The Relationship between Goal Difficulty and Performance in the Context of a Physical Activity Intervention Program

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ABSTRACT
This paper addresses the relationship between goal difficulty and performance within the context of an ongoing activity intervention program called New Wellness Solutions (NWS). The NWS program employs a mobile device to enable moment-to-moment monitoring and progress feedback. In order to assess the relationship between goal difficulty and physical performance, we analyzed the data of a recently completed NWS program test. We found a significant positive linear relationship between goal difficulty and performance for individuals with an inactive lifestyle. No significant relationship was found for individuals with an active lifestyle. This may be explained by the active participants’ low level of commitment to the assigned goals. We conclude that sufficiently difficult goals combined with timely progress feedback are effective in increasing activity levels of inactive people. Future studies should address the effect of additional mobile persuasion techniques to further improve physical activity patterns of inactive individuals and to enhance goal commitment of active individuals.

Categories and Subject Descriptors
J.3 [Life and Medical Sciences] - health.

General Terms
Measurement, Human Factors, Experimentation.

Keywords
Behavioral change, physical activity intervention, goal setting, timely feedback, mobile persuasion.

1. INTRODUCTION
Physical activity has numerous beneficial effects on physical health and mental well-being [6]. However, modern conveniences have encouraged large numbers of people to adopt a sedentary way of living and this has resulted in the negative health consequences that accompany this lifestyle. Governments, communities, and health promotion researchers are attempting to address the growing problem by developing physical activity intervention programs. Despite the fact that these programs often rely on insights from various health behavior theories, few programs have proven to be effective in promoting physical activity [10]. As a consequence, increased effort is now directed at augmenting the persuasive power of these programs in changing people’s attitude and behavior towards activity. The upcoming domain of mobile persuasion provides promising methods to change human attitudes and behaviors by means of mobile devices. A major advantage of mobile persuasion over more conventional persuasion methods (e.g., printed adverts or the internet) is the possibility to support an individual on a moment-to-moment basis, thereby increasing an individual’s attention to the desired changes [1]. Recent results in the area of physical activity intervention seem to suggest that the incorporation of mobile technology into an intervention program may be a powerful means to impact people’s behavior [2] [3]. Within this context, mobile technology has two clear advantages over more traditional intervention modalities. The first advantage is that mobile technology allows for on-body accurate and real-time measuring of the amount and intensity of physical activity performed by the individual. The second advantage is that a mobile device can be used to provide real-time feedback about the progress towards a pre-specified goal.

Goals and timely feedback about progress towards the goal are known to play a key role for an individual’s performance [8]. Goals enhance people’s awareness of the so-called goal-performance discrepancy, i.e., the discrepancy between their current level of performance and the desired level of performance [4]. A vast amount of literature addresses the impact of goals on people’s performance (for an overview, see [5]). A core finding in the literature is the positive linear relationship between goal difficulty and performance (with performance leveling off or decreasing when approaching competence boundaries). However, in order for this relationship to hold, timely feedback about progress towards the goal is essential [8]. Although the effects of goal difficulty and progress feedback on performance have been obtained robustly across numerous studies [5], these studies were mainly performed in the work-place environment. In contrast, the effects of goals and feedback on performance have been explored much less extensively in the domain of physical activity promotion in people’s daily lives [9]. A better understanding of these effects is required in order to employ them to enhance the effectiveness of daily-life physical activity intervention programs.

In this paper, we examine to what extent goal difficulty combined with real-time progress feedback on a mobile device enhances performance within the context of an ongoing activity intervention program called New Wellness Solutions (NWS).
NWS aims to increase the amount of physical activity people perform in their daily lives. One of the key elements of the program is the use of an unobtrusive mobile device that monitors the user’s physical activity and visualizes the user’s progress towards a daily-specified activity goal. While mobile technology has been used in activity intervention programs before [3], few of these programs have analyzed the relationship between goal difficulty and performance given real-time progress feedback in a systematic manner. Our investigations aim to do so, by analyzing the data obtained in a recently completed NWS program test (results of which are described in [2]). Moreover, since we expect that the relationship between goal difficulty and activity performance will be affected by someone’s initial activity level, we examine the relationship separately for individuals that were inactive and those that were active prior to entering the NWS program.

The outline of the remainder of this paper is as follows. Section 2 describes the set-up of the NWS program test, the goals and timely progress feedback as employed in the NWS program, and our data analysis. Subsequently, section 3 presents the results of our data analysis. This is followed in section 4 by a discussion of the results and their implications. Finally, section 5 provides our conclusions and identifies interesting ideas for future research.

2. METHODS

In order to gain insight into the relationship between goal difficulty and performance in the context of physical activity intervention, we analyzed the data of 212 individuals that participated in the NWS program test. Below, we briefly describe the set-up of the NWS program test, the goal-setting and timely progress feedback within the NWS program, and our data analysis.

2.1 The Set-Up of the NWS Program Test

In order to optimize people’s engagement in the program, NWS exploits various persuasion modalities including a web-service and the mobile activity monitor that provides timely feedback about progress towards an assigned goal (for a more detailed description of the NWS program test, see [2]). The 212 participants that participated in the NWS program test were recruited by an email invitation within two companies. At the start of the program test, participants entered a so-called ‘assessment week’, during which they wore the mobile activity monitor. The measured physical activity during the assessment week served as a baseline measurement. Moreover, it was used to select from four predefined activity plans, an appropriate activity plan for the participant, aimed at increasing the activity level during the 12 weeks of the program. The activity plan corresponded to a final activity goal.

2.2 Goals and Timely Progress Feedback

In the NWS program, participants are gradually guided towards their final activity goal by means of daily-specified goals. While the web service provides participants with a historical overview of their performances and their progress towards their goal, the mobile activity monitor allows for timely progress feedback. The activity monitor is a small device that contains a 3 dimensional accelerometer, which is an extended version of the Tracmor device developed within Philips Research [7]. The mobile monitor is worn unobtrusively on the body by means of a key cord or in the trouser pocket. It monitors physical activity and visualizes progress towards the daily goal by means of a number of LED’s arranged in a straight line. The end of the line (indicated by a small marker on the device) corresponds to the daily-specified goal. By observing the number of LED’s that light up, the participant is able to assess daily progress in an easy manner at any convenient time of day and adjust activity accordingly.

2.3 Data Analysis

Our analyses aimed to reveal to what extent goal difficulty had affected the increase in the levels of daily-life activity of the NWS program participants. In particular, we examined the relationship between goal difficulty and the increase in the average level of physical activity during the assessment week and during the last week of the program. While it is possible to analyze the data on the basis of absolute goal and performance values, we used relative rather than absolute values for two reasons. First, the amount of kilocalories (KCal) needed to perform a certain activity varies with body composition, weight and stature, leading to considerable differences across individuals. Second, the perceived difficulty of a certain physical activity goal is likely to depend on the baseline physical activity level of an individual (e.g., while a half-hour walk can be experienced as an extreme challenge for a sedentary person, it is likely that this is less of a challenge for a professional marathon runner). Considering the individual character of caloric expenditure and the subjective nature of perceived goal difficulty, calculations were performed in terms of relative changes with respect to baseline levels.

For each participant goal difficulty was defined as the relative increase in the level of physical activity of the goal with respect to the baseline physical activity level (as measured during the assessment week). Despite the fact that the program employed only four predefined activity plans (corresponding to an activity goal), degrees of goal difficulty covered a wide range of values across participants, because they were expressed as the relative increases with respect to baseline physical activity levels. In a similar manner, the increase in physical activity was defined as the relative increase of the measured activity level during the last week with respect to the measured baseline activity level.

After calculating relative goal difficulties and physical activity increases, correlation analyses were run to assess the degree of linear relationship between goal difficulty and activity increase. As mentioned previously, we expected that initial activity levels will have an impact on the relationship between goal difficulty and activity increases (see also section 4). Therefore, separate correlation analyses were performed for the group of initially inactive participants (defined as PAL$^1$ (physical activity level)<1.7) and the group of initially active individuals (defined as PAL$\geq$1.7). For our initial analyses, we used the data of 138 participants that persisted until the end of the program. Data of 2 of these participants were discarded because of a measured average activity level during the last week that was below 33% of their activity level measured during the assessment week, suggesting that measurements were inaccurate during this last week. For the remaining 136 participants, patterns of measured physical activity during the last week suggest that they wore the

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1 PAL = total energy expenditure / resting energy expenditure. According to the World Health Organization statistics a PAL>1.7 is desirable to maintain good health.
monitor during the last week of the program and that measurements were accurate.

3. RESULTS
The results of our correlation analyses show a different pattern for the group of initially inactive participants and the group of initially active participants.

For the group of initially inactive participants (N=50), a significant positive linear relationship was obtained between goal difficulty and physical activity increase, R=0.52, p<0.01. Figure 1 presents the physical activity increase as a function of goal difficulty² for the inactive group (a) and for the active group (b).

For the group of active participants (N=86), correlation analysis revealed no clear linear relationship between goal difficulty and physical activity increase, R=0.05, p>0.5.

Overall, the data demonstrate a positive linear relationship between goal difficulty and physical activity increases for the group of participants that were inactive when they entered the NWS program test. In contrast, no significant relationship between goal difficulty and physical activity was found for the participants that were already active when they entered the NWS program test.

4. DISCUSSION
The results show a clear difference between the group of initially inactive and the group of initially active participants. We found a significant positive linear relationship between goal difficulty and performance for the inactive group and no relationship for the active group. Below, we first discuss a plausible explanation for the difference found between the initially inactive and the initially active group of participants. Subsequently, we elaborate on the possible confounding effect of excluding the data from the data analyses of participants that dropped out before the end of the program.

A possible explanation for the difference in results for the initially inactive and the initially active group of participants, with respect to the relationship between goal difficulty and physical activity increase, is postulated as being due to the differences in commitment levels to their goals. Goal commitment has been identified by numerous studies as a moderator of the relationship between goal difficulty and performance [5]. This relationship is strongest when individuals are committed to their goals and loses strength with decreasing commitment levels. We expect that a low level of goal commitment of the active participants in the NWS program test may explain why we were unable to find a positive relationship between goal difficulty and performance for this group. Two main categories of factors facilitating an individual’s commitment to a goal can be distinguished. The first category contains factors that enhance the importance of attaining the goal and the accompanying outcomes. The second category consists of the factors that relate to the belief in the competence of attaining the goal (also referred to as self-efficacy). Given their activity level, it is highly likely that the initially active participants have a sufficient degree of self-efficacy to facilitate their commitment to the activity goals. Therefore, we expect their commitment to be hindered by an insufficient level of importance that they assign to the goal rather than by an insufficient degree of self-efficacy.

Typically (highly) active individuals, are very well aware of the fact that their activity level is considerably higher than average and there is no need to increase it for health purposes. We can argue that their personal reasons for participating in the program were of a different nature than the initially inactive participants. They may have been driven by curiosity about the program and the mobile device or they may have been looking for a tool to measure their actual activity level rather than increase it. As a consequence, the timely progress feedback on the mobile activity monitor, possibly served to validate the activity level rather than provide information on goal- attainment. For these reasons, it is likely that they placed less importance to assigned goals. In contrast, the initially inactive individuals are (made) aware of their low and unhealthy level of activity and might experience a sense of urgency to improve. The participation in the NWS program augments their realization that goal attainment is important and brings positive outcomes for their health. Timely progress feedback as well as feedback on the website of NWS

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² For reasons of confidentiality as formulated by the NWS program development team, exact goal difficulty values are not provided. However, the positive linear relationship between goal difficulty and physical activity increase is clearly visible.
gives the inactive people insight into how they are doing, when they are most active, and where there are still opportunities to increase activity. We can imagine that this sort of feedback encourages exploration of one’s capabilities, effectively increasing self-efficacy and goal-commitment. We believe that the difference in goal commitment between initially inactive and initially active individuals forms a plausible explanation for the obtained results: a positive relationship between goal difficulty and physical activity increase for the inactive participants and the absence of such a relationship for the active participants. This explanation in terms of differences in goal commitment is supported by the fact that physically active individuals showed no increase in physical activity levels over a course of 12 weeks, while initially inactive individuals showed an average increase of 10% [Goris, personal communication]. In order to motivate already active individuals to increase their activity, the activity program could attempt to enhance commitment levels to their goals. A possible solution is to enable self-set goals or goals that are tailored to the wishes, and not just capabilities, of the participant. This may be combined with various types of mobile persuasion techniques to enhance goal commitment and engagement in the program, e.g., timely triggers on the mobile device that effectively persuade the participant into physical activity at appropriate points in time.

The exclusion of the data of the participants that dropped out before the end of the program may have confounded our results with respect to the positive linear relationship between goal difficulty and activity increases for the initially inactive group of participants. Several studies have shown that the positive relationship between goal difficulty and performance is limited to competence boundaries, showing a decrease in performance and severely reduced levels of commitment to the goal when these boundaries are approached or exceeded [5] [8]. A similar loss in goal commitment may have led to an early drop out of the NWS program test for those participants that perceived their goal as being extremely difficult. If so, it is possible that exclusion of the data of the dropped-out participants has provided us with a distorted picture of the relationship between goal difficulty and activity increase. In order to assess whether goal difficulty had affected early dropping out of the NWS program, we performed an additional analysis in which we compared the goals of those who dropped out before the end of the program (i.e., the ‘drop-outs’) with those that persisted until the end of the program (i.e., the ‘persisters’) in terms of difficulty. The results of an unbalanced ANOVA demonstrated that there were no statistically significant differences between levels of goal difficulty for drop-outs and persisters. Nevertheless, we expect that goal difficulty will have an impact on dropping out of the program when goals of an extremely high level are assigned, but apparently this did not play a role in the NWS program test under consideration. From this we conclude that the exclusion of early drop-outs from our data analysis has not affected our results with respect to the relationship between goal difficulty and physical activity increase.

5. CONCLUSIONS
The development of mobile technology opens an enormous field of persuasion possibilities that should be carefully studied in order to reveal their impact and persuasive power. Insights on behavioral change from traditional psychology may be helpful to direct these studies. In this paper we have made a first attempt to address the use of psychological insights on behavioral change in the context of mobile-technology supported physical activity intervention. The NWS program makes use of psychological insights on goal-setting and timely feedback and exploits some of the persuasive techniques that mobile technology may offer for effective physical activity change. Our results show that this is a promising direction to take. Goal difficulty coupled with timely progress feedback significantly influences daily life physical activity of individuals with an inactive lifestyle in the context of the NWS program. Further investigations into mobile persuasion will help us to make positive physical activity changes in people’s lives.

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7. REFERENCES