69 adults (25 women and 44 men) with an average age of 35.2 years (ranging from 18 to 61 years). In terms of body composition, the average body mass index (BMI) for participants was 23.3, which falls within the normal range (BMI 18.5 to 25). The sample represented a range of body compositions, including normal, underweight, and overweight, but excluded individuals with anorexia or morbid obesity.

3.2. Protocol

The study was conducted in a laboratory setting and consisted of two phases. The initial phase entailed administering a battery of self-report measures to determine the regulatory focus orientation, motivational state, and physical activity level of each participant.

In the second phase, participants performed two sessions of physical activity on a stepper, with a break in between to allow for rest. The first session was the same for all participants and was a controlled trial. The task was to take as many steps as possible, with a maximum of 1500 steps. Participants' progress was tracked using a connected watch, and feedback (the achieved number of steps) was displayed every 65 seconds on a computer screen facing the participant (Figure 1).
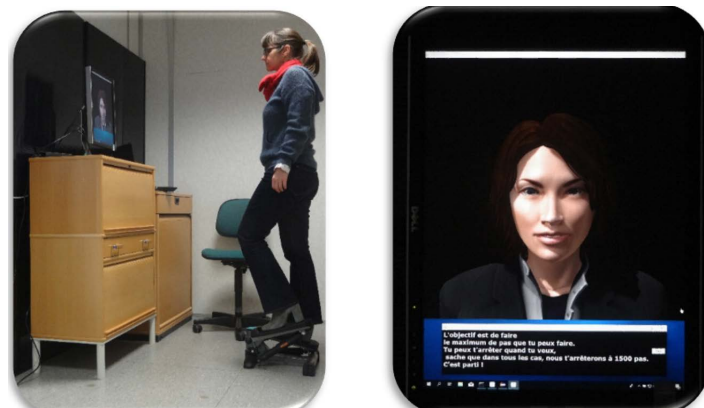

Figure 1. Experimental setup.

The second session was the experimental trial. Participants were randomly assigned to one of three conditions: Fit, NoFit, or Control. In the *Fit condition*, participants received personalized motivational messages that aligned with their regulatory focus orientation (promotion or prevention). In the *NoFit condition*, participants received non-personalized motivational messages that did not align with their regulatory focus orientation. In the *Control condition*, participants received no motivational messages.

In the *Fit* and *NoFit* conditions, a virtual coach was displayed on a screen in front of the participant and remained present throughout the exercise. The virtual coach communicated motivational messages designed to fit either the Promotion or Prevention profile of the participant. The messages were formulated in a positive form for promotion-oriented participants, focusing on the goal as the desired end state, self-esteem, and accessibility of the goal. This translates into messages such as: "*You have taken x steps. Keep up the good work!*" or "*Step by step, you will reach your goal, be brave, you have everything to go far*" or "*Nothing is impossible with a valiant heart, it's time to give it your all*". For prevention-oriented participants, messages focused on avoiding an undesired end state, not deviating from the goal, effective behavior, and a sense of duty. This translates into messages such as: "*You have taken x steps, keep this attitude and there is no reason for you to fail*", or "*Continue like this, you must not slacken your efforts*", "*Congratulations, by continuing like this, you will preserve your achievements*". During this second experimental trial, the task was also to take as many steps as possible, with a maximum of 1500 steps. Participants' progress was always tracked using a connected watch. Feedback was provided on a computer screen every 65 seconds according to the experimental condition.

After the second session, participants completed a final questionnaire to assess their perception of the virtual coach (if applicable). Data were collected and analysed to examine the impact of personalized messages on engagement and continuation in physical exercise, and the relationship between regulatory focus and motivation.

3.3. Measures

Behavioral measures. We recorded the number of steps and the duration of the exercise for each participant and each session. We also computed cadence (walking rate in steps per minute) by dividing the number of steps by the duration of the exercise and analyzed the change in this ratio between the two sessions (control trial and experimental trial).

Psychological measures. All predictor variables were assessed prior to the second phase. Participants completed two self-report questionnaires and provided responses to several demographic and physical activity-related questions. The Regulatory Focus Questionnaire—Proverbs Form (RFQ-PF, Faur et al., 2017) was utilized to measure chronic regulatory focus, and the 28-item General Motivation Scale (EMG-28; Guay et al., 2003) was used to evaluate participants'

motivation levels. This scale is composed of 7 dimensions that characterize various types of motivation, ranging from intrinsic motivation to amotivation.

4. Results

In this section, we present the results of our study. We examined the distribution of our data and found that the Kolmogorov-Smirnov tests supported the assumption of normality ($p > 0.05$). We then conducted an ANOVA to test hypothesis H1 and linear regression to explore hypotheses H2 to H5. For all analyses, we report the significance level ($p < 0.05$) and effect size, as measured by eta-squared (η^2) and R-squared (R^2). In addition, in order to comply with APA standards, we report the means, standard deviations, and sample sizes for each group in the tables.

4.1. The Impact of Virtual Coaching on Cadence

To examine the overall impact of the virtual coach on physical effort, we compared the average cadence for each experimental condition. Results indicated a significant increase in the average step-to-time ratio between the two sessions regardless of the condition ($F(1, 66) = 59.924$, $p < 0.00001$, $\eta^2 = 0.476$). However, there was no significant difference in the change in the cadence between the experimental conditions ($F(2, 64) = 0.97041$, $p = 0.38443$). These findings suggest that the mere display of a virtual coach and motivational messages did not lead to greater physical exertion when they were not tailored to the participant's profile. Additionally, there was no significant interaction effect between the virtual agent's characteristics and the participant's profile on the change in cadence ($F(2, 61) = 1.2889$, $p = 0.28297$).

Independent-sample T-tests were conducted, and results, presented in **Figure 2**, revealed a trending effect among participants with the Prevention profile in
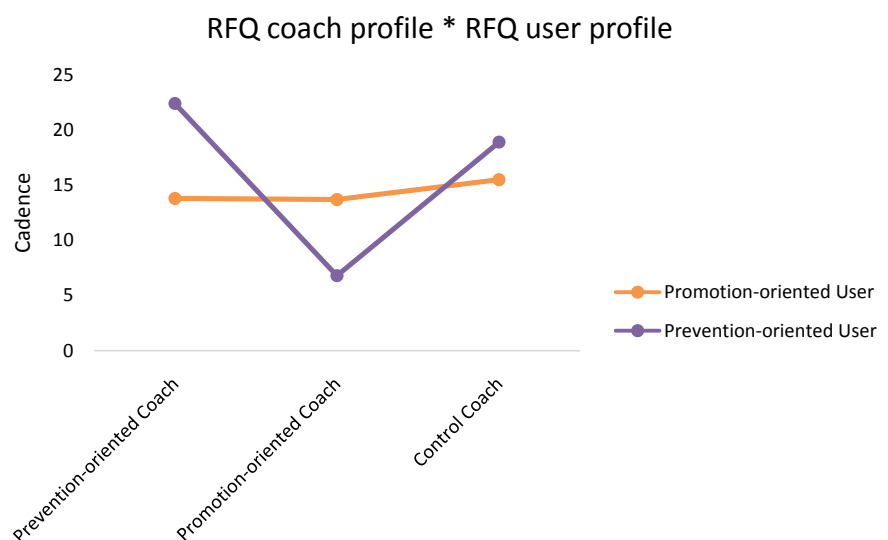
Figure 2. Relation between Cadence (walking rate), the profiles of the user and the profile of the coach.

the *NoFit* condition compared to the *Fit* condition ($t(15) = 1.75759$, $p = 0.099$) and the *Control* condition ($t(14) = -1.76835$, $p = 0.099$). However, no significant effects were observed for the Promotion profile. Among participants with a Promotion profile, performance progression was similar across the three conditions.

4.2. Relationship between Participants' Regulatory Focus and Change in Cadence across Sessions

A linear regression was conducted to examine the relationship between promotion scale scores and changes in cadence across sessions. Results showed that there was a significant positive correlation between the promotion scores of participants and changes in cadence when subjects were in the Fit condition and interacted with a promotion-oriented virtual coach ($F(2.21) = 7.02$, $p < 0.015$; Adjusted $R^2 = 0.216$). This suggests that as the promotion scores of participants increase, the cadence also increases across sessions (beta adjusted = 9.25). Additionally, a significant linear regression was found when participants had high prevention scale scores and were in the Fit condition, interacting with a prevention-oriented virtual coach ($F(1, 22) = 4.41$, $p < 0.047$, adjusted $R^2 = 0.167$). In this condition, the higher the prevention scale score of participants, the greater the increase in cadence across sessions (beta adjusted = 10.19).

These results align with our H1 hypothesis, revealing a correlation between the virtual coach's profile and the agent's profile. This correlation varies depending on the participant's promotion or prevention profile. The results only partially support H1, indicating that there is no main effect of fit on cadence across sessions. However, the results also suggest that prevention-oriented participants are more sensitive to the alignment of the virtual coach's profile with their own profile, compared to promotion-oriented participants. Linear regressions further demonstrate that the greater the alignment between the participant's and virtual coach's profile, the more significant the change in cadence.

4.3. Correlation between Forms of Motivation and Change in Cadence across Sessions

In order to examine the relationship between different forms of motivation and the change in the cadence across sessions, simple linear regression analyses were conducted. Results revealed that *intrinsic motivation to know* (IM-to know) did not have a significant effect on the change in the ratio, regardless of the experimental condition.

Furthermore, results revealed that *intrinsic motivation to accomplish things* (IM-to accomplish) was found to have a significant linear relationship with the change in cadence across sessions, as evidenced by a regression equation of $F(1, 65) = 7.93$, $p < 0.0064$, and an adjusted $R^2 = 0.095$. This relationship was observed across all groups and indicated that a higher score in *IM-to accomplish* was associated with a greater positive change in the ratio between sessions.

However, when the relationship was examined separately for each experi-

mental condition, it was found to be only statistically significant in the *Fit condition* ($F(1, 22) = 5.61$, $p < 0.027$, adjusted $R^2 = 0.167$) and not in the *Control* or *No Fit conditions*.

No significant relationships were found between the change in cadence and intrinsic motivation to experience stimulation, extrinsic motivation, or amotivation.

These results support our H2 hypothesis, which posits that individuals with a high level of self-determined motivation will exhibit greater persistence in physical exercise than those with a low level of self-determined motivation. Furthermore, the data revealed that intrinsic motivation to accomplish things is specifically related to the evolution of the cadence between the two sessions. These findings contribute to a deeper understanding of the relationship between motivation and persistence in physical exercise.

4.4. Correlation between Motivation and Regulatory Focus

As expected, correlations were observed between regulatory orientation and motivational profile. The higher the subjects' scores in promotion, the higher their scores in intrinsic motivation to know (IM-to know) ($r(65) = 0.29$; $p < 0.05$), intrinsic motivation toward accomplishments (IM-to accomplish things) ($r(65) = 0.44$; $p < 0.05$), intrinsic motivation to experience stimulation (IM-to experience stimulation) ($r(65) = 0.44$; $p < 0.05$), and identified extrinsic motivation ($r(65) = 0.29$; $p < 0.05$). For prevention-oriented participants, it was found that the higher the participant's score in prevention, the higher the score for amotivation ($r(65) = 0.26$; $p < 0.05$), extrinsic introjected motivation ($r(65) = 0.33$; $p < 0.05$) and IM-to experience stimulation ($r(65) = 0.26$; $p < 0.05$).

These correlations vary according to context, i.e., the type of agent: promotion versus prevention, or the level of adaptation of the agent's profile to the user's profile: Fit versus NoFit.

A positive correlation was observed between the promotion scale score and intrinsic motivation (IM-to-know, $r(21) = 0.54$, $p < 0.05$; IM-to-accomplish things, $r(21) = 0.66$, $p < 0.05$) when participants interacted with a *promotion-oriented virtual coach*. Additionally, a positive correlation was observed between the prevention scale score and extrinsic motivation with introjected regulation ($r(21) = 0.57$, $p < 0.05$). These results suggest that as the promotion score increased, so did the intrinsic motivation score. Conversely, as the prevention score increased, the extrinsic motivation score with introjected regulation also increased.

When participants interacted with a *prevention-oriented virtual coach*, a correlation was observed between the score of the participant on the prevention scale and the IM-to-know ($r(21) = 0.43$; $p < 0.05$), the IM-to-accomplish things ($r(21) = 0.42$; $p < 0.05$), and IM-to-experience stimulation ($r(21) = 0.58$; $p < 0.05$), as well as with amotivation ($r(21) = 0.43$; $p < 0.05$). Results indicate that the higher the prevention score, the higher the score for intrinsic motivation and

amotivation. Additionally, a correlation was found between the promotion score and IM-to-experience stimulation ($r(21) = 0.54$; $p < 0.05$). Thus, when participants interacted with a prevention-oriented virtual coach, the higher their promotion score, the higher their intrinsic motivation to experience stimulation.

In the Fit condition, i.e., when participants interacted with a virtual coach which displayed motivational messages adapted to their profile, we observed significant positive correlations between the prevention score and the scores of intrinsic motivation to know ($r(22) = 0.53$; $p < 0.05$), to accomplish things ($r(22) = 0.48$; $p < 0.05$), and to experience stimulation ($r(22) = 0.50$; $p < 0.05$). These results indicate that as the prevention score increased, the intrinsic motivation score also increased.

In the NoFIT condition, i.e., when participants interacted with a virtual coach which displayed motivational messages not adapted to their profile, we observed significant positive correlations between the promotion score and the scores of intrinsic motivation-to know ($r(20) = 0.46$ $p < 0.05$), to accomplish things ($r(20) = 0.81$; $p < 0.05$), to experience stimulation ($r(20) = 0.54$; $p < 0.05$). These results suggest that as the promotion score increased, the intrinsic motivation score also increased. Additionally, there is a significant positive correlation between the prevention score and extrinsic motivation with introjected regulation ($r(20) = 0.48$, $p < 0.05$).

These results partially confirm hypotheses H3 and H4. In the presence of a promotion agent, there is a correlation between the participant's promotion score and their intrinsic motivation to know and accomplish things. Similarly, in the presence of a prevention agent, there is a correlation between the participant's prevention score and their intrinsic motivation or amotivation. However, this correlation between the participant's focus and motivation varies depending on context. In the *Fit condition*, there was a correlation between the prevention score and intrinsic motivation. In the *NoFit condition*, there was a correlation between the promotion score and intrinsic motivation. This seems to suggest that the effectiveness of framed messages in terms of promotion or prevention depends on the individual's intrinsic and extrinsic motivation profile for physical activity and their regulatory focus. However, these results do not show any link with the change in cadence.

4.5. Correlation between Cadence, Motivation and Regulatory Focus

The results partially support the hypothesis that there is a correlation between cadence, and motivation, and regulatory focus. In the *Fit condition*, significant correlations were observed between cadence and prevention score ($r(22) = 0.41$, $p < 0.05$) as well as intrinsic motivation to accomplish score ($r(22) = 0.45$, $p < 0.05$). Participants who interacted with a virtual coach adapted to their profile demonstrated an increase in cadence between the two sessions, with higher scores in prevention or intrinsic motivation to accomplish being positively correlated with a higher cadence.

However, in the *NoFit condition*, there was no significant correlation between cadence and either motivation or profile. Additionally, no significant correlation was found in the *Control condition*, indicating no link between cadence and the participants' motivational profile or regulatory focus.

Thus, the impact of a prevention or promotion-framed message depends on the individual's intrinsic and extrinsic motivation for physical activity and their regulatory focus. However, these results do not reveal any relationship with cadence.

5. Discussion

The purpose of this study was to investigate the relationship between regulatory focus and motivation, and their impact on users' physical activity. We also wanted to assess how a virtual coach can influence users' performance. We combined two widely used theories in health psychology, the Regulatory Focus Theory and the Self-Determination Theory. We hypothesized that there would be a fit between regulatory orientation and motivation forms. Our findings partially support this hypothesis.

We first tested whether a virtual coach providing motivational feedback during an exercise would improve participants' performance. Contrary to our expectations, our results did not show any significant improvement in performance between participants with and without the virtual coach. However, we observed that the participants' cadence increased significantly for all participants between the 1st and 2nd exercise, regardless of the presence of a virtual coach.

Our results are consistent with previous research, suggesting that individuals with a promotion focus are less sensitive to external elements that modify their behaviour, and those with a prevention focus are more sensitive to external elements that modify their behaviour (as expected, these participants were more sensitive to the context). Our results also confirm the results of other studies in the field of physical activity and sport (Motyka et al., 2014; Plessner et al., 2009; Daryanto et al., 2010) which underline that the effectiveness of the motivational messages depends on the adequacy between the user profile and the content of the message. These motivational messages do not need to be positive to be effective. Additionally, our findings suggest that intrinsic motivation impacts cadence more than promotion-oriented messages. This raises questions about the design of our promotion-oriented messages, indicating that they may not be perceived as promotional enough by our participants.

The study we presented in this article displays some limitations, such as measuring the level of motivation using self-reported responses, and the number of steps, which might not be the most accurate indicators of motivation. In addition, this study was conducted in a laboratory setting, so it is unclear how well the results would generalize to real-world situations. Future research should focus on studying the long-term effects of virtual coaches on physical activity and consider the potential influence of the virtual agent's appearance and gender.

6. Conclusion

In conclusion, this study provides valuable insight into how regulatory focus and motivation impact users' physical activity. It underscores the importance of aligning the feedback provided by a virtual coach with the user's regulatory orientation to maximize the effectiveness of an intervention. While our current findings have set a foundation, more nuanced explorations are essential to better understand the multifaceted relationship between regulatory orientation, motivation, and physical activity. As technology and health psychology continue to intersect, future studies may look at diversifying the virtual coaching methods and tailoring interventions to individual profiles more comprehensively, thereby enhancing the effectiveness of virtual coaching in promoting physical activity and overall well-being.

Ethical Considerations

All procedures involving human participants were carried out in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the ethics committee of Université Paris Saclay under reference CER-Paris-Saclay-2018-037.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Avnet, T., & Higgins, E. T. (2003). Locomotion, Assessment, and Regulatory Fit: Value Transfer from "How" to "What". *Journal of Experimental Social Psychology, 39,* 525-530. https://doi.org/10.1016/S0022-1031(03)00027-1

Baumeister, R. F., & Leary, M. R. (1995). The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. *Psychological Bulletin, 117,* 497-529. https://doi.org/10.1037/0033-2909.117.3.497

Bethancourt, H. J., Rosenberg, D. E., Beatty, T., & Arterburn, D. E. (2014). Barriers to and Facilitators of Physical Activity Program Use among Older Adults. *Clinical Medicine & Research, 12,* 10-20. https://doi.org/10.3121/cmr.2013.1171

Cekin, R. (2015). Psychological Benefits of Regular Physical Activity: Evidence from Emerging Adults. *Universal Journal of Educational Research, 3,* 710-717. https://doi.org/10.13189/ujer.2015.031008

Daryanto, A., de Ruyter, K., Wetzels, M., & Patterson, P. G. (2010). Service Firms and Customer Loyalty Programs: A Regulatory Fit Perspective of Reward Preferences in a Health Club Setting. *Journal of the Academy of Marketing Science, 38,* 604-616. https://doi.org/10.1007/s11747-009-0165-x

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. Plenum. https://doi.org/10.1007/978-1-4899-2271-7

Faur, C., Martin, J.-C., & Clavel, C. (2017). Measuring Chronic Regulatory Focus with Proverbs: The Developmental and Psychometric Properties of a French Scale. *Journal*

of Personality and Individual Differences, 107, 137-145.
https://doi.org/10.1016/j.paid.2016.11.037

Gellert, P., Ziegelmann, J. P., Krupka, S., Knoll, N., & Schwarzer, R. (2014). An Age-Tailored Intervention Sustains Physical Activity Changes in Older Adults: A Randomized Controlled Trial. *International Journal of Behavioral Medicine, 21,* 519-528.
https://doi.org/10.1007/s12529-013-9330-1

Guay, F., Mageau, G., & Vallerand, R. J. (2003). On the Hierarchical Structure of Self-Determined Motivation: A Test of Top-Down and Bottom-Up Effects. *Personality and Social Psychology Bulletin, 29,* 992-1004.
https://doi.org/10.1177/0146167203253297

Higgins, E. T. (1997). Beyond Pleasure and Pain. *American Psychologist, 52,* 1280-1300.
https://doi.org/10.1037/0003-066X.52.12.1280

Higgins, E. T. (2000). Making a Good Decision: Value from Fit. *American Psychologist, 55,* 1217-1230. https://doi.org/10.1037/0003-066X.55.11.1217

Hui, C. M., Molden, D. C., & Finkel, E. J. (2013). Loving Freedom: Concerns with Promotion or Prevention and the Role of Autonomy in Relationship Well-Being. *Journal of Personality and Social Psychology, 105,* 61-85. https://doi.org/10.1037/a0032503

Kamali, M. E., Angelini, L., Caon, M., Carrino, F., Rocke, C., Guye, S., Rizzo, G., Mastropietro, A., Sykora, M., Elayan, S,. Kniestedt, I. Ziylan, C., Lettieri, E., Khaled, O., & Mugellini, E., (2020). Virtual Coaches for Older Adults' Wellbeing: A Systematic Review. *IEEE Access, 8,* 101884-101902. https://doi.org/10.1109/ACCESS.2020.2996404

Kanaoka, T., & Mutlu, B. (2015). Designing a Motivational Agent for Behavior Change in Physical Activity. In *CHI EA '15: Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 1445-1450). Association for Computing Machinery. https://doi.org/10.1145/2702613.2732924

Kay, S. A., & Grimm, L. R. (2017). Regulatory Fit Improves Fitness for People with Low Exercise Experience. *Journal of Sport & Exercise Psychology, 39,* 109-119.
https://doi.org/10.1123/jsep.2016-0274

Lalot, F., Quiamzade, A., & Zerhouni, O. (2019). Regulatory Focus and Self-Determination Motives Interact to Predict Students' Nutrition-Habit Intentions. *Journal of Experimental Psychology. Applied, 25,* 477-490.
https://doi.org/10.1037/xap0000196

Laroche, M., Roussel, P., Cury, F., & Boiché, J. (2019). Understanding Physical Activity Practice in Health Context through Regulatory Focus and Self-Determination Theories. *PLOS ONE, 14,* e0216760. https://doi.org/10.1371/journal.pone.0216760

Latimer, A. E., Rivers, S. E., Rench, T. A., Katulak, N. A., Hicks, A., Hodorowski, J. K., Higgins, E. T., & Salovey, P. (2008). A Field Experiment Testing the Utility of Regulatory Fit Messages for Promoting Physical Activity. *Journal of Experimental Social Psychology, 44,* 826-832. https://doi.org/10.1016/j.jesp.2007.07.013

Lee, A. Y., & Aaker, J. L. (2004). Bringing the Frame into Focus: The Influence of Regulatory Fit on Processing Fluency and Persuasion. *Journal of Personality and Social Psychology, 86,* 205-218. https://doi.org/10.1037/0022-3514.86.2.205

Lucas, G. M., Krämer, N., Peters, C., Taesch, L. S., Mell, J., & Gratch, J. (2018). Effects of Perceived Agency and Message Tone in Responding to a Virtual Personal Trainer. In *IVA '18: Proceedings of the 18th International Conference on Intelligent Virtual Agents* (pp. 247-254). Association for Computing Machinery.
https://doi.org/10.1145/3267851.3267855

Ludolph, R., & Schulz, P. J. (2015). Does Regulatory Fit Lead to More Effective Health Communication? A Systematic Review. *Social Science and Medicine, 128,* 142-150.

https://doi.org/10.1016/j.socscimed.2015.01.021

Luerssen, M. H., & Hawke, T. (2018). Virtual Agents as a Service: Applications in Healthcare. In *Proceedings of the 18th International Conference on Intelligent Virtual Agents* (pp. 107-112). Association for Computing Machinery. https://doi.org/10.1145/3267851.3267858

Martinez, J. L., Duncan, L. R., Rivers, S. E., Latimer, A. E., & Salovey, P. (2013). Examining the Use of Message Tailoring to Promote Physical Activity among Medically Underserved Adults. *Journal of Health Psychology, 18,* 470-476. https://doi.org/10.1177/1359105312445798

Meslot, C., Gauchet, A., Allenet, B., François, O., & Hagger, M. S. (2016). Theory-Based Interventions Combining Mental Simulation and Planning Techniques to Improve Physical Activity: Null Results from Two Randomized Controlled Trials. *Frontiers in Psychology, 7,* Article 1789. https://doi.org/10.3389/fpsyg.2016.01789

Motyka, S., Grewal, D., Puccinelli, N. M., Roggeveen, A. L., Avnet, T., Daryanto, A., de Ruyter, K., & Wetzels, M. (2014). Regulatory Fit: A Meta-Analytic Synthesis. *Journal of Consumer Psychology, 24,* 394-410. https://doi.org/10.1016/j.jcps.2013.11.004

Op den Akker, H., Cabrita, M., op den Akker, R., Jones, V. M., & Hermens, H. J. (2015). Tailored Motivational Message Generation: A Model and Practical Framework for Real-Time Physical Activity Coaching. *Journal of Biomedical Informatics, 55,* 104-115. https://doi.org/10.1016/j.jbi.2015.03.005

Perski, O., Blandford, A., West, R., & Michie, S. (2017). Conceptualising Engagement with Digital Behaviour Change Interventions: A Systematic Review Using Principles from Critical Interpretive Synthesis. *Translational Behavioral Medicine, 7,* 254-267. https://doi.org/10.1007/s13142-016-0453-1

Pfeffer, I. (2013). Regulatory Fit Messages and Physical Activity Motivation. *Journal of Sport and Exercise Psychology, 35,* 119-131. https://doi.org/10.1123/jsep.35.2.119

Plessner, H., Unkelbach, C., Memmert, D., Baltes, A., & Kolb, A. (2009). Regulatory Fit as a Determinant of Sport Performance: How to Succeed in a Soccer Penalty-Shooting. *Psychology of Sport and Exercise, 10,* 108-115. https://doi.org/10.1016/j.psychsport.2008.02.001

Rothman, A. J., Bartels, R. D., Wlaschin, J., & Salovey, P. (2006). The Strategic Use of Gain- and Loss-Framed Messages to Promote Healthy Behavior: How Theory Can Inform Practice. *Journal of Communication, 56,* S202-S220. https://doi.org/10.1111/j.1460-2466.2006.00290.x

Scholer, A., & Higgins, E. T. (2011). Promotion and Prevention Systems: Regulatory Focus Dynamics within Self-Regulatory Hierarchies. In K. D. Vohs, & R. F. Baumeister (Eds.), *Self-Regulation: Research, Theory, and Applications* (pp. 143-161). Guilford Press.

Shah, J., Higgins, E. T., & Friedman, R. S. (1998). Performance Incentives and Means: How Regulatory Focus Influences Goal Attainment. *Journal of Personality and Social Psychology, 74,* 285-293. https://doi.org/10.1037/0022-3514.74.2.285