Transtheoretical Model for Designing Technologies Supporting an Active Lifestyle

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ABSTRACT
There has been considerable research on methods of fostering behavioral change towards a healthy lifestyle. However, enabling this change to be consistent and long-standing remains an open challenge. In this paper, we explore how the design of persuasive technologies supporting a physically active lifestyle can be oriented by psychological theories of behavior change and motivation, specifically the Transtheoretical Model of Behavior Change (TTM) and Self-Determination Theory (SDT). In this study, we explore the relationships between participants' motivation, their current stage of the TTM and how well they perform at different physical exercises related to specific body areas. Our results support previous research carried out in the exercise context and in other domains, and suggest that it would be advantageous for a mobile interface to adopt different persuasive mechanisms for users at different stages of the TTM. Finally, we explore different intervention strategies which could be implemented in each TTM stage to sustain a consistent behavioral change toward a physically active lifestyle.

Author Keywords
Transtheoretical Model of Behavior Change; Self-Determination Theory; Exercise; Active Lifestyle; Design Strategies; Mobile Technologies.

ACM Classification Keywords
H.1.2. Human Factors; H.5.2. Theory and methods; J.3. Health.

General Terms
Human Factors; Theory; Design; Measurement.

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INTRODUCTION
Recently, a well-established trend in HCI has been devoted to the design of persuasive technologies to change human behavior toward a healthy lifestyle [3, 17], self-management strategies [14, 20] and sustainable behaviors [9, 10]. However, fostering consistent and long-lasting behavioral changes remains an open challenge. Though it is well documented that physical activity can prevent different health problems [25], and despite people desiring to be healthy and fit, sedentary lifestyles and poor eating habits are still leading to serious health disorders [18].

In several application fields, such as that of exercise behavior, the design of persuasive technologies can be oriented by relevant psychological and social theories, which can suggest specific behavioral and cognitive strategies to foster the initiation of an active lifestyle and its maintenance over time. For example, Goal-Setting Theory [19] describes the impact of different types of goals and the characteristics they should have to be more effective and motivating for individuals. Presentation of Self in Everyday Life Theory [11] focuses on how people attempt to manage their impressions on others in daily social interactions, and can thus provide directions for the public presentation of personal information. Cognitive Dissonance Theory [7] addresses what happens when individuals' behaviors and attitudes are inconsistent, and can be useful to develop strategies for inducing behavioral changes.

Two of the more promising theories that have been recently widely applied to the study of persuasive technologies are the Transtheoretical Model of Behavior Change (TTM) [24] and Deci and Ryan's Self-Determination Theory (SDT) [5, 6]. The first conceptualizes behavioral change as a longitudinal process across different stages, while the second is a motivational theory describing behavioral change as a gradual process starting from amotivation (no intention to change) toward increasing levels of internal regulation, finally reaching intrinsic motivation. According to the TTM and SDT, an effective behavior change could be obtained by providing personalized feedback to people with different motivational levels or at different stages of the behavior change process. Nevertheless, most commercial technologies aiming at encouraging behavioral change use a *one-size-fits-all* approach, where all users

receive the same feedback, regardless of their different motivations and current stage of change [12]. In this paper, we show the relationship between the TTM stages, different types of motivation and the actual levels of physical activity, proposing specific design guidelines for a mobile interface that adopts different persuasive mechanisms for users at different stages of the TTM.

In the next section, we introduce the theoretical background that inspired this work, briefly describing TTM and SDT applied to exercise behavior. Then we describe FitCity, the project under which the present study has been conducted, reporting an analysis of empirical findings supporting previous research on the correlations between the stages of TTM and motivational dimensions. Finally, based on empirical findings associating different levels of physical performance to different TTM stages and motivational dimensions, we suggest the adoption of an adaptive approach for the design of a mobile application aimed at supporting a physically active lifestyle.

TRANSTHEORETICAL MODEL OF BEHAVIOR CHANGE AND SELF-DETERMINATION THEORY

The TTM [24] emphasizes behavior change as a dynamic process, in which an individual progresses through different stages to intentionally modify her/his behavior. The core of the model consists in five stages of change, which in the context of physical activity refer to the readiness or propensity to engage in regular exercise:

- *Precontemplation*: an individual in the precontemplation stage is not engaged in regular exercise and has no intention to start exercising in the future.
- *Contemplation*: a contemplator is not exercising yet but has committed to taking action and is planning to start within six months.
- *Preparation*: a person in this stage is seriously considering to start exercising and has taken some steps, although unsuccessful, toward this objective.
- *Action*: an individual in action has been exercising consistently for less than six months.
- *Maintenance*: someone in maintenance has had an active lifestyle for six months or more.

TTM addresses behavioral change as a sequential process occurring over time, but a nonlinear progression across the stages can also be possible: for instance, individuals can regress from later stages to earlier ones, or remain in the same stage without progressing further for a long time.

SDT [5, 6] focuses specifically on motivation and claims that an individual's propensity to change her/his behavior depends on the extent to which s/he in motivated to change. The theoretical framework of SDT conceptualizes motivation along a continuum starting from amotivation, where there is no intention to act, through progressively increasing levels of internal self-regulation, ending in intrinsic motivation. Amotivation refers to a lack of purpose or intention to undertake some action, and essentially consists in a lack of motivation. Extrinsic motivation refers to behaviors which are engaged not for their inherent pleasure, but to obtain some kind of reward that is external to the activity itself. Vallerand and colleagues [27] showed that there are at least three types of extrinsic motivation:

- *Extrinsic motivation – external regulation*: externally regulate behaviors are motivated by external rewards. This is the case of a person who engage in physical activity to show others s/he is in good shape.
- *Extrinsic motivation – introjected*: with introjected regulation, the person has started to internalize her/his motivation, like an athlete feeling guilty for not practicing.
- *Extrinsic motivation – identified*: as the behavior becomes progressively important for the individual, the extrinsic motivation becomes internalized. An example of internalization in the exercise context is the athlete going to practice in order to perform better during the next game.

On the other hand, intrinsic motivation pertains to an action undertaken for the inherent pleasure and satisfaction the activity itself provides. In our context, a person who is intrinsically motivated to have a physically active lifestyle will exercise regularly for the pleasure of feeling good and healthy. Similarly to extrinsic motivation, Vallerand and colleagues proposed three types of intrinsic motivations:

- *Intrinsic motivation to know*: performing a behavior for the pleasure to learn something new, like the athlete wishing to improve her/his training techniques.
- *Intrinsic motivation to accomplish*: it refers to an activity which is undertaken to reach some accomplishments, like the runner who practices for the personal satisfaction of improving her/his performance.
- *Intrinsic motivation to experience stimulation*: engaging in an activity for the deriving sensory pleasure. This is the case of a person motivated to exercise for the pleasure of feeling immersed and involved in the training.

Considering the motivational continuum, in this study we were particularly interested in intrinsic motivation to experience and to accomplish, extrinsic motivation (external regulation), and amotivation.

In the next section we describe the initial study conducted in the FitCity project, aimed at establishing connections between the aforementioned motivational constructs, the stages of the TTM, and different levels of physical performance, in order to inform the design of an adaptive mobile application aimed at promoting a healthy lifestyle based on regular exercise.

FITCITY PILOT STUDY

Fitcity is a two-years project started in January 2013 and aimed at promoting a physically active lifestyle through the use of a mobile application that integrates elements of gamification techniques [22, 28], psychological theories and peer-pressure mechanisms.

In this pilot study, we addressed two research questions. The first research question was whether earlier stages of the TTM were related to amotivation and vice versa, if more advanced stages of the TTM were associated to intrinsic motivation. The second research question was to investigate whether there was a relationship between performance at several fitness tests and the stages of the TTM and motivational dimensions.

The relationship between motivation and different stages of the TTM has been investigated by several studies in different domains. However, while some of these studies did not use a direct measurement of motivational constructs, interpreting related dimension such as physical appearance or enjoyment as extrinsic or intrinsic motivation [13], others did not measure amotivation [1], or found a relationship between SDT and TTM in domains other than exercise, such as drug abuse [16].

The association between TTM stages and physical activity levels was investigated by previous studies mainly implementing questionnaires to measure exercise behavior [15, 26]. Among those using behavioral indices of physical activity, Findorff and colleagues [8] measured exercise adoption (walking and balance exercise) in older sedentary women. Buckworth and Wallace [2] used biometric measures of physical fitness such as cardiovascular variables and maximal oxygen uptake, but focused only on the upper stages of the TTM, action and maintenance. In the current study, we contribute to the past literature by investigating the relationship between all TTM stages and SDT, and their association with participants' performance in different exercises related to specific fitness areas.

Method

During the initial design phase, we involved the participants to the project UNI.Fit, (http://www.unisport.tn.it/unifit), promoted by the University of Trento, Italy, to enhance the physical shape of its students and employees. At the beginning of the academic year, 138 UNI.Fit participants volunteered to undertake a battery of fitness tests to measure their performance in six exercises corresponding to six body areas: 1) the *Astrand* test to measure aerobic endurance, through the evaluation of cardiovascular variables and maximal oxygen uptake; 2) the *squat-wall* exercise to measure leg strength; 3) the *push-up* exercise to measure arms strength; 4) the *sit-up* exercise to measure abdominals strength; 5) the *stork* test to measure balance ability; 6) the *sit & reach* test to measure flexibility.

After the initial evaluation, participants were given a personalized training plan based on their performance on each test, and were asked to come back for a second evaluation after three months. Participants also had the possibility to access the University fitness centers and join specific training classes purposefully organized for UNI.Fit. Before the second evaluation taking place in March 2013, we surveyed participants in order to understand:

- The extent to which they thought to have been training in each body area (labeled *freq. aerobic*, *leg strength*, *arms strength*, *abdom. strength*, *balance*, *flexibility* in Table 1);
- In how many different months they had been exercising regularly (labeled *months of training* in Table 1);
- In how many sites they had been training (home, fitness center, outdoor; labeled *sites of training* in Table 1);
- How many UNI.Fit services they had used (gyms, training courses and other services; labeled *UNI.Fit services* in Table 1)
- Their current stage of the TTM;
- Their motivation to exercise.

In order to measure the stage of TTM we used an Italian translation of the questionnaire developed by [21] specifically for the exercise context. To measure motivation, we used a reduced Italian version of the Sport Motivation Scale [23], originally developed to measure the seven aforementioned motivational constructs in athletes. Since our participants were not athletes but generally sedentary people wishing to start exercising, we did not measure intrinsic motivation to know, which is more appropriate for athletes aiming at refining their technique. Moreover, since the boundaries between the seven motivational constructs are not clearly defined (it can be difficult to distinguish between introjected and identified external motivation), we included items measuring the constructs we were particularly interested in, namely: intrinsic motivation to experience and to accomplish, extrinsic motivation (external regulation), and amotivation.

Out of the initial 138 participants, 81 completed the questionnaire (38 males and 43 females, mean age = 26.3 years, range 18–55). Out of these, 55 respondents participated in the second evaluation in March 2013.

For both scales, respondents were asked to indicate how much they agreed or disagreed with a series of statements previously associated to the stages of change [21] and to distinct motivational constructs [23]. In order to assess construct validity, the data were then subjected to two distinct exploratory factor analyses using principal components with varimax rotation. With regard to the TTM scale, the analysis suggested the existence of six factors corresponding to the stages of change detected by Marcus [21]: *precontemplation (non-believers in exercise)*, *precontemplation (believers in exercise)*, *contemplation*, *preparation*, *action*, and *maintenance*. As for the motivational scale, the analysis identified three distinct dimensions, corresponding to *amotivation*, *extrinsic*

Stage of Exercise Behavior	Participants
Precontemplation (non-believers in exercise)	9
Precontemplation (believers in exercise)	14
Contemplation	16
Preparation	12
Action	14
Maintenance	16
Motivation	**Participants**
Amotivation	18
Extrinsic motivation (external regulation)	31
Intrinsic motivation (to experience and to accomplish)	32

Table 1. Participants distribution across TTM stages and motivational levels.

motivation (external regulation), and *intrinsic motivation (to experience and to accomplish)*. Participants' distribution across TTM stages and motivational dimensions is reported in Table 1. For both scales, internal consistency was assessed using Cronbach's alpha.

Results

The first research question investigating the relationship between TTM stages and motivational constructs was addressed using Pearson's correlations, which showed:

- a positive correlation between precontemplation (non-believers in exercise) and amotivation (r=.547; N=81; p<.001);
- a positive correlation between precontemplation (believers in exercise) and amotivation (r=.221; N=81; p=.048);
- a positive correlation between preparation and extrinsic motivation (external regulation; r=.235; N=81; p=.035);
- a positive correlation between maintenance and intrinsic motivation (to experience and to accomplish; r=.260; N=81; p=.019).

In order to investigate the second research question, a correlation analysis was carried out (see Table 2), which generally showed a relationship between performance at the fitness test of March and the stages of the TTM and motivational dimensions.

	Stages of Exercise Behavior						**Motivation**		
	PC (nb)	**PC (b)**	**C**	**P**	**A**	**M**	**AM**	**E**	**I**
Retest results (N=55)									
Astrand	-.118	**-.308***	-.146	-.003	-.063	-.156	**-.273***	-.136	-.090
Squat	-.122	-.170	-.051	-.173	-.049	-.057	-.212	.015	.223
Push-up	.102	-.037	.096	.014	-.126	**.272***	-.038	**.393****	**.452****
Sit-up	.015	.180	.115	.084	.140	**.310***	.015	.257	.202
Stork	-.116	-.026	.058	.038	.044	-.178	.044	-.134	.264
Sit & reach	-.219	-.155	-.080	-.222	.255	.093	-.156	-.042	.159
Self-reports (N=81)									
Freq. aerobic	-.168	-.218	-.106	-.023	**.320****	**.340****	**-.251***	.148	**.388****
Freq. leg strength	-.140	-.058	.064	-.075	**.251***	.213	-.164	.015	**.227***
Freq. arms strength	-.007	-.102	-.107	-.062	.157	**.287****	-.203	-.004	.113
Freq. abdom. strength	-.128	-.185	-.007	.109	**.227***	**.303****	-.215	.178	**.248***
Freq. balance	.066	.110	-.091	-.097	**.230***	.133	-.142	-.091	**.235***
Freq. flexibility	-.039	-.166	.000	-.077	**.259***	**.282***	-.140	.009	**.261***
Months of training	-.145	-.099	**-.319****	-.171	-.031	**.568****	**-.319****	.029	.110
Sites of training	-.159	-.098	-.012	-.096	.022	.211	**-.228***	-.048	.156
UNI.Fit services	-.065	.073	.078	.099	**.296****	.168	.114	.210	-.062

Table 2. Pearson correlation coefficients between performance levels at fitness test, self-reports of physical activity and TTM stages and motivational dimensions. PC (nb): Precontemplation (non-believers in exercise); PC (b): Precontemplation (believers in exercise); C: Contemplation; P: Preparation; A: Action; M: Maintenance. AM: Amotivation; E: Extrinsic motivation (external regulation); I: Intrinsic motivation (to experience and to accomplish). * p < .05. ** p < .001.

More specifically, the results showed a negative correlation between performance at the Astrand fitness test, precontemplation and amotivation. Similarly, the number of months of regular exercise were negatively correlated with contemplation and amotivation. Other significant negative correlations were found between self-reported frequency of aerobic training, the number of months of regular exercise, the number of sites of training and amotivation. On the other hand, overall positive correlations were found between the performance at the push-up and sit-up test, several self-reported measures and the upper TTM stages and intrinsic motivation. It is not surprising that no significant correlation were found between performance at the stork and sit & reach tests, TTM stages and motivation. Indeed, the stork test is used to measure balance ability by standing for as long as possible on the ball of the foot while keeping the hands on the hips and the non-supporting foot against the inside knee of the supporting leg. Reasonably, the performance at this test depends much, besides on training, also on the participant's concentration and contextual factors like the presence of other people in the room, noise or other distracting elements. On the other hand, the sit & reach test consists in sitting on the floor with the legs fully extended, bending forward as far as possible and holding the position for a few seconds. So, it seems reasonable that this measure of flexibility depends on joints' structure, muscles' tightness, tendons and ligaments, as well as on training.

DISCUSSION AND CONCLUSION

In this paper, we presented the study conducted during the initial design phase of a mobile application aimed at encouraging and maintaining over time a regular physical activity. We focused on the TTM and SDT, according to which an effective and consistent behavioral change can be obtained by providing personalized feedback to people, taking into account their different stages of change and motivational needs.

In particular, we addressed two research questions. First, we wanted to investigate the relationship between motivation and TTM stages. Past research in this area analyzed the relationship between SDT and TTM in other domains that fitness, such as drug abuse [16], employed indirect measurements of motivation [13], or did not take into account amotivation [1].

The second research question we addressed was whether or not there was an association between performance at the fitness tests, TTM stages and motivational dimensions. Past studies investigating the relationship between physical activity and TTM stages mainly relied upon self-reports to measure exercise behavior [15, 26]. Studies using behavioral indices of physical activity focused on walking and balance exercises in older sedentary women [8], while others using biometric measurements of physical fitness focused only on the upper stages of the TTM [2].

In this paper, we contributed to the past literature by investigating the relationship between different levels of motivation, including amotivation, and TTM stages in the exercise domain. Moreover, we studied the relationship between TTM stages and physical activity levels by measuring the performance at six fitness tests employing biometric measures.

We surveyed participants to measure their motivation to engage in a physically active lifestyle and their actual stage of change according to the TTM. Moreover, we employed biometric measurements of physical fitness, such as cardiovascular variables and maximal oxygen uptake, assessing their performance in a battery of exercises related to different body areas. The results showed a significant relationship between performance, TTM stages and motivation, suggesting that better performances may be associated to the upper stages of TTM and to intrinsic motivation, while poorer results at the physical tests may be related to the initial TTM stages and to amotivation to engage in physical exercise.

The results support previous research carried out in the exercise context and in other domains, and allow us to envision the advantages of a mobile interface adopting different persuasive mechanisms for users belonging to different stages of the TTM. Most technologies aiming at inducing a behavioral change use a *one-size-fits-all* approach, which consists in providing the same feedback to all users, without regard to motivational aspects and the current stage in the intentional behavior change process [12]. However, the theoretical framework provided by TTM and SDT suggests that a much more effective way to sustain consistent behavioral change toward a more active lifestyle may be to take into account these aspects, providing personalized feedback to users. In this section, drawing from the aforementioned psychological theories and from our empirical results, we turn the focus on the different intervention strategies which should be implemented in each TTM stage to sustain a consistent behavioral change toward a physically active lifestyle. Users in the lower stages could be persuaded to increase their physical activity through education and gamification techniques, while users in the upper stages could benefit from peer-pressure and other incentives that leverage their intrinsic motivation to a healthy and active lifestyle. The main intervention strategies proposed are further explained below and summarized in Figure 1.

Precontemplation: our results showed a positive correlation between precontemplation and amotivation, and thus actions targeted at precontemplators should be directed to induce motivation, for example by highlighting the detrimental effects on health of sedentary behavior and the beneficial effects of adopting a healthy lifestyle. Nevertheless, we should still distinguish between non-believers and believers in exercise. The former do not typically have the intention to change their behavior, and

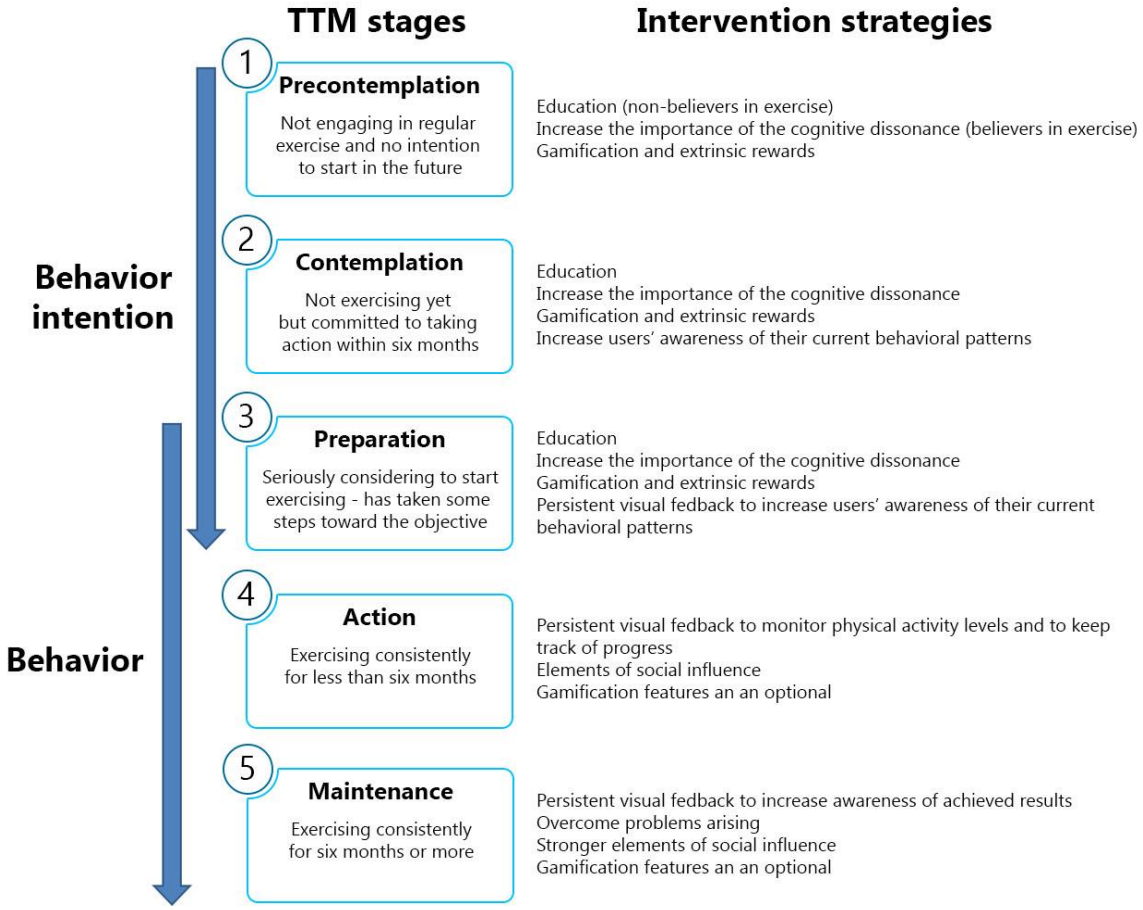

Figure 1. Specific intervention strategies for each stage of the Transtheoretical Model of Behavior Change .

neither believe in the benefits of exercise, thus the main focus in this stage should be on education, to increase the awareness of the benefits of a regular exercise behavior for health [4]. On the other hand, believers in exercise should be expected to experience a psychologically uncomfortable cognitive dissonance between their positive attitude toward exercise and their actual sedentary behavior. According to Cognitive Dissonance Theory [7], these individuals will try to reduce the dissonance in three different ways according to their motivation to engage in regular exercise: by changing their attitude, by changing their behavior, or by reducing the importance of the dissonance. Education strategies directed at these stagers should then be focused on increasing the importance of this cognitive dissonance, leading them to take a first step toward physical activity. Moreover, since the earlier stages of the TTM are related to lower motivation, gamification techniques providing a fun exercise environment and a system of extrinsic rewards should be introduced at this phase [5, 22, 28]. On the contrary, it would be preferable to limit the implementation of peer-pressure techniques, since they seem to perform better for motivated individuals who are consistently physically active [17].

Contemplation: contemplators are considering to change their behavior, but have not started to exercise yet. Similarly to the previous stage, education and strategies aimed at increasing the importance of the cognitive dissonance may help to sustain an initial behavioral change, even if inconsistent. Persuasive visual feedbacks should be aimed at increasing users' awareness of their current level of physical activity without making them feel uncomfortable [4]. Rewards for performing the desired behavior [4], in the form of badges or virtual goods in a gamified system [22, 28], should be provided to users. Similarly to the previous stage, peer-pressure and social support should be limited or provided as an optional feature.

Preparation: individuals in this stage are more motivated than precontemplators and contemplators to change their behavior and have started exercising, although inconsistently. Our results showed a significant positive correlation between preparation and extrinsic motivation

(external regulation). Thus, individuals in the preparation stage could benefit from the extrinsic rewards provided by gamification techniques. At this stage education could still be useful to increase the cognitive dissonance. Persistent visual feedback increasing users' awareness of their behavioral patterns and rewards for exercising should be provided [4]. Element of social support and peer-pressure should still be provided as optional.

Action: people in this stage have been exercising consistently for less than six months. Persuasive technologies should thus help users to monitor their exercise behavior and to keep track of their progress toward their objectives in order to support consistency [4]. Gamification features at this point should be reduced, while elements of social influence may be further integrated to sustain peer-pressure [4].

Maintenance: individuals in this stage have consistently performed the desired behavior for at least six months, and therefore should be helped to increase their awareness of their achieved results and to overcome possible problems arising [4]. Moreover, considering the significant positive correlation between maintenance and intrinsic motivation (to experience and to accomplish), gamification techniques providing extrinsic rewards should be reduced and provided as an optional, while social support may be implemented more strongly.

It is important to recognize that behavior change is a dynamic process that takes place over time and is characterized by different motivational levels. We believe that an adaptive, personalized approach informing the design of persuasive technologies to encourage a physically active lifestyle would be more effective than a *one-size-fits-all* approach. This paper presents such an approach, based on psychological theories and empirical results, which will be implemented in the design of a persuasive application for mobile systems. The next steps in our research agenda will be aimed at implementing the adaptive mobile interface and testing it with users, taking into consideration the persuasive strategies mentioned above and further examining how to incorporate elements of peer-pressure to promote a change toward a physically active lifestyle in sedentary people.

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