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Motivational Effects of a Gamified Training Analysis Interface

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Abstract

Physical exercising is important; yet, many people have difficulties in finding the motivation to do exercise on a regular basis. This paper investigates a combination of two current approaches to increase motivation: *quantified self tools* and *gamification*. Quantified self means using technology to provide detailed quantitative measures of user performance, which can motivate one to set, and aim to achieve, specific goals. Gamification adds game elements and game-like reward systems that can help to increase motivation by providing regular positive feedback. While we are not the first to address physical exercising with gamification, this work investigates the combination of both approaches in a specific application area: electronic muscle stimulation training. The results of a first user study with 8 participants over 2 weeks indicate that there is a strong positive effect of combining both approaches in terms of intrinsic motivation and emotional valence and that this area is a worthy candidate for further study.

1 Introduction

Physical exercising is an important ingredient of an overall healthy lifestyle for people of all ages. Yet, many people have trouble finding the motivation and discipline in their daily life to actually perform physical exercises and stick to a regular routine. While feelings of pride after a hard workout or the joy of moving and performing exercises are motivation enough for some people, they are clearly not enough for many others and even for those who exercise regularly there is room for improvement in terms of short and long term motivation. When exercising, it is often the case that one improves very quickly in the beginning, which is very motivating but then – as is the nature of all training – the feeling of improvement stagnates and at this point, many people get frustrated or lose the motivation to continue.

There are different approaches conceivable to tackle this challenge. One approach is to design exercises and exercising devices to be as intrinsically motivating a possible. Another important ingredient and the focus of this paper is the role of short term goals and meaningful feedback. Short term goals and feedback are key ingredients of games and so it is

not surprising that the application of game elements or gamification (Deterding et al. 2011) is a natural fit to this application area and many projects have investigated different uses and design possibilities of gamification for exercising or sports (cf. section 2). In line with this general trend, we take a specific look at combining gamification methods in a meaningful way with digital training analysis including *quantified self* (QS) techniques (Li & Forlizzi 2010). We do so for a specific type of high-tech training method: *electronic muscle stimulation training* (EMS), reporting on a study with 8 users over the course of four sessions. The results show how motivational and affect measures improved significantly for the gamification group compared to a control group.

2 Related Work

Our study brings together several fields of research where prior work has been done and applies their approaches to a specific area. Firstly, it is related to the QS approach (Li & Forlizzi 2010), which is a label for an ongoing trend of using information systems to provide exact, objective and quantitative measurements of various personal data and performance indicators. Getting detailed computer feedback on personal performance can be a strong motivating factor in the fitness training domain (Annesi 1998). Our interface also makes use of this approach by providing detailed statistics and diagrams on the performed physical exercises. However, in addition to QS and computer feedback we also include gamification elements (Deterding et al. 2011; Groh 2012) to Potenzially increase the motivation by providing additional means of receiving positive feedback and to aid in overcoming times of stagnating progress that can be detrimental to motivation. While other researchers have investigated the use of games as a reward for doing physical exercises (Lin et al. 2006; Fujiki et al. 2008), game elements which are employed in our work are tied more directly to the analysis and personal training goals. This work is related to some commercial approaches like *NikeFuel*, *Runtastic*, etc.[1], but focuses on a specific application area.

3 Design and Implementation

We designed and implemented a digital interface in order to investigate the effects of gamification elements in combination with training analysis reports on the motivation and emotional affect of the participants. We chose EMS training as a testbed because it had not been investigated in the past, the concept of different voltage levels provides interesting opportunities for gamification approaches, and because this training method was well established in the gym that cooperated with us on the study. EMS is a physical training method where the training effect of conventional physical exercises like push-ups or sit-ups is increased by applying low-voltage electrical stimuli to the muscles. This causes the

[1] NikeFuel: https://secure-nikeplus.nike.com/plus/what_is_fuel/, last viewed: 2014-06-02
Runtastic: https://www.runtastic.com/, last viewed: 2014-06-02

muscles to contract, increasing the difficulty of – or resistance during – performing the exercises. The intensity level (8 steps in the system we used) of the stimuli is usually increased over time up to a certain healthy maximum but may also vary depending on training goals, phases or the form of the day.

Figure 1: Performance overview with date picker and comparison of latest workout with past workout.

Building on informal feedback on a paper prototype we designed the technical prototype used for the evaluation with the goal to provide a good long and short term overview of the current training results and to include motivational elements that provide personal short term goals and rewards. Data was fed to the system manually in a *Wizard of Oz* fashion prior to each session. The overall interface design consists of several different screens. Some screens are devoted to regular "bookkeeping" functionality, akin to the way that people would record their training performance manually (an overview screen with typical data like name, date(s), number of repetitions, EMS level used, etc.). These screens provide interface elements like calendars to select dates and, in addition to numerical values, they also include bar charts visualizing important data, such as the EMS intensity (figure 1). The design of these pages was inspired by QS approaches, i.e. intended to provide detailed documentation and quantitative data on the training progress, thereby facilitating an objective view on the current training state and providing means to set explicit and checkable goals. We also included three types of gamification elements that are presented in the award screen (figure 2): score points, leader boards, and achievements. Some of these elements are also presented in an abbreviated version on other screens (e.g. the profile overview), but the award screen is the main overview screen for these elements.

Figure 2: Award screen with high-scores and overall score.

Score points are awarded based on the performed workout, intensity/stimulation level and special awards. We designed the system to include two kinds of workouts – each a specific combination of typical exercises – but in principle, additional workouts or exercise combinations are possible. For the regular training we determined a base score of 50 points and for the assessment workout (that would only be performed from time to time), a base score of 75. Intensity levels and achievements work as multipliers and bonus points on top of the base score. Achievements are awarded for different kinds of accomplishments, such as breaking one's personal record. We added four leader boards to account for different aspects and training types: points, intensity level, personal best in a single exercise, and personal best overall.

4 User Study

In total, 9 members of a local gym volunteered for participating in our study. From these we selected 8 participants (4 male / 4 female) and divided them randomly into two groups, each composed of 2 male and 2 female participants. Each participant was asked to perform 4 exercise sessions within a time span of 2 weeks for the study. We employed a between subjects design with usage of the analysis interface as the independent variable. The control group would perform regular training, i.e. without using our analysis interface. The treatment group would do the same physical exercises and use the analysis interface as presented above. The dependent variables were emotional affect and motivation measured using the *self-assessment manikin* (SAM) (Bradley & Lang 1994) and the *intrinsic motivation inventory* (IMI) (McAuley et al. 1989), respectively. Additionally, we collected quantitative data on the exercise intensity (via a *Borg rating of perceived exertion*; RPE) (Borg 1982) and general qualitative feedback from the participants together with basic demographic information and a general physical activity questionnaire. Each training session lasted about

45 minutes, including time for changing and EMS device configurations. For the treatment group, each session started with using the analysis interface to check on their current progress (5 - 8 min.) before performing the physical exercises (20 min. for both groups). Before and after the physical exercise block, the participants were asked to fill out the SAM and RPE questionnaires. After each session, they also responded to the detailed IMI motivation questionnaire. The participants were supported by a trainer in using the analysis interface, however, the trainer was instructed to only guide the interface usage and to avoid providing any direct feedback (positive or negative) on the participants' training results or progress.

4.1 Results and Discussion

All participants were physically active, reporting at least four days with light intensity workouts, two days of medium intensity physical activities, and 1 day with high intensity physical activity per week (session min. duration: 20 min.). The mean age of the interface group was 36 years (SD = 6.06), the mean age of the control group was 32.25 years (SD = 2.5). All participants had prior experience with EMS training (M = 16.6 months), reducing the risk of training effect biases resulting from this uncommon form of exercising. The Borg RPE results show that the participants were challenged by the fitness program, as their heart-rate was notably elevated following each workout (pre-values: 90 - 130 bpm; post-values 170 - 200 bpm). The means of post-pre RPE differences were similar (6.25 - 8.75, which translates to ~ 63 - 88 bpm) in both groups with slightly elevated overall differences observed in the interface group (7.25 – 8.75). The IMI results are visualized in figures 3 to 7. In our sample groups, we observed clear trends on the *interest enjoyment*, *perceived competence* and *effort importance* dimensions. All three measures are coherently in favor of the interface intervention. While the results from the measure on *tension pressure* are less clear, they also appear slightly in favor of the interface intervention, at least during the first two sessions (since higher values are arguably "worse"). Accordingly, the overall measure of *intrinsic motivation*, which is calculated as the mean value of all four dimensions of the test, again shows a clear trend in favor of the interface group.

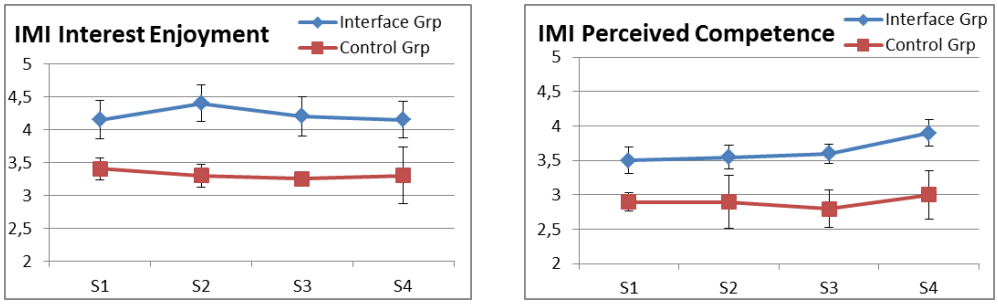

Figure 3/4: IMI interest enjoyment / perceived competence means over all sessions. Error bars show standard error.

For the following statistical inference tests we dismissed sessions one and four, since the first session might be highly influenced by novelty and training effects and the last session was

announced as such, which is also likely to bias outcomes. We performed t-tests and also report the effect size (Cohen's d).

We found a significant effect on the session two and three mean of the *interest enjoyment* dimension of the IMI (interaction group: (M = 4.3, SD = 0.56), control group: (M = 3.27, SD = 0.17), t(3.55) = 3.50, p = 0.03, d = 2.48). We also found a significant effect on the *effort importance* dimension (interaction group: (M = 4.28, SD = 0.48), control group: (M = 3.09, SD = 0.6), t(5.74) = 3.09, p = 0.02, d = 2.18), but not on the perceived competence or the pressure tension dimension. Finally, the overall measure of *intrinsic motivation* also showed a significant effect (interaction group: (M = 3.59, SD = 0.28), control group: (M = 2.89, SD = 0.25), t(5.94) = 3.78, p = 0.009, d = 2.67).

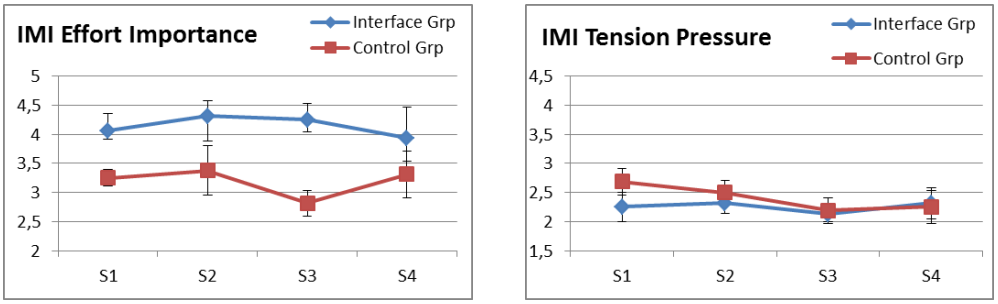

Figure 5/6: IMI effort importance / tension pressure means over all sessions. Error bars show standard error.

The statistical inference results, as reported above, appear clear and coherent, and t-tests are known to be robust against violations of the assumptions of normality and homogeneity in parametric tests. Still, they should only be interpreted as promising indications for generalizable effects, due to the small number of participants per group. Shapiro-Wilk tests on the normality of the data and Levene's tests on the homogeneity of the data are not significant. However, it should be kept in mind that the tests are null hypothesis tests against the assumption of normality and homogeneity respectively and as such do not deliver definite evidence for adherence of the data to the assumptions of normality / homogeneity. We visually confirmed a rough adherence to a normal distribution in all cases by plotting normal Q-Q plots for all data points.

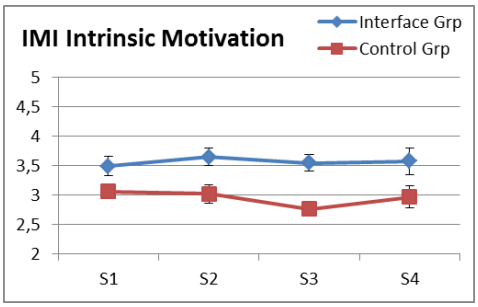

Figure 7: IMI combined measure of intrinsic motivation means over all sessions. Error bars show standard error.

SAM results indicate slightly elevated values across the valence, arousal and dominance measures in the interface group. Following the same procedure as with the IMI analysis, session two and three means indicate a significant difference on the *valence* dimension (interaction group: ($M = 1.00$, $SD = 0.00$), control group: ($M = 0.12$, $SD = 0.25$), $t(3) = 7$, $p < 0.01$). Means were calculated from the differences of pre- and post-treatment assessments for each session using the 5-point scale SAM in order to adjust for the general emotional state of a participant before starting a session. This outcome appears to be coherent with the IMI results, especially with the difference on the interest enjoyment dimension. Even though the interface features high-scores, tension pressure, which may intervene with intrinsic motivation, was not elevated in the interface group. We find that our results strongly support the usage of gamified training analysis interfaces, as they appear to be enjoyable and might foster sustained training effort.

A number of limitations apply to this study. Making fixed appointments for the training sessions might impact motivation measures. However, this should affect the control condition to the same extent. Furthermore, the setup and study focused on short term training motivation within training sessions ("performing well in a particular session") and not on long-term adherence to a training schedule. It can be assumed that the EMS target group is open-minded with regard to technical equipment and might react differently to using a digital training interface than a more general audience. The impact of employing the interface on the dependent measures cannot fully be separated from the impact of a trainer being present to discuss the progress. This may factor in on the valence measure. Lastly, the inferential results must be treated with caution, due to the low sample size. Yet, since the trends appear clear and coherent, our results are worth reporting and future work should follow-up on these insights, considering the impact of QS and gamification elements on motivational factors.

5 Conclusion

The results presented in this paper suggest a very positive motivational effect of combining a quantified self approach with additional gamification elements. While the motivational measures of *interest enjoyment*, *perceived competence*, *effort importance* and the overall *intrinsic motivation* appear clearly increased for the group of participants which used the playful training analysis interface, the measure of *tension pressure*, which contributes to the overall measure of intrinsic motivation, but may perhaps not be seen as the most desirable component, did not appear notably increased. This study differs from prior studies (e.g. Annesi 1998) in the detailed observation of motivational components as opposed to measures of gross training adherence, drop-out rates, etc. Our results indicate that employing a playful training analysis interface has an effect on multiple dimensions of intrinsic motivation. Additional work has to be done in order to confirm these effects and analyze them in more detail. It will be interesting to add an additional condition to future studies that includes an analysis interface without the gamification elements, in order to quantify precisely the added value of gamification elements.

Acknowledgements

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